The circular business case

Exploring the role of the business case in creating financially feasible and circular biobased housing developments

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Abstract

The construction industry has a significant environmental impact, consumes a large amount of scarce resources, generates a lot of waste, and causes a lot of emissions such as CO_2 which contribute to global warming and are all reasons of great concern. A significant portion of these negative environmental impacts are caused by the building sector and attendant linear construction process. Developments with biobased materials as a circular strategy help encounter this. However, this implementation is still lacking in the building industry and the linear to a circular economy transition is still in the early stages. Moreover, real estate developers are struggling to make their business cases for circular projects financially feasible, as costs are a significant barrier. To research and understand how current circular biobased business cases are adapted and if they are future proof or use temporary measures, the following main research question is used: *How are business cases adapted in order to create financially feasible and circular biobased housing developments?* To answer this question, a literature study, case studies and interviews are done with the aim to gain insights into current complications and possible solutions in the business case of biobased housing developments. As well as gather perspectives from identified stakeholders & experts on these or alternative opportunities to help and speed up the transition to biobased houses. Results show that the business cases were not drastically adapted to fit the circular strategy, but temporary emergency measures were found to help realise the projects. These were: less profit for the parties involved, investors paying extra and for construction stored carbon credits, lower land price or more focus on sustainability and less on price by municipalities, subsidies, and building only partly with biobased materials and partly with e.g. concrete and bricks. It can be concluded that the traditional business case is not fitted for biobased construction as a circular economy strategy, which also contributes to why the wider necessary shift to such strategies stays out. But also that developers and other parties are willing and working on limiting the environmental impact of the building industry.

Keywords: circular economy, biobased, real estate developers, financially feasible, business case, stakeholders, built environment.

Preface

My journey started back in September 2018 when I began with the BSc of Architecture, Urbanism and Building Sciences (Bouwkunde) at Delft University of Technology. It had not been easy to choose a study, I wanted to make the best choice and also visited completely other studies at other universities. During the bachelor, it soon became clear that my interests were less at design courses and the direction of becoming an architect and more in the direction of the master track Management in the Built Environment (MBE) within the MSc Architecture, Urbanism and Building Sciences at TU Delft.

Sustainable energy was already a relevant topic during the bachelor, but the topic of the circular economy, sustainable resources and housing developments with wood and other biobased materials only got my attention during the MBE master. This is also something Synchroon is actively focusing on, as they want and try to bring their emissions to zero and reduce their climate impact. My research for this thesis and as a graduate intern at Synchroon allowed me to explore and learn more about this very relevant subject to reduce the climate impact of the building industry.

This thesis represents my research, results and conclusions for the final part of my study at the TU Delft. The road to this moment has been a roller-coaster in which I learned a lot and gained valuable experiences. I would like to take this opportunity to thank everyone who helped me get through the roller-coaster and to this point. In particular my supervisors from the TU Delft: dr. Hilde Remøy & ing. Peter de Jong, and the delegate of the Board of Examiners: prof.dr.ir. Machiel van Dorst for guiding me through the process and providing me with feedback and their support. But I also want to sincerely thank ir. Maaike Perenboom, my supervisor from Synchroon, who helped me make connections with interviewees, make choices and to set boundaries on the topic along the way and find a way through this incredibly complex but relevant topic. I am grateful that I had the opportunity to do my graduation internship at Synchroon among many kind employees. This thesis would also not have been possible without the time and help from all the interviewees from all the different companies mentioned in this thesis, who were all very enthusiastic to talk about their knowledge, experience and ideas on the topic. A special thanks to Peter Fraanje from Built by Nature, who also helped in my research as an interviewee with discussing case study findings and to connect with other relevant interviewees.

Last but not least, I want to thank my parents and family for their encouragement and support along the way.

Yours sincerely,

Arthur Knibbe

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Executive summary

Introduction

The construction industry has a significant environmental impact, consumes a large amount of scarce resources, generates a lot of waste and causes a lot of emissions such as CO_2, which contribute to global warming and are all reasons of great concern. A significant portion of these negative environmental impacts are currently caused by the building sector and attendant linear construction process. This lineair construction process follows the take-make-waste pattern. The circular economy (CE) aims at the opposite by preventing waste production, hazardous environmental impacts and the depletion of resources. Developments with biobased materials as a circular strategy help encounter this negative impact of the building industry. The Dutch government has recognised the current problems with the linear economy and the opportunities with the circular economy. Therefore the Dutch government set out objectives to help achieve a policy program with the aim for the Netherlands to be completely circular and climate neutral in 2050. However, the circular economy implementation is still lacking in the building industry and the linear to a circular economy transition is still in the early stages. Moreover, real estate developers are struggling to make their business cases for circular projects financially feasible, as costs are a significant barrier for circular (biobased) housing developments. Real estate developers are seen as a crucial party to initiate the circular economy, because of their connection and role between supply and demand. Therefore, the focus of this research is to investigate and understand how current circular biobased business cases are adapted to be feasible and if they are future proof and optimised for the circular economy. Or if they use temporary emergency measures which do not make for a sound business case, and limit a wider transition. If this is the case, further research could be required into possible needed adaptations. For this, the following main research question was used: *How are business cases adapted in order to create financially feasible and circular biobased housing developments?*

Methodology

To answer the main research question, several sub-questions were created in order to properly answer the main question and guide the process. Furthermore, the research used qualitative research methods and is explorative. For this, a literature study has been conducted, 7 case studies were carried out and 10 stakeholder/expert interviews were conducted with parties relevant to changes/solutions found in the business case of the circular biobased housing developments analysed in the case studies.

The purpose of the literature study was to examine what the circular economy and its transition entails, but also how using biobased materials fit as a strategy in the building industry. In addition, a closer look at a real estate developer, its business case, value influence, and possible (indirect) stakeholders was taken. The aim of the case studies was to get a better understanding about the current developments and their business cases, and to identify stakeholders of the used solutions and made adaptations. Lastly, the stakeholder and expert interviews aimed at discussing the identified adaptations/solutions with them. To understand their view and opinion on them and for possible other future proof adaptations.

Results

Many definitions describing the CE and strategies for its transition were identified. The most well-known one being from the Ellen MacArthur Foundation (2013). The definitions of the CE come in short down to an economic system that minimises waste, pollution and the use of scarce resources by using sustainable and reusable resources and keeping them in use for as long as possible. Examples of strategies for this are shown in the R-strategies and the ReSOLVE framework and aim to go from ‘take-make-waste’ to ‘design-use-recover’ systems. Reports from organisations, companies, consultants and experts show that they are working on an unambiguous language, definitions and strategies for the building industry to implement the circular economy and lower its climate impact. Construction with biobased materials is seen as one of the strategies by the consultants/experts and scientific literature that fits this aim and the circular economy. Biobased materials can significantly contribute to reducing the climate impact of construction through storing carbon in a building, being a renewable resource and thus not using scarce resources and offering better reuse and cascading options. Therefore helping the building industry go from being part of the problem, to offering part of the solution.

The literature also showed that developers function as the market party for the match between local demand for space and societal challenges, have the habit with self-initiated projects to create a building and then sell it to another party, and are therefore not focused till the end of the building's lifespan. The most important parameters, whether to develop, are the costs and earnings in the business case, but also other interests/goals such as social, ecological and cultural factors come into play. The business case examines if a project fits within the strategy of the company and is financially feasible, and is drawn up simultaneously with the concept for a project and is kept up to date along the way. Moreover, it was shown that the unclear and unfeasible financial case is one of the biggest obstacles for implementing circularity strategies in building projects. As well as that the business strategy of developers differs from the lifespan of a building, the investment is usually recouped earlier than the lifetime of a building.

The case studies identified different biobased building methods, cross-laminated timber (CLT) is better suited for high-rise construction, but also possible for low-rise. Modular building concepts or the use of wood frame construction is chosen for low-rise or apartments with few levels. Bamboo was also used, often because of the better fire safety qualities. Apart from the modular concept homes, concrete was used for the foundation, underground garages and the core of the higher buildings. The biobased developments primarily fit the circular economy because of the natural/renewable resources which have a much lower impact on the environment and store CO_2, unlike when using scarce resources. But also strategies from the literature such as dismantability, reusability and flexibility were mentioned on how the projects were made circular. However, the emissions and kind of materials were more focused upon.

The cases also showed management commitment and motivation of developers, but also clients and other parties with certain objectives regarding their CO_2 budget or sustainability were found important for choosing biobased materials. Furthermore, the projects are built with financially feasible business cases, but several solutions/adaptations were found to make this happen. These were: less profit for the parties involved, investors paying extra

and for construction stored carbon credits, lower land price or more focus on sustainability and less on price in a tender by municipalities, subsidies, and building only partly with biobased materials and partly in a more traditional/standard manner with concrete and bricks. Several parties had an important role for this, such as municipalities, investors, contractors, advisors and developers themselves. The implementation of biobased materials as a circular strategy influenced the financial feasibility of the business case negatively, therefore the changes and solutions were needed. Developers in the case studies noted that monetary help was necessary for the projects to be developed, as the upfront investment costs were higher than for traditional/standard (concrete and bricks) projects. Moreover, it can be concluded that the traditional business case does not work for the biobased implementations and is not fitted for the circular economy. The influence of the implementation results in developers needing to use emergency measures and patch-ups for the business case to counter the extra costs and be financially feasible. Developers and experts also noted that the building methods need to change and that more conceptual, modular, and industrial construction with more standardisation, repetition, and prefabricated elements/building packages can help with lower costs. Together with when the production and supply of biobased materials increases. They also thought that the measures (temporary additional real and fictitious cash flows) could help with the upscaling of the biobased industry which will lead to lower costs after which the measures are less/not needed anymore.

The stakeholders and experts linked to these measures did not all have the same view on all the possibilities, and also noted other measures. Overall, they were positive on (decentralised) governments helping the market by leading, steering and supporting the transition with a lower land price and subsidies for biobased construction. But also by CO_2 pricing to ‘punish’ construction with larger environmental impacts. They agreed that the MPG needs to be updated for biobased materials. (The MPG (MilieuPrestatie Gebouwen) is an important measure to show the sustainability of a building. The more sustainable materials used, the lower the MPG.) The opinions were most divided on construction stored carbon credits, some stakeholders and experts saw more/better potential in direct governmental aid with real/fictitious cash flows, others did see potential but noted the importance of a well designed system against greenwashing and other ‘frauds’. They mostly saw the adaptations as something for the short-term, to boost and help with the transition, but all agreed that CO_2 pricing was something for the long-term. Stakeholders and experts also noted the structure of the traditional business case not working for the circular economy as these temporary solutions and emergency measures are needed, and came up with other possibilities not mentioned by the developers, such as the total cost of ownership and life cycle costing as possibilities to help in the business case of developers and better being able to include the climate impact. But also to involve the residual value with fictitious cash flows better in the beginning. It was also noted that this could be interesting for investors, as developers often sell the homes to investors, but also to individuals and housing corporations, and are therefore not the owner anymore. How the approaches could help exactly was not mentioned/known. In addition, it became clear that not all temporary solutions are in the short-term available on a larger scale, especially wider (decentralised) government support could take some time.

Limitations & recommendations

It is also important to note some remarks and limitations to the conclusion of this thesis. The research used a limited amount of case studies, interviews and time for the literature study to gain insight and answer the sub-questions and main research question. Moreover, it is important to be careful with generalising the results, as there is a large difference between housing developments, for example high- and low-rise projects. The precise costs and earnings in the business cases of the cases were not shared with the researcher. Therefore, further in-depth research is necessary to gain more knowledge about this topic, recommendations are made at the end of chapter 7.

However, from this explorative research a conclusion can be drawn. It can be concluded that the traditional business case is not fitted for biobased construction as a circular economy strategy, which also contributes to why the wider necessary shift to such strategies stays out. But developers and other parties are willing and working on limiting the environmental impact of the building industry. From this, a direction towards a solution to reduce climate change has been identified: developments with biobased materials as a circular strategy help reduce climate impact. However, opinions on possible solution measures to make the business cases feasible differ from temporary patch-up measures such as subsidies, land price discounts, sustainability focus in tender and construction stored carbon credits, to more long-term thinking in the business case, CO_2 pricing, updating the MPG and using approaches such as the total cost of ownership and life cycle costing and incorporating the residual value. Furthermore, it is concluded that the emergency measures do not make a solid healthy business case for the future. Moreover, not only adaptations in the business case are necessary, but adaptations in the building methods such as more conceptual, modular and industrial construction and standardisation could help the financial feasibility of biobased housing.

Table of contents

Preface 3
Executive summary 4
Table of contents 8

1. Introduction 10
    1.1. Background 10
    1.2. Problem statement 12
    1.3. Goals and objectives 14
    1.4. Research questions 14
    1.5. Societal & scientific relevance 16
    1.6. Reading guide 17

2. Research method 18
    2.1. Type of study 18
    2.2. Methods and techniques to be used 18
        2.2.1. Methods and techniques in general 18
        2.2.2. Methods and techniques per sub-question 19
    2.3. Data collection 21
    2.4. Data analysis 22
    2.5. Data plan 23
    2.6. Ethical considerations 24

3. Research output 25
    3.1. Deliverables 25
    3.2. Dissemination and audiences 25

4. Literature study 26
    4.1. Circular economy 26
        4.1.1. Circular economy definition 26
        4.1.2. Transition from linear to circular economy 27
        4.1.3. Circular real estate development 32
        4.1.4. Wood & biobased as circular development 34
        4.1.5. Value system influence 36
    4.2. Real estate development process 37
        4.2.1. Real estate developer 37
        4.2.2. Business case 38
        4.2.3. Circular value creation 42
        4.2.4. Stakeholders 44
    4.3. Conclusion 45

5. Results 46
    5.1. Results case studies 46

5.1.1. Case 1: Xylino 46
5.1.2. Case 2: Swanladriehoek 48
5.1.3. Case 3: HAUT 49
5.1.4. Case 4: Horizons 50
5.1.5. Case 5: SAWA 52
5.1.6. Case 6: De Nieuwe Es 53
5.1.7. Case 7: Zuiver Bosrijk 54
5.2. Results stakeholder and expert interviews 56
5.2.1. Interview Built By Nature 57
5.2.2. Interview Klimaatverbond 58
5.2.3. Interview province of Utrecht 59
5.2.4. Interview Climate Cleanup 60
5.2.5. Interview biobased building expert 61
5.2.6. Interview graduate on CO_2 pricing / developer 62
5.2.7. Interview municipality of Amsterdam 63
5.2.8. Interview municipality of Utrecht 64
5.2.9. Interview Triodos Bank 65
5.2.10. Interview Alba Concepts 65
5.3. Conclusion 67

6. Conclusion 69
6.1. Conclusion literature study 69
6.2. Conclusion case studies 70
6.3. Conclusion stakeholder interviews 72
6.4. Main research question 73

7. Discussion 75
7.1. Discussion 75
7.2. Limitations 76
7.3. Recommendations 77
7.3.1. Recommendations for future research 77
7.3.2. Recommendations for practice 77

References 78

Appendix 89
Appendix A: Data plan 89
Appendix B: Informed consent form 94
Appendix C: Interview protocol developers 96
Appendix D: Interview protocol stakeholders & experts 99
Appendix E: Personal study targets 105
Appendix F: Reflection 106
Appendix G: Advice report 109

1. Introduction

1.1. Background

Impact of the building sector

Buildings have a significant environmental impact, consume a large amount of resources, and generate a lot of waste. According to Eurostat (2022), the building sector is the largest contributor to the total waste (for construction and demolition) in Europe, with 37.5 % in 2020. It is expected that the population will grow even more, which results in more materials being used for construction (McKinsey Global Institute, 2011) and thus getting more expensive and more scarce (Benton and Hazell, 2013; Defra, 2012; Ecorys, 2012). These are all reasons of great concern (Eberhardt et al., 2022). Discussions on circularity and flexibility of buildings have become more prevalent as a result of this and environmental concerns (Rios et al., 2021; Guerra & Leite, 2021).

Currently, a significant portion of the world's total waste generation and CO_2 emissions are caused by the building sector and attendant linear construction process (Gerding et al., 2021), which contradicts the circular construction and is ineffective in reducing production and consumption rates (Mulhall & Braungart, 2021). Additionally, Akimien et al. (2020) mention that there is growing pressure on the built environment to reduce this impact, for example with the circular economy approach proposed by the Ellen MacArthur Foundation (EMF) could help with this. Incorporating circularity & adaptability help encounter the large impact from buildings on the environment (Hamida et al., 2022). The EMF & McKinsey & Company (MCK) (2014) state that a possibility to address this is by changing the current system and by moving towards a circular economy system. This provides benefits according to EMF & MCK (2014) as for example: minimising the use of primary materials, safeguarding material resources, and lowering the carbon footprint.

Circular economy

The circular economy (CE) aims at, but also limits itself to, preventing waste production, hazardous environmental impacts and the depletion of resources (Hamida et al., 2022) by for example using the principles of the 9R-strategies (R0: refuse, R1: rethink, R2: reduce, R3: reuse, R4: repair, R5: refurbish, R6: remanufacture, R7: repurpose, R8: recycle and R9: recover (Kirchherr et al., 2017)). The R-strategies help avoid these matters, by creating closed-loop supply chains for materials (Sanchez & Haas, 2018; Akhimien et al., 2020; Antonini et al., 2020). With the circular economy this entails that resources and building components are aimed to be maintained at their highest possible value to keep them for as long as possible in a cycle of construction using, deconstruction, reusing, repairing and after that, recycling to go back to materials for other constructions (Ingemarsdotter et al., 2019; Bullen, 2007). According to Ingemarsdotter et al. (2019), this helps reduce waste and prevent emissions e.g. CO_2, but also avoid increasing prices, delays, and other negative effects of volatile commodities markets (Akhimien et al., 2020). The emphasis will move to sustainable sourcing, keeping material productivity across the lifespan of developments, and lowering loss in non-renewable resources by implementing circular techniques (Antonini et al., 2020). Benefits for the economy, society, and environment will result from this (costs of raw materials, less waste (management) and reduced climate impact) (Carra & Magdani, 2017). Therefore, a strong opportunity to cut back on the use of raw materials, saving scarce

resources and lessening the carbon emissions is provided according to the EMF (2013b; 2015) by the circular economy. Carra and Magdani (2017) also note that for this, a new value chain is required in which collaboration is needed. But they note that: “So far, we haven’t seen a single solution” (p. 34).

Biobased as circular strategy

The previous paragraph discussed the negative impact of the construction industry, according to Dräger and Letmathe (2022) this impact affects climate change. One prominent effect is their greenhouse gas emissions (Dräger & Letmathe, 2022), these emissions such as CO_2 lead to global warming and climate change (Yoro & Daramola, 2020). The UN Climate Panel: IPCC recently (March 2023) stated that the 1,5 goal from the Paris Agreement is quickly disappearing from sight (NOS, 2023). Their new report underlines the urgency of taking immediate strong action against climate impact and according to Van Vuuren (one of the contributors to the report) if we do not reduce emissions, the next report will conclude that the 1,5 degree goal is out of sight (NOS, 2023).

Alba Concepts (2022) also notes that with the current way of building, no answer can be given to the current housing demand and the task of reducing climate impact. They mention one of the solutions is to think differently and focus on carbon based design. The transition team of the Dutch circular building economy investigated reducing climate impact by focusing on CO_2 emissions and storages as opportunities for the construction industry. Together with experts from TNO, DGBC, W/E and others, the circular building economy transition team concluded in a report called ‘Carbon Based Design’ (Cityförster, 2022) that impact of the building process and production of materials is currently often disregarded but also has a large impact. These material bound emissions are according to DGBC (2021) still a blind spot in the construction industry, but that carbon based design and storing carbon has potential to help reach circularity goals. Cityförster (2022) states that there is an opportunity for the built environment to use building materials to store carbon in buildings to lower the CO_2 in the atmosphere. According to them, wood construction has an important opportunity for Dutch housing developments (Cityföster, 2022).

Dutch Green Building Council (DGBC) is a foundation committed to rapidly make the built environment future-proof. They researched a path to a CO_2-neutral built environment. Two possible material related solutions within the circular economy are the added value of urban mining and using biobased materials, based on the butterfly model of the Ellen MacArthur Foundation (figure 5) (DGBC, n.d.). Where building materials can be used to absorb CO_2 from the air during production, to retain it for a long time in order to extract CO_2 from the atmosphere and are renewable. This helps the construction industry to shift from the problem to contributing to the solution, and this can have a positive impact when valuing the storage (DGBC, n.d.).

Experts from Metabolic, Copper8, Alba Concepts and NIBE als see biobased construction as one of the strategies fitted for the circular economy to reduce climate impact, to not exceed global warming of 1,5 °C and the CO_2 budget (Copper8 et al., 2023). Moreover, biobased construction is considered as a real path of change in the development of housing by Het Nieuwe Normaal (2023). Moreover, Kayaçetin et al. (2022) notes that bio-based designs also reduce the negative environmental effects, because of the better end-of-life reuse and recycling possibilities in end of life scenarios.

According to Oorschot et al. (2023) an alteration has to be made in building and demolition practises in order to create a low-carbon built environment. The likelihood that biobased products will be chosen to a larger extent in the future should rise as a result of more attention being paid to how building materials affect the climate within the construction sector Markström et al. (2018).

1.2. Problem statement

The implementation of the circular economy in the built environment is still lacking (Adams et al., 2017; Rios et al., 2021; Eberhardt et al., 2021; Guerra & Leite, 2021). This is a problem, because the built environment's linear economy has a larger negative impact with its waste and emissions than the circular economy (Gerding et al., 2021; EMF, 2013). In addition, the Dutch government wants to be completely circular and climate neutral in 2050 (Rijksoverheid, n.d.a and Rijksoverheid, n.d.b). Immediate action is required to stop global warming, according to the IPCC (NOS, 2023). According to DGBC (n.d.), construction in biobased materials has a large potential, however the current market share of wood at around 2-3,5% and other biobased materials at around 0,1%, is still limited. Therefore, change is needed to reduce the impact from the building industry and to reach the governmental goals by 2050. Biobased construction can help with this, but Peñaloza (2017) noted that other strategies such as using renewable energy are also necessary to maximise the climate mitigation.

A considerable amount of research has been describing the circular economy and implementations, as well as looking into barriers and enablers. Despite these studies, real estate developers are still struggling to realise biobased housing developments, the absence of a financially feasible business case is a significant reason/issue for this (Synchroon, 2021; Copper8, Metabolic, Nibe & Alba Concepts, 2023). Because the direct building costs for circular construction are 15% - 30% higher compared to the traditional/standard (concrete & bricks) way (Alba Concepts & Sweco, 2022).

Mhatre et al. (2023) analysed literature on barriers to adopt the CE in the built environment. Their findings show that costs are a significant barrier according to several sources. For example, high waste sorting and processing costs (Ratnasabapathy et al., 2021), cost constraints (Rios et al., 2021), budget and upfront costs, but also costs because of the lack of in-house knowledge and therefore the necessity to hire external consultants (Guerra & Leite., 2021; Morel et al., 2021), increased construction cost (Haselsteiner et al., 2021), increased cost (Shooshtarian et al., 2020) and the cost is also according to Densley Tingley et al. (2017) a barrier. Rios et al. (2021) conducted several interviews and the participants mentioned the cost and schedule constraints barrier most. The initial investment costs when using circular strategies are higher (Hart et al., 2019), as well as the costs for storage and processing of components and the hurdle between the life cycle costs and the first-time costs was also raised in the interviews. Giorgi et al. (2022) also concluded from several interviews that compared to the possible savings from reusing the same materials, or the potential earnings from selling the reusable material, the diligent removal of components and pieces is too expensive. According to Adams et al. (2017), uncertainty about the costs and benefits of implementing the circular economy for each stakeholder, as well as the widespread belief that the initial investment might not benefit, contribute to the challenge of the unclear financial case. Owojori and Okoro (2022) mention that the prices for construction

material related to the CE also plays a role in the high investment price, which increases the risks connected to the initial investment.

Developers want to incorporate circularity and biobased construction, but are also looking for ways to create financially feasible business cases for circular real estate projects (Glennon, 2022; Synchroon, 2023). Synchroon is one of them and is part of several movements/initiatives such as City Deal Circular & Conceptual Building and Het Nieuwe Normaal, in which the parties work together, note the importance of the circular economy in the built environment and try to limit its environmental impact. Their vision document (Synchroon Circulair, 2021) indicates that they are not just financially driven, but want a shift from money driven to a healthy balance between entrepreneurship focused on financial, social and environmental impact. According to the document Synchroon believes in the urgency of the circular economy, which is why they look for ways the company can contribute to this. They are calculating their CO_2 emissions from their projects since 2021, steer on Paris proof budgets according to the DGBC, and reserve a budget for CO_2 reduction in their real estate exploitation. Construction according to a Paris proof budget drastically changes the way of building, as in 2050 the building industry has to be CO_2 neutral (DGBC, 2022). In addition, Synchroon also works with Alba Concepts and NIBE and asked Copper8 to investigate other ways they can reduce their impact towards zero, as they see the time sensitive matter with the long development & construction processes to be CO_2 neutral in 2030 (Copper8 & Synchroon, 2022). In 2021 a lot of trees were planted to assist in compensating their CO_2 emissions of their entire portfolio to move towards zero, because the other measures taken are currently not enough/possible (Synchroon, 2022).

However, they also note that the developer is the risk-bearing party, and that cancelling their profit to be Paris proof is currently not enough to cover the additional costs and the increased risks of innovation/change (Synchroon, 2021). The document further discusses that it is not yet clear to them how the extra expenses could be financed. According to them, it is a joint task for developers, municipalities, investors and advisors to find a solution for the circular business case. To make it feasible, it needs to be possible to value and validate sustainability impact and goals for which measuring the impact is needed (Synchroon, 2021).

The previous paragraphs show that the costs are a significant barrier for developers and that a larger shift to a circular economy to the extent for example Synchroon aims for (being climate neutral) stays out. This is also necessary according to IPCC and other experts from the built environment such as Copper8 (Copper8 & Synchroon, 2022). The business case is under pressure due to all the wishes, requirements and costs (Synchroon, 2021; Copper8, Metabolic, Nibe & Alba Concepts, 2023). However, there are some developments which use biobased materials (such as SAWA in Rotterdam, HAUT in Amsterdam, Zuiver Bosrijk in Eindhoven and Swanladriehoek in Zevenhuizen), which are being or have been developed. Hence, additional research is needed to explore these projects and investigate their business cases to understand how and if they are feasible or not. This could make clear what needs to change and what possible solutions are to making a circular biobased business case for housing developments, or if palliative/emergency measures were used. With the aim of investigating if a future proof circular business case was created which helps the built environment go from the linear economy to a circular economy with not only a few

experimental housing developments, but in the full width, which uses less scarce resources and produces less harmful emissions to reduce climate impact.

1.3. Goals and objectives

The main goal of this thesis is to understand the business case for circular biobased housing developments to investigate if and how they are made feasible, and if that is possible on a larger scale over the width of housing developments, because a great leap forward is necessary. Or if compilations are encountered, if these business cases use only temporary emergency measures, and therefore further research is required into possible needed adaptations. This wider implementation is important so the building sector can reduce its impact on the environment by using natural resources and reducing CO_2 emissions. This research also helps to understand what the differences and complications are between a business case for biobased housing development and one with concrete and bricks and which stakeholders are important for and relevant to solutions and how they look at possible solutions and what needs to happen according to them, experts and the developers.

1.4. Research questions

Therefore, this thesis will contribute to the research of this topic. This will be done with the following **main research question:**

How are business cases adapted in order to create financially feasible and circular biobased housing developments?

To answer this question, several sub-questions (SQ) will first need to be investigated. This will be done with a literature study to examine the current knowledge about the topic, with case studies investigating recent biobased development projects, and by interviewing developers, (indirect) stakeholders and experts. These methods will be further explained in chapter two. The aim is to understand if and how the current business cases allow to include the circular economy via biobased construction, and if complications occurred in the business case for these projects and how the business case dealt with it. To understand if these are solutions for the future or if the traditional business case needs to change and to come up with advice for the developers on the business case of circular biobased housing developments. The objective of this research is therefore to contribute to the wider shift from a linear to a circular economy in the building industry.

SQ 1: *What does the circular economy entail, specifically within the built environment?*

Figure 1 shows the conceptual model of this study. The model shows several concepts related to the main research question and which are linked to the sub-question. The sub-questions help answer the main question. First the circular economy and what the transition entails will be looked into and discussed, but also how using biobased materials fit to this is examined with a literature study for SQ 1. This gives more clarification and control about the direction of the subject of this thesis and serves as theoretical background for the empirical research.

SQ 2: *How does a developer and its business case for a real estate development work?*

Then, a closer look at a real estate developer, its business case and possible (indirect) stakeholders is taken for SQ2, also with the literature study. The sub-question related to these concepts analyses and helps understand his/her 'normal' way of working and what the other parties are.

SQ 3: *How are biobased housing projects currently being developed?*

For SQ 3 a closer look is taken into current developments, to investigate how they are done. In terms of construction and business case, to determine why/if they are circular and if the developers encountered barriers as mentioned in the introduction and literature. Several projects are analysed for this in several case studies with interviews.

SQ 4: *What is the influence of these implementations on the business case?*

SQ 4 closely follows SQ 3, as this SQ analyses the influence of the switch from the traditional/standard (concrete and bricks) housing to biobased construction, on the business case. How did the developers manage to make a feasible business case, what solutions did they come up with, was the business case drastically changed or were other solutions found and what were important (indirect) stakeholders for this? The same case studies and interviews from SQ 4 are used for this.

SQ 5: *To what extent are the changes made in the business case a solution?*

These business case changes are further discussed in SQ 5 to determine if actually a different business case was made which is sustainable and future proof. Or if temporary solutions helped make it financially feasible which are not long-term oriented. For this, also stakeholders of the used measures are interviewed. It is furthermore important to clarify that with the stakeholders in this thesis, parties involved with solutions or changes in the biobased business case and experts are meant. These stakeholders are therefore not necessarily direct business case stakeholders, but have a relevant role to the changes/solutions. The word 'stakeholders' is used to bundle these parties such as municipalities, experts from foundations or an NGO and consultants.

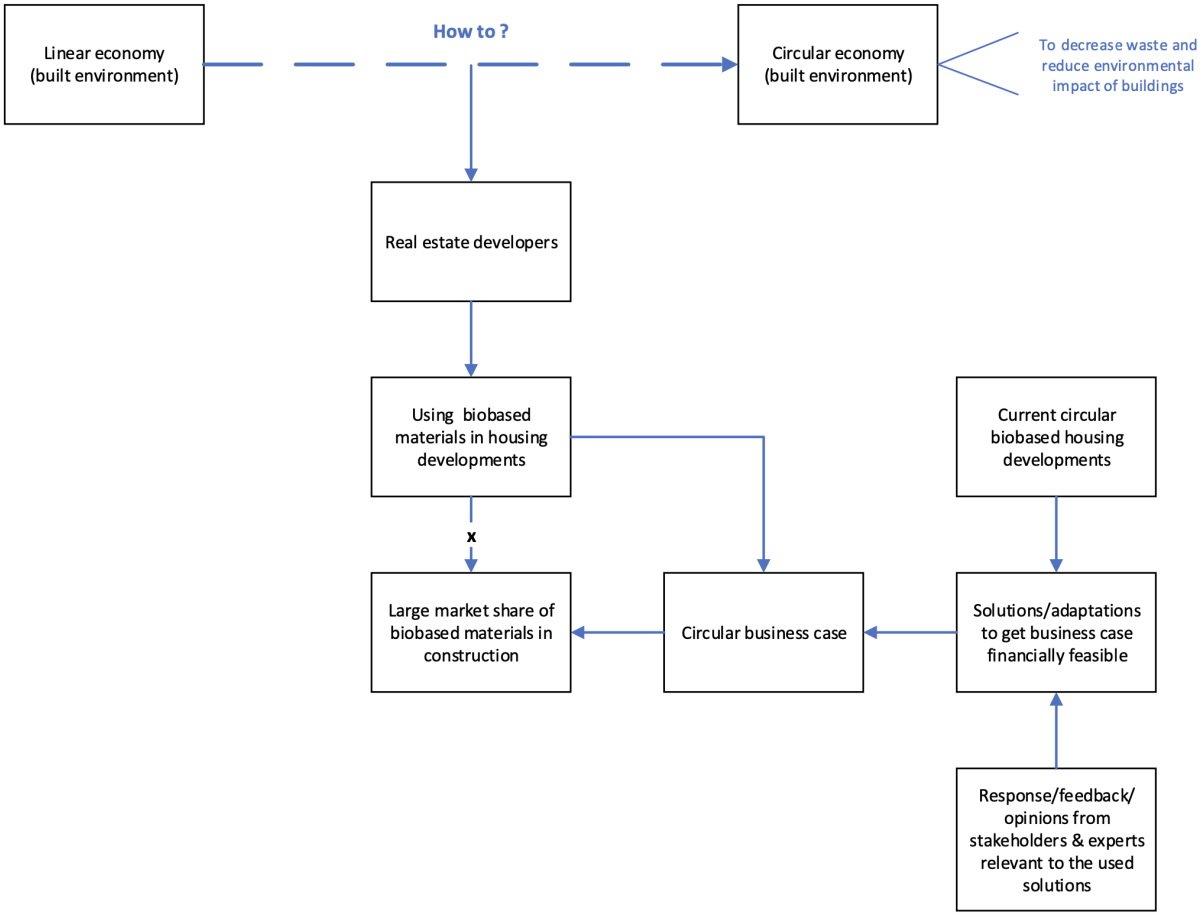

Figure 1, Conceptual model (own work, 2023).

The reason to choose to focus on developers is that developers play an important role, Coiacetto (2000) wrote the following: "*planners do not build cities and towns. Rather, they are built by private sector interests, developers in particular*." (p. 353). Coiacetto (2000) states with this that a better understanding of developers is needed to achieve planning, sustainable cities and affordable housing goals. Rood (2015) also noted: "real estate developers maybe the best party to initiate the circular economy given his/her linking function of supply and demand."

1.5. Societal & scientific relevance

Societal relevance

This research has societal as well as scientific relevance. First of all, the constructions in the built environment have a significant impact on the environment, society and economy (Gencel et al., 2012; Smol et al., 2015). The current linear economy used in the built environment has a societal relevance, because its activities are mainly responsible for resource and material shortages (Ghisellini et al., 2018), but also for increased pollution (Çimen, 2021). Moreover, the waste generated from construction equals 37.1% of the total waste created in Europe (Eurostats, 2022) and the construction sector is one of the largest CO_2 contributors (Licciardello et al., 2017). Therefore, finding solutions to this problem is of great importance to society, because the building industry also provides jobs for 611.000 people in 2021 (CBS, n.d.) and has other positive influences by creating homes and climate resilient areas. The vision document 'Synchroon Circulair' (Synchroon Circular) of a Dutch

real estate developer (Synchroon, 2021) and personal communications, made clear that developers are also concerned with the environmental state of the world and feel a moral obligation to help. Therefore they are also interested in the results of this subject. It is therefore useful to determine if the current business cases used in the investigated projects are a solution and if so how, or if the current business case doesn't fit the circular economy and more changes and further research is necessary.

Scientific relevance

Second, this thesis also has a scientific relevance. Not only is the circular economy a relevant and much talked about topic in literature, this study will also explore current research gaps by addressing the cost barrier in circular business cases and investigating what developers currently use to achieve a financially feasible business case for circular real estate developments. Future research will also be able to use outcomes from this thesis to continue with recommended future research. In addition, according to developers there is currently not enough information in the current sources for developers to actually implement it in feasible business cases. As they noted that the current theories for the circular economy do not lead to new/extra cash flows at the start of construction, where higher costs are made (Synchroon, 2021). This research could help identify if there is a gap between theory and the current circular economy in practice for biobased housing development, and possibilities for future research. The results could also be interesting for foundations and consultancy firms such as: Built By Nature, het Klimaatverbond, Copper8 and Alba Concepts for example, are also working on and researching about this topic and try to help with the transition.

1.6. Reading guide

This paragraph makes the end of the first chapter of this thesis, which consists of a total of seven chapters and several appendices. All the chapters have their own short introduction. The next chapter (two) describes the type of study, research methods used to collect and analyse data for this research. Chapter three discusses the research output and its goal. After which chapter four entails the literature study which forms the theoretical framework for this study. In chapter five the results from the case studies and stakeholder interviews are described after which in chapter six the answers to the research questions are given together with the main conclusion. The last chapter is chapter seven and entails the discussion, the research limitations and recommendations for future research as well as for practice. The appendices are included after the references and contain the data plan, informed consent form, interview protocols, personal study targets, reflection and advice report.

2. Research method

This chapter discusses: the kind of study, what the used research methods are, how the data has been collected, how it is analysed, but also how the data is managed and its ethical considerations.

2.1. Type of study

This research uses a research design based on qualitative research and the type of study is explorative. Qualitative research gives the possibility to develop knowledge and a better understanding of the subject of this research (Fossey et al., 2002). It aims for depth of understanding a situation in a particular context (Merriam, 2002). In addition, it helps answer relatively broad questions, instead of testing specific hypotheses (as could be done with quantitative research) (Fossey et al., 2002). Moreover, Fossey et al. (2002) also note that qualitative research gives the possibility to be more flexible. For example, the research question(s) could be refined when the study progresses. According to Merriam (2002), the researcher is the main tool for collecting and analysing the data. This also gives the possibility to be flexible and be instantly responsive and adaptive. In addition, qualitative research gives a better opportunity to answer 'how' and 'why' questions, than quantitative research. This research explores how the business case worked and who the stakeholders involved were to make it work, but also if this is a sustainable future focus solution for circular development projects. Because the researcher is already familiar with the sector in which the research is done, the study is not completely explorative. The qualitative research methods will be explained in the next paragraph.

2.2. Methods and techniques to be used

This research uses qualitative research methods (figure 2). For the qualitative methods a literature study is done, case studies and semi-structured in-depth interviews with developers as part of the case studies are conducted, and additional semi-structured in-depth (expert) interviews with relevant stakeholders and experts of the adaptations and possible solutions in the business case for a real estate developer are done. Now first a general description of the methods and techniques used will be given, and then each sub-question is discussed.

2.2.1. Methods and techniques in general

The research starts with a literature study to find answers for sub-question 1 and 2. But it is also used as the theoretical background of this thesis for the other subquestions. The literature sources are searched via Google Scholar, Scopus and the repository of the TU Delft, but also reports with research from expert and consultancy firms are analysed. To find useful papers, keywords matching the subject of the research (sub-)question are used, but also references in papers are used to find other sources. When a possible source was found, first the title and abstract were scanned to determine the usefulness of the reference before reading it in more depth or continuing searching. According to Blaikie and Priest (2019), including a literature study helps establish what is already known about the subject, to be used for possible theories and explanatory ideas and to provide boundaries.

Empirical methods

After the literature study has largely been done, there is a shift for conducting the empirical part of the research. Case studies and semi-structured in-depth interviews are done to answer sub-questions (the interviews both as part of the case studies, as interviews additional to the case studies). Blaikie and Priest (2019) imply that case studies give the possibility to investigate one part of a topic in some depth with a limited budget and time schedule (Blaxter et al., 2002; Bell, 2005). In addition, it serves as a method to study a contemporary phenomenon in practice (Yin, 2003). Therefore, this technique will be used in this research to get a better understanding about a developer's business case. The interviews are according to Blaikie and Pries (2019) a common way to collect qualitative data. Which are also useful as semi-structured interviews give the possibility to be flexible for interviewer and interviewee for themes that emerge during conversation (Jackson II et al., 2007). With this method it is possible to get to know more the reasons behind certain decisions, or to get answers to something which could need more clarification after the case studies or in interviews. The internship is a tool which helps make connections to the interviewees for this study.

Sampling methods

The sample method for the interviews is purposive/judgmental sampling (Bryman, 2016). The goal with this is to sample with the aim of creating a relevant sample for the empirical research, with a variety in interviewees (Bryman, 2016; Fossey et al., 2002). But also a bit of snowball sampling is used, when talking to developers or other employees of real estate developers to understand which stakeholders could be important and if the interviewee could help with contact information for them. But also later on, with the stakeholders themselves. Snowball sampling entails that (early) participants suggest other participants relevant to the research (Bryman, 2016; Fossey et al., 2002). This is useful as the researcher can be helped to get a better view on who could or should be talked with, as the small groups might have more knowledge about all the relevant actors. As will be discussed further in the paragraph, there are criteria for the interviews of several sub-questions. The cases are also selected via purposive/judgmental sampling, to have a combination of cases that represent different developments from different developers and not one in specific.

2.2.2. Methods and techniques per sub-question

Now a description per sub-question and its research methods will be given, which is also shown in figure 2 and in table 2.

SQ 1

The first sub-question examines what the circular economy, the transition and the translation to the built environment entails. For this, a literature study is done. Keywords related to the questions will be used in the Google Scholar, Scopus and the TU Delft Repository databases. First titles will be checked together with the abstract to determine if a source is useful or not, before examining it in further detail.

SQ 2

The second sub-question investigates, with the help of a literature study, how a real estate developer and its business case works, but also identifies possible stakeholders. The literature study is done as described in the previous paragraph. Unstructured interviews

and/or personal communication is also done with employees from a developer to better understand the general current aspects, which might not occur in the literature.

SQ 3

The third sub-question looks into how current circular developments with biobased materials are being done or have been done. For this, 7 case studies are conducted with the help of semi-structured in-depth interviews with developers or employees of a developer closely involved (such as a cost expert or project/development manager). The cases are shown in table 1, and have been selected as developments from different developers, as well as low- and high-rise and had to be constructed (largely) in wood and/or other biobased materials.

Case	1	2	3	4	5	6	7
Project	Xylino	Swanladriehoek	HAUT	Horizons	SAWA	De Nieuwe Es	Zuiver Bosrijk
Developer	Koopmans (Synchroon handed over)	Synchroon	Lingotto	Ballast Nedam Development	Nice Developers & ERA Contour	Koopmans	BPD

Table 1, Overview of the cases with project name and developer (own work, 2023).

SQ 4

Sub-question 4 uses the same case studies and interviews as described in SQ 3, to investigate the influence of the implementations on the business case, and what the influence of the encountered barriers were on the business case.

SQ 5

Sub-question 5 investigated with semi-structured in-depth (expert) interviews if the changes and solutions used by the developers actually are suited for a long-term sustainable circular business case, or only temporary measures. The interviews are done with the stakeholders and experts related to the solutions, these are for example municipalities, banks, foundations, associations and consultancy firms.

Main research question

The next step after all the information of the sub-questions is gathered, is to return to the start and answer the main research question. When drawing conclusions from the interviews with the developers it is important to compare their possible solutions and also other results such as complications with the results later on from the other stakeholders and scientific literature and reports/research from other parties, to get a solid and scientific answer.

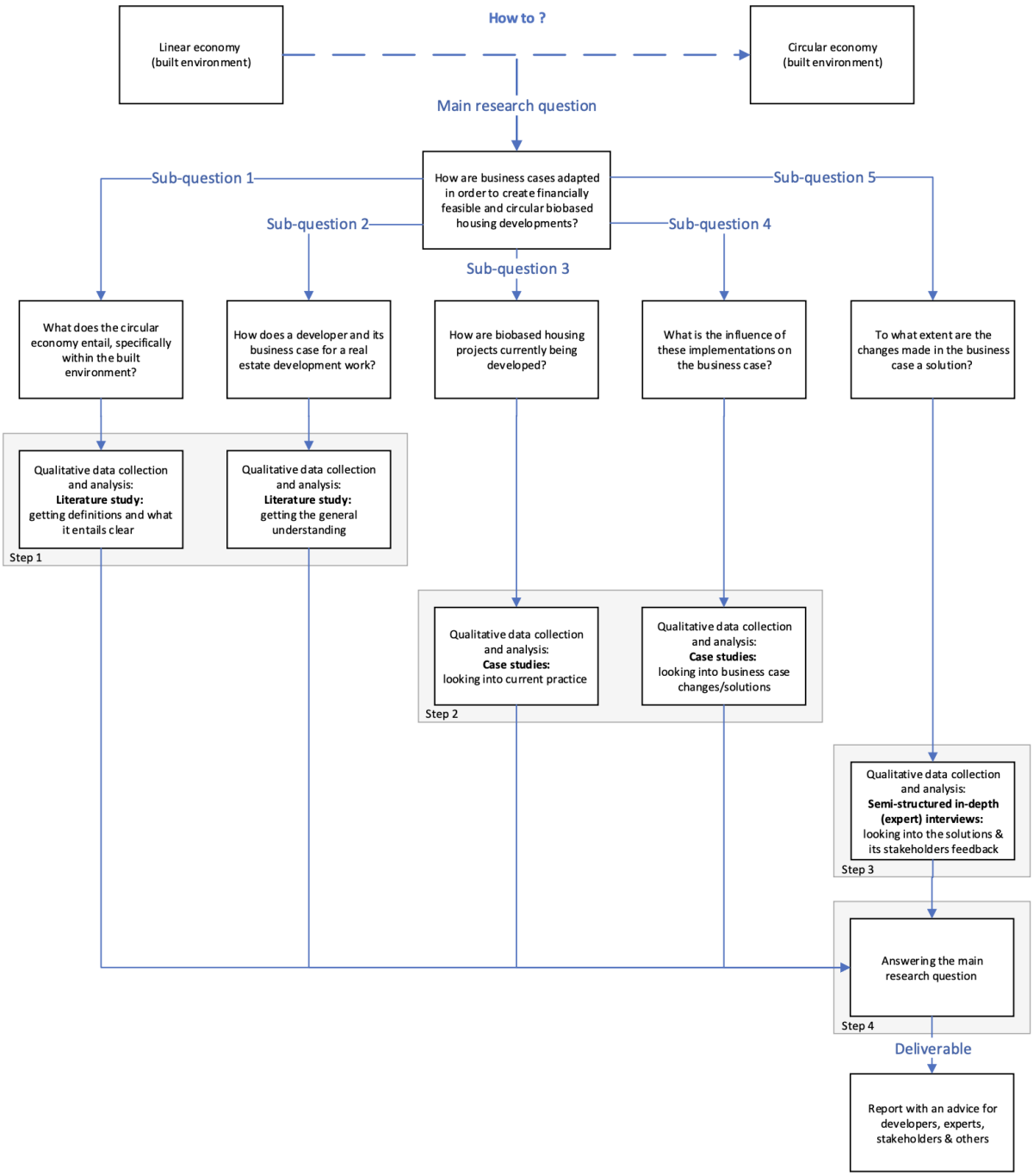

Figure 2, Research design method (own work, 2023).

2.3. Data collection

The data collection resulting from the methods discussed in the previous paragraphs results in the collection of tertiary data (literature study) and primary data (case studies and semi-structured in-depth interviews). These data collection methods allow to first get a better understanding and first results from the literature, after which cases can be examined which are supported by interviews related to the cases and other subquestions. This allows for an in-depth view and understanding on the investigated unit (Merriam, 2002). But it also allows to verify data from the case studies and interviews with data from literature/reports/research. Table 2 gives an overview of the subquestions and its sources of evidence. Several different

sources of evidence have been chosen, according to Yin (2003), the conclusion or any findings from a case study based on multiple different data sources is expected to be far more reliable and convincing.

Criteria related to case studies

During this thesis and with subquestion 3 and 4 case studies are conducted, all representing different housing developments and its business cases in the Netherlands. The case studies will be done for understanding the possible complications of adding circularity in the form of biobased materials in a business case and what this means for the business case of the developer. To look into if and what changes were done to the business case and which parties were important for this. The criteria for the circularity implementations is focused on reducing the emissions from the project and the exhaustion of the natural resources of the earth by using biobased materials. Another criteria for these implementations, is that they should be done in either or in both the structure and skin layer described by Brand (1994) (figure 3). The structure layer is about the structure of the building and its load-bearing components (lifespan: 30-300 years) and the skin layer is about the exterior surface (lifespan of about 20 years) (Brand, 1994, p. 38). The reason for this is that these layers are currently using mostly scarce resources and could help reduce climate impact if biobased materials are used for these layers. With new housing developments a large part of the material bound emissions are linked to these layers, with 61% for the structure and 31% for the skin according to DGBC (n.d.). Other criteria are that high-rise as well as low-rise should be examined and that the developments should come from different developers. This gives a better overview of the overall situation in the wider market of developers.

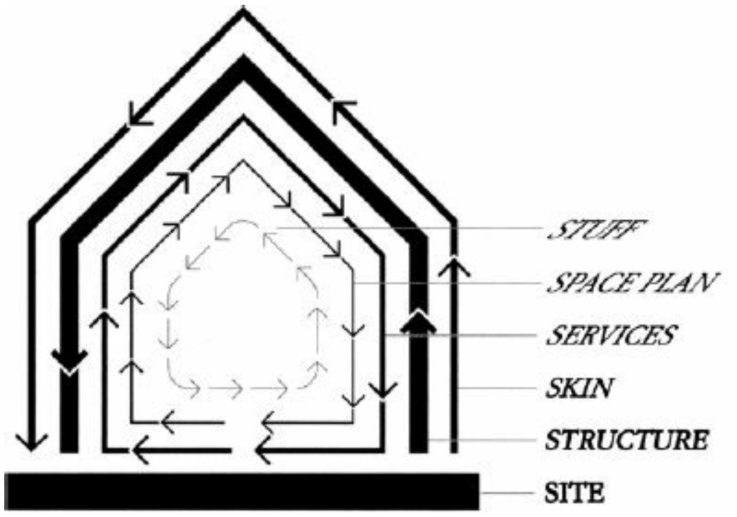

Figure 3, Six S's (longevity layers of built components) (Brand, 1994).

2.4. Data analysis

As explained in the previous paragraphs, the data is collected through three methods, the literature study and two empirical methods: case studies and interviews. This means that for the data analysis qualitative methods are needed to analyse the gathered information. Reviewing, combining and interpreting are all steps in the process of analysing (Fossey et al., 2002). The methods that are used for this thesis to draw conclusions and answer the questions are: making descriptions, coding the data and comparing the data. In addition, for

the case studies, the collection of all the data is also already part of the analysis, because the analysis starts simultaneously with the collection in qualitative research (Merriam, 2002). This allows for making adjustments along the way (Merriam, 2002). The descriptions are (mostly) done in words, instead of numbers and for the coding, categories will be made to organise the data. For the coding, transcripts are made which can be used in the Atlas TI software. Not only will Atlas TI help with coding, but also assist in organising the data to let the researcher draw conclusions from possible connections. These methods help organise the data to make it easier to compare and draw conclusions from it. Direct quotations are used to support the conclusions drawn from the data.

Logic of inquiry

As shown in table 2, for the explorations and descriptions of the data, the inductive approach is taken. This is a bottom-up approach which starts with the data collection and then leads to descriptions, categories and a theory (Blaikie and Priest, 2019; Fossey et al., 2002). According to Merriam (2002), qualitative data analysis is ultimately an inductive strategy, as the researcher begins with a unit of data and compares it to another unit of data. Using the inductive approach results in interviews being discovery-oriented, instead of wanting to prove or disprove a theory/hypothesis (Cooper et al., 2012). In addition, according to Schamber (2000), a benefit of using the inductive approach is that it allows the researcher to better evaluate the interviewee's replies without impairing the original expression.

SQ	Methods	Sources of evidence	Analysis method	Logic of inquiry
SQ 1	Literature study	Existing literature, reports, research and empirical studies	Descriptions	Inductive
SQ 2	Literature study	Existing literature, reports, research and empirical studies	Descriptions	Inductive
SQ 3	Multiple case studies (and literature study)	(Online) documentation, and interviews	Comparing results by transcribing, coding and making descriptions	Inductive
SQ 4	Multiple case studies (and literature study)	(Online) documentation, and interviews	Comparing results by transcribing, coding and making descriptions	Inductive
SQ 5	Semi-structured in-depth (expert) interviews (and literature study)	Interviews	Comparing results by transcribing and making descriptions	Inductive

Table 2, Overview subquestions and their methods (own work, 2023).

2.5. Data plan

To make a data plan for the research of this thesis, the DPMonline tool of the TU Delft has been used. The results of this procedure are added to this document in appendix A. The strategies which concern data management, safe storage, data types, data purpose and

data plan related topics are part of this appendix. Feedback from the data steward of the faculty (Bouwkunde) was requested on 22 January 2023 and received on 25 January 2023.

2.6. Ethical considerations

It is also important to think about the ethical part of the research, especially since this research involves the participation of other humans and their sensitive information, as well as that from the internship company. First of all, all participants for the interviews are asked permission to interview and record them via an informed consent form. Moreover, they have the possibility to withdraw at any given moment from the research without any reason. They can also indicate in the informed consent form if they want to view and/or approve the transcription before it is used in the analysis and if they are interested in the final thesis. The data is not used of those that decide to withdraw and their data will also be destroyed right away. Second, all the data is stored in a safe place, as shown in the data plan of the previous paragraph (2.5). When the research is done, the thesis becomes available in the repository of the TU Delft and the other personal data is deleted. Third, all the sensitive and personal information from the interviews and case studies are anonymized. Finally, the research questions and methods are thoroughly set up in the process of the research proposal for this thesis, to make sure the right questions are asked with the fitting methods.

3. Research output

How the research is done has been explained in the previous chapter, this research will result in a research output which will be discussed in this chapter. The output is meant to help achieve the goals and objectives with deliverables. Moreover is the dissemination and audience for the results discussed.

3.1. Deliverables

To assist the reach, the goal and objective of this research, an advice report is made as the main deliverable of the research for this thesis. The short advice report discusses the main findings and conclusions of the research. Therefore, it shows what changes were in the business case for biobased housing developments, if these are solutions and if the current business cases support these projects. But also relevant parties to the solutions are discussed. This can help create a better understanding of the relevance, problem and importance for the audience. Moreover, it aims to help understand further research directions.

3.2. Dissemination and audiences

The audience for this thesis consists mainly of developers, but also other parties involved with used solutions of or influence on the business case of housing developments, such as the government, municipalities and NGOs working on opportunities. Because the aim is to reduce the impact of the built environment with biobased materials. Therefore it is necessary that this thesis is familiar to them so they have the possibility to read it and understand opportunities and problems. But other researchers and consultancy firms are also important, as they can further go in-depth or investigate other aspects linked to this topic. Nevertheless, this thesis is also for everyone who is interested in this topic and for other parties that may be involved and want to know more of the topic.

4. Literature study

Before starting with the empirical research, it is important to clarify several concepts from the research questions in this thesis. According to Blaikie and Priest (2019), including a literature study helps establish what is already known about the subject, to be used for possible theories and explanatory ideas and to provide boundaries. Therefore, this chapter discusses the real estate development process, what is a real estate developer, how does the business case work and who are the stakeholders involved. But also the circular economy will be discussed, what is the definition, what does the transition entail, how does the value system play a role and how can this be translated to real estate developments.

4.1. Circular economy

This chapter will discuss the circular economy definition, the transition from the linear economy, what this means for a building and how values play a role.

4.1.1. Circular economy definition

First, how is the circular economy (CE) defined in existing literature?

Kirchherr et al. (2017) analysed 114 different definitions of the circular economy. Their aim was to create transparency, because practitioners as well as scholars have become more interested in the circular economy concept. Moreover, its momentum has increased among them. A reason for their significant interest in the CE concept is that it is seen as an operationalization for companies to pursue the trending notion of sustainable development (Ghisellini et al., 2016; Murray et al., 2017). According to critics however, the concept means a lot of different things to many different people (Kirchherr et al., 2017). Table 3 shows four principles of the circular economy from the main literature sources, of which various definitions have been derived, created by Adams et al. (2017).

Principle	**Source**
Increasing the productivity of materials by doing the same or more with less.	Fuller (1973), Hawken et al. (1999), Lund (1955), Stahel (2010), Womack et al. (1990).
Eliminating waste by defining materials as either technical or biological nutrients enabling them to be within closed material loops; ‘waste as food’.	EMF (2013a, 2013b), Lyle (1994), McDonough and Braungart (2002).
Maintaining or increasing the value of materials, environmentally and economically.	EMF (2013a, 2013b), Weizsäcker et al. (1997).
Thinking in systems by studying the flows of material and energy through industrialised systems, understanding the links, how they influence each other and the consequences, enabling closed-loop processes where waste serves as an input.	Graedel and Allenby (1995), Meadows and Wright (2008), Pauli (2010).

Table 3, Circular economy principles (compiled from the main sources within the literature) (Adams et al., 2017).

Table 3 shows that overlapping elements in the principles are about increasing the value of materials and reducing or even eliminating waste. Moreover, the EMF (2013a) stresses the importance to “design out negative externalities” and highlights system thinking (Adams et al., 2017).

According to Geissdoerfer et al. (2017) and Schut et al. (2015), the Ellen MacArthur Foundation (2013a) give the most prominent definition of the circular economy. Moreover, Kirchherr et al. (2017) claim that, from their collection of 114 definitions, the definition of the EMF (2013a) is in fact the most employed one. Therefore, this definition will serve as the primary source for this thesis' definition of the CE:

“A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.” Ellen MacArthur Foundation (2013a, p. 7).

In addition to the definition by the EMF (2013a), it is also relevant to look into the description of the circular economy of the Dutch government. Because the research is done in the Dutch context. According to Potting et al. (2017), the government intends to support the CE transition by improving the material and product supply chains to make them more efficient. Moreover, the description for the CE by the Dutch Ministry of Infrastructure and the Environment that fits with this is that according to them: reusing products and product components, recycling materials and conserving natural resources are the basis of the economic system for the CE, while also striving for establishing extra value for each link in the system (Potting et al., 2017).

To conclude, there are many definitions describing what the CE entails. The definitions of the CE come in short down to a desired end situation of an economic system that minimises waste, pollution and the use of scarce resources by using sustainable and reusable resources and keeping them in use for as long as possible. Examples of strategies used for this include recycling, repairing, and designing components to make reuse possible. The objective and definition of the government together with the one from the EMF (2013a) are the main line and source about what the CE entails. However, this definition is still quite broad and general for the built environment and the case studies, therefore paragraph 4.1.3 will discuss what the CE means in the context of a real estate development. Paragraph 4.1.2 looks into the transition from the current linear economy to a CE, because the built environment’s linear economy has a larger negative impact with its waste and emissions than the circular economy (Gerding et al., 2021; EMF, 2013).

4.1.2. Transition from linear to circular economy

Now that the definition of the CE from the literature is discussed, the transition from a linear to a circular economy can be examined to clarify what this entails according to existing literature.

According to the Ellen MacArthur Foundation (2013a), the term ‘circular economy’ translates to an industrial system that is intended to be restorative, focuses on using renewable energy,

minimises, tracks, and completely avoids the use of hazardous chemicals, and completely eliminates waste via thoughtful design. The understanding of non-linear systems serves as the foundation for the circular economy idea. Additionally, it entails the careful monitoring of material flows. Therefore, the circular economy clearly distinguishes between the consumption and use of materials. Which means that retailers and/or manufacturers should stay in control of their products and instead of selling their products as a one-way consumption, sell the right to use the products (EMF, 2013a).

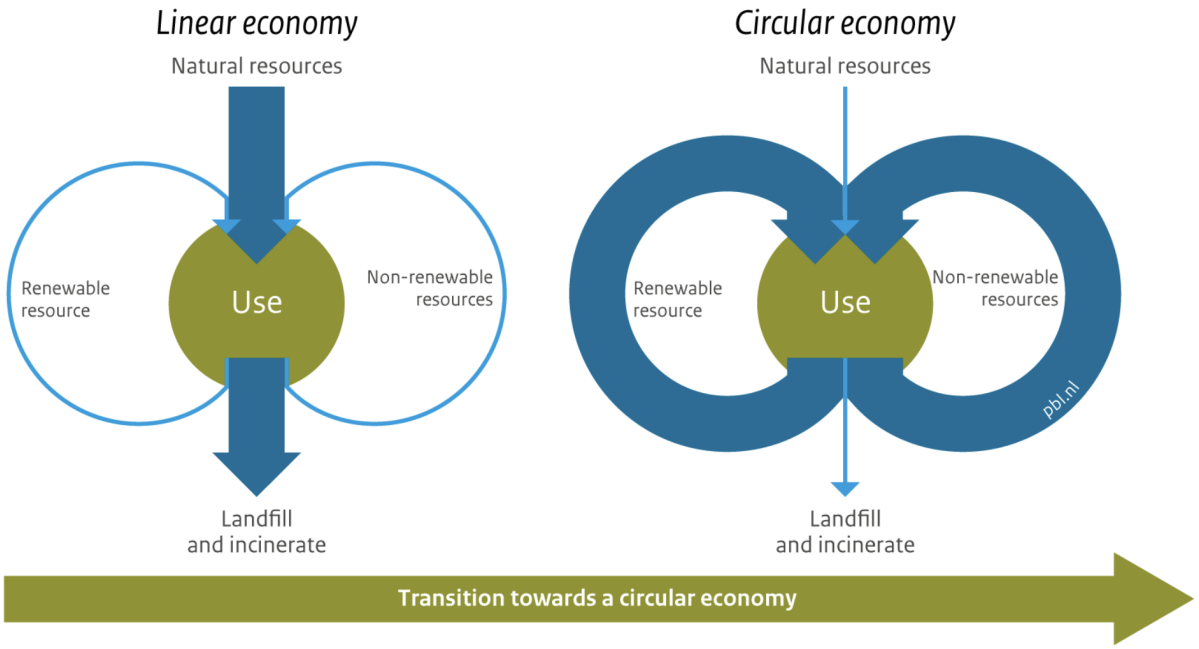

Figure 4, From a linear to a circular economy (PBL, 2016; Potting et al., 2017).

To go from a linear economy to a circular economy (figure 4) requires specific economic activities (e.g. recycling or remanufacturing) to close material loops and create value for the system (Leising, 2016). These closed material loops are shown in figure 5, by the EMF (2013a). In addition, the Ellen MacArthur Foundation (2013a) discusses five 'simple' principles on which the CE is based and how to put the CE concept into practice. These five principles are:

1. Design out waste:
   This principle means that components are designed for disassembly and refurbishment. That technical nutrients are designed to be reused with minimal quality loss and minimal energy, and that biological nutrients are composted (EMF, 2013a).
2. Build resilience through diversity:
   This principle focuses on 'modularity, versatility and adaptivity'. These features allow for more resilience in products, which is needed in a volatile and constantly evolving world (EMF, 2013a).
3. Rely on energy from renewable sources:
   The idea for this principle is to use renewable sources for systems and the production process. But also a shift from labour tax to taxation on energy and materials could benefit circular business models (EMF, 2013a).
4. Think in 'systems':

This principle is about understanding the interaction between the total and the pieces as well as how the different pieces affect one another within the total. The link between an element and its infrastructure, environment, and social context is taken into account (EMF, 2013a).

5. Waste is food (think in ‘cascading’):

   This principle aims to reintroduce the nutrients of materials from products in the biosphere, after cascading them through many uses while going from technical to biological nutrients (EMF, 2013a).

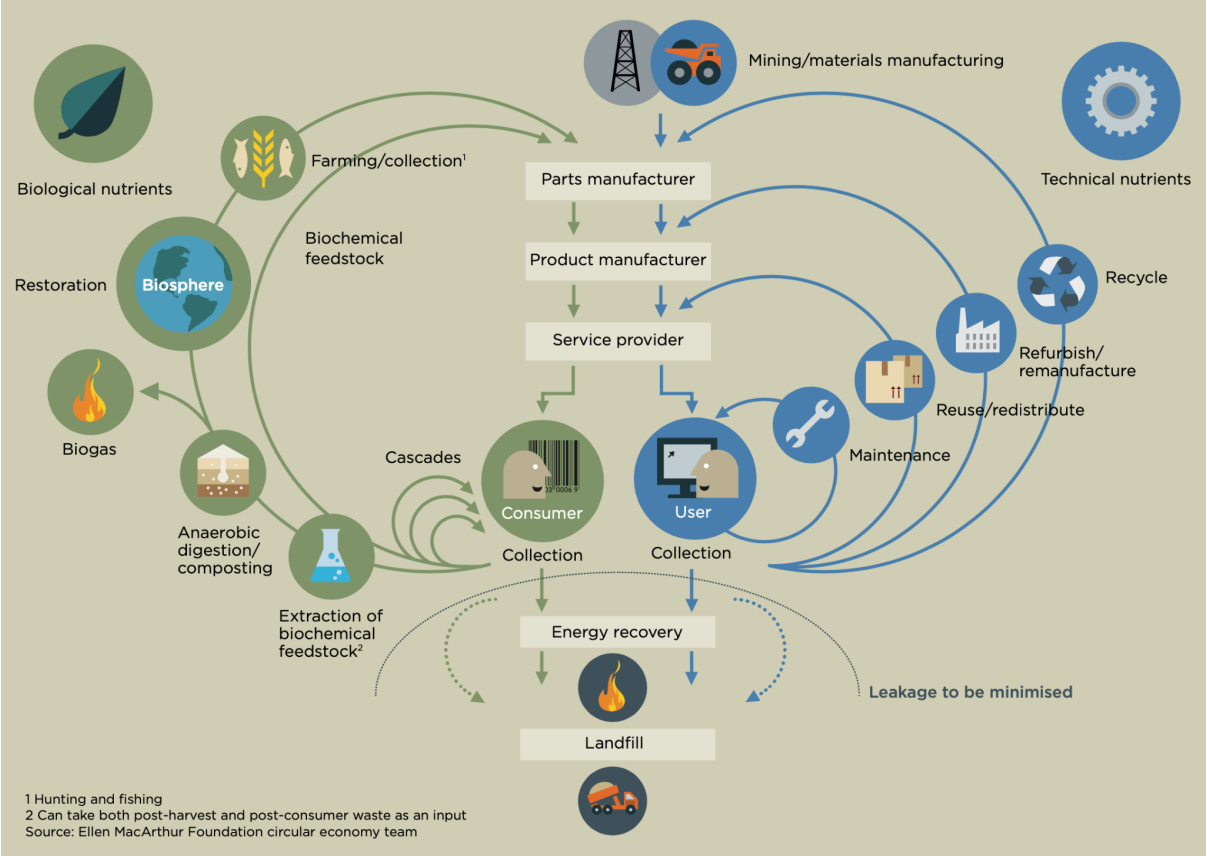

Figure 5, Schematic overview of the circular economy and its activities (Ellen MacArthur Foundation, 2013a).

In addition to the five principles, the Ellen MacArthur Foundation (2013a) also describes four sources of value creation in a circular economy (figure, 6). These four 'simple' principles are valid even though the economic value creation for various products, parts, or materials might vary a lot. The four principles are:

1. Power of the inner circle:

   According to the Ellen MacArthur Foundation (2013a), the underlying costs for labour, energy, material, capital and other related consequences of externalities, such as emissions. If the cost of a linear system is higher than that of the “circle”, it is economically interesting to choose the circular option. However, the opposite is also the case.

2. Power of circling longer:

With the rising prices of resources, longer circling of materials, products and components could also be of value. For example by keeping something longer in the same cycle by extending its use. Or by going through more cycles by several consecutive refurbishments for one original product (EMF, 2013a).

3. Power of cascaded use and inbound material/product substitution:
   Cascading materials, products or components between multiple product categories also presents an opportunity. Instead of putting the materials back into repurposed usage, the possible value creation results from the reduced costs because the reuse-principle is used, instead of new materials (EMF, 2013a).
4. Power of pure, non-toxic, or at least easier-to-separate inputs and designs:
   Improvements such as easier separation, improved incorporated component identification, and material replacement in the design of products result in a decrease of costs of the reverse cycle. In addition, the nutrients are preserved at a higher quality, particularly technical nutrients, through the cycles. This increases product lifetime and its productivity (EMF, 2013a).

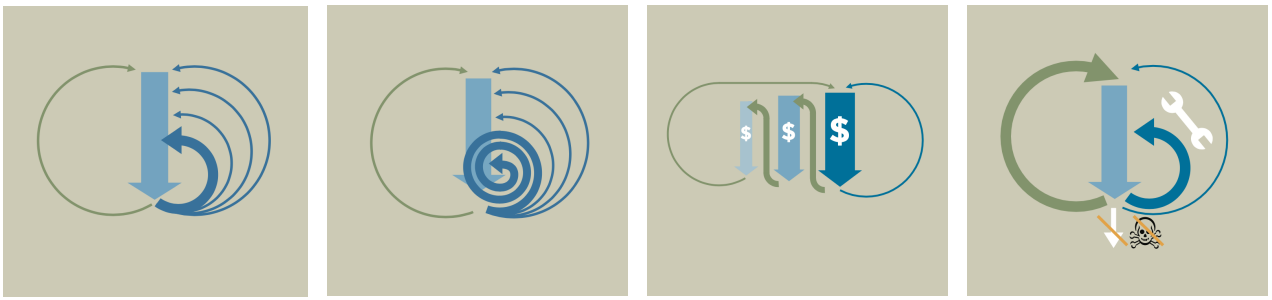

Figure 6, Sources of value creation in a circular economy (Ellen MacArthur Foundation, 2013a).

The circular economy is aimed to be established by the second coalition government in the Netherlands led by Prime Minister Mark Rutte (Potting et al., 2017). Therefore, Utrecht University and the PBL Netherlands Environmental Assessment Agency were asked by the Dutch Ministry of Infrastructure and the Environment to investigate how to measure the development of a shift toward a circular economy in supply chains. Their research focuses on determining what metrics are required. For this, Potting et al. (2017) created a conceptual framework for the involvement of innovation in product chain shifts to the CE.

The Ministry of Infrastructure and the Environment set objectives to help achieve the CE policy programme of the national government (“A circular economy in the Netherlands by 2050” (Ministry of IenM, 2016; Potting et al., 2017)). They are ((Ministry of IenM, 2013; 2014; 2015; Potting et al., 2017):

1. Identifying, sustainably managing and collecting natural capital;
2. Focus design and development of products on circularity;
3. Increasing, making applicable and distribute knowledge of the circular economy;
4. Promote resource-independent entrepreneurship;
5. Making chains circular;
6. Developing financial and other market incentives;
7. Making consumption patterns and purchasing circular;

8. Focusing waste policy on the circular economy and improving waste collection and recycling;
9. Developing indicators and statistics that provide insight into the transition to a circular economy.

Different methods to adopt circularity, or R-strategies (examples of circular strategies starting with the letter 'R'), have been created to scale back on the use of raw materials, natural resources as well as the accumulation of waste. Depending on how circular they are, they can be arranged in order of priority (Potting et al., 2017). Potting et al. (2017) used the R-strategies shown in figure 7. These are a combination of RIi (Council for the Environment and Infrastructure) (2015) and Vermeulen et al. (2014). Vermeulen et al. (2014) come with R-strategies, familiar to the ones shown in figure 7, which they call levels. These levels could be translated in an open and more specific tender. The levels (which Vermeulen et al. (2014) translated to a specific demand from buyers to the market) can be used to determine the level for the evidence of the quality. RIi (2015) comes up with *a* and as RIi states not *the* vision for a circular economy and steps for the state to take for the transition to a CE. In addition, the Ladder van Lansink, which sets a priority ranking for waste treatment methods of the strategies, is covered in this list. This priority is also present in figure 5, the preference is with the inner circles (Leising, 2016).

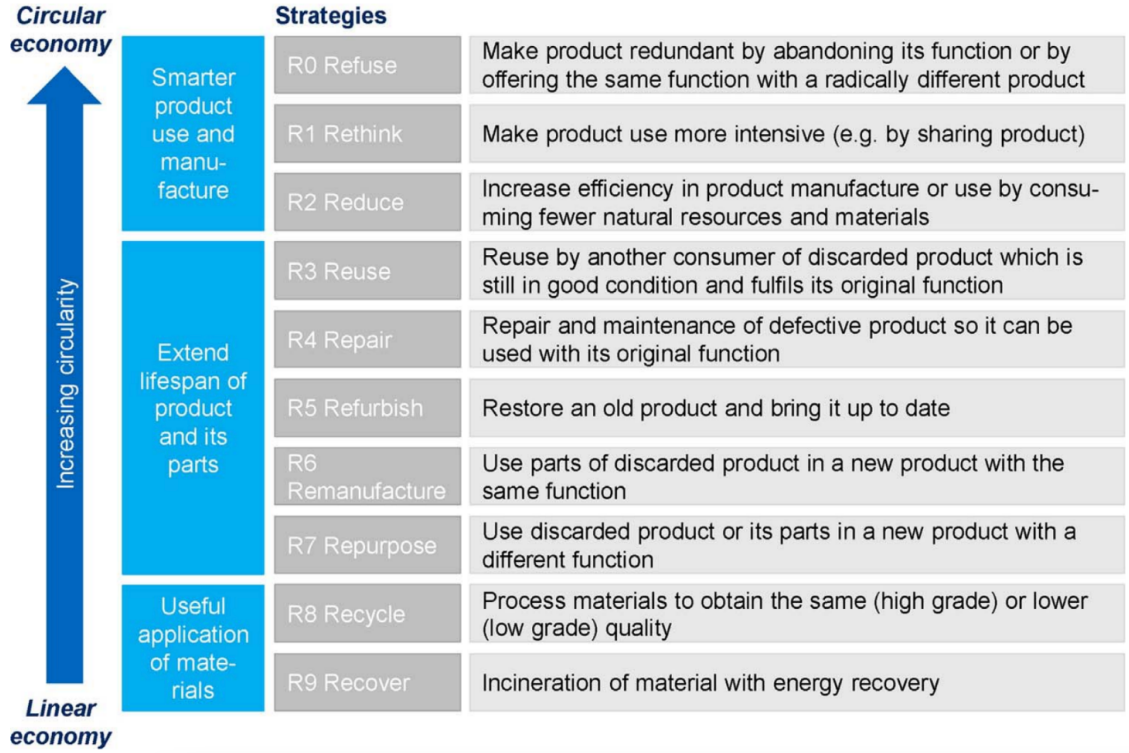

Figure 7, Strategies (in order of priority) for circularity within the production chain (Kirchherr et al., 2017, adapted from Potting et al., 2017).

The priority in figure 7 is not the one and only option, but contributes to thinking about the different strategies. For example, several of the R-strategies from figure 7 are also present in the ReSOLVE framework by McKinsey & Company (2016) in figure 8. These six actions, described in figure 8, improve the use of physical assets, lengthen their life span, and switch from using limited to renewable resources. Additionally, each action enhances and quickens

the utilisation of the others. They could have a significant influence both individually and together (McKinsey & Company, 2016). This shows that it is not necessary to stop at, for example, R-strategy 2, but it is possible to look further to use also other strategies. This can be done by choosing several strategies. For example, reduce as much as possible, reuse what is possible, repair or refurbish what can't be reused and if that is not an option choose for example the recycle strategy. According to Potting et al. (2017), different actors could play a role in different strategies (for example the manufacturing industry and consumers).

Figure 8, The ReSOLVE framework by McKinsey & Company (Williams, 2016).

To conclude, several researchers have come up with strategies to move from a linear system, where the 'take-make-waste' principle is normal, to a system focused on (re)using renewable resources and products as long as possible ('design-use-recover'). To achieve this, several principles and strategies have been created, such as the butterfly model, the R-strategies and the ReSOLVE framework. The primary objective of this transition is to decrease the industry's environmental impact and to enhance sustainable economic growth.

The next paragraph will discuss what the CE definition and the transition entail for a circular real estate development. The empirical research helps look into current projects to see how they are made circular, or if this transition is still complicated and barriers occurred.

4.1.3. Circular real estate development

Paragraph 4.1.1 showed that according to the literature, there is no one, widely-accepted definition of circular real estate. The Ellen MacArthur Foundation's definition has served as the basis for many academics' definitions (Kusters, 2013; van de Kaa, 2013; van Odijk & van Bovene, 2014 and Loppies, 2015). Rood (2015) states that one of the reasons a truly circular structure does not yet exist in actuality is the lack of a definition. It is challenging to realise it without being clear on a definition that is generally recognised. There are parties claiming to have a circular development, which indicates that there are ideas about what circular real estate is (Rood, 2015). Now, members of knowledge organisations are working on "een taal voor ons allemaal" (a language for us all) (Het Nieuwe Normaal, 2023). Het Nieuwe Normaal (The New Normal) is an initiative between several parties with different

backgrounds, these are clients (a.o. Rijkswaterstaat, Rijksvastgoedbedrijf and communities), as well as real estate developers (a.o. Bam, Dura Vermeer, Synchroon and Heijmans) which are both supported by experts (a.o. TU Delft, Copper8, Metabolic and Witteveen Bos). They want to create by the end of 2023 (with version 1.0) an unambiguous language and an unambiguous performance level (Het Nieuwe Normaal, 2022). In their newest version (version 0.5), they present a framework for a building, which consists of three parts: (1) 'standaard': Het Nieuwe Normaal ('standard': the new normal), (2) sustainable context and (3) accelerators.

The first one consists of four sub-themes with in total ten subjects all focusing on materials related to building in a circular way. The second one provides insight into the context within which the performance of materials has been established. The third one is focused on a better understanding about the accelerators for building circular. Overview of the framework is shown in table 4. This indicates that they recognise the importance of reducing climate impact and CE strategies, by creating a clear language to work on the CE for the building industry.

Part 1: 'Standard': The New Normal	**Part 2: Sustainable context**	**Part 3: Accelerators**
● Environmental impact & Material use (theme 1) ○ Environmental-impact (MPG) ○ Embodied carbon (MPG-2) ○ Construction stored carbon (CSC) ○ Material-usage ○ Reuse-potential ● Building flexibility (theme 2) ○ Adaptability ○ Detachability ● Residual materials handling (theme 3) ○ Handling residual material (demolition) ○ Handling residual material (construction) ● Healthy materials (theme 4) ○ Toxicity of materials	● Energy ● Water ● Nitrogen	● Social ● Management

Table 4, Overview of The New Normal framework (adapted from: Het Nieuwe Normaal, 2022).

Utmani (2021) also identified four categories with in total eight principles which will help make the translation from a theoretical definition to practical examples. These examples are also intended to serve as a foundation for developers to think even more sustainably. The four categories are: (1) narrowing: refers to fewer resources being used for a building (over its lifespan, (2) slowing: refers to the longer usage of materials, and components, (3) closing: refers to the reintroduction of resources into the economic cycle and (4) regenerating: refers to employing renewable and nontoxic materials and operating on renewable energy while maintaining and preserving natural ecosystem functions (Utmani, 2021; Çetin et al., 2021). Overview of the circular building principles per category from Utmani (2021) is shown in table 5.

Narrow	● Use as little material as possible to reduce the amount of raw resources consumed. ● Reduce the amount of 'new' (virgin) material used.
Slow	● Design for a maximum functional life. ● Design for optimal use and maintenance.
Close	● Design for future life cycles. ● Increase the amount of recycled material while retaining the value of products and materials that have been discharged.
Regenerate	● Increase the quantity of (sustainable) bio-based materials. ● Maximise the potential for high-quality reuse, if materials are appropriate for reuse due to their high quality or lack of harmful substances, for example.

Table 5, Overview of categories to help translate theoretical definition into practice (adapted from: Utmani, 2021).

To conclude, this paragraph showed that businesses and other organisations are trying to get a grip on the definition of a circular building, but that it is still a broad subject with several possibilities. Moreover, this paragraph has shown principals which make the CE more concrete for developers. To end this paragraph, a definition will be given from Rood (2015, p. 40), which has been slightly adapted with the literature gathered in the previous two paragraphs:

“Circular real estate development is a multifaceted business, encompassing activities that range from the renovation and re-lease of existing buildings to the purchase of raw land and the sale of improved parcels to others where the value of used natural resources is maximised and depreciation of resources is minimised throughout the whole process. developers are the coordinators of those activities, converting ideas on paper into a circular building with the observance of closed material flows to minimise waste, the use of scarce resources and emissions.”

4.1.4. Wood & biobased as circular development

This definition is still broad, what does this mean? How do developments with wood and other biobased materials fit this definition? The introduction already briefly discussed the view of experts and its possible future role, but this paragraph will discuss this in more detail.

Researchers such as Husgafvel et al. (2018) are also noting that the environmental and resource efficiency objectives shared by the circular and bioeconomy frameworks are significant. The preservation of natural resources, using resources in a sustainable way, and the sustainability of biomass are highlighted in the EU bioeconomy policy (EC, 2012). An important factor in guaranteeing long-term economic and environmental sustainability is the bioeconomy (OECD, 2009).

According to Jørgensen et al. (2015), bio-based materials can significantly contribute to the mitigation of climate change through temporary carbon storage. Improvements in material and energy efficiency and a large expansion in the utilisation of wastes and leftovers as valuable raw materials are all part of the global and EU circular economy objectives (EMF and MCK, 2014; Sitra, 2014). Peñaloza, 2017 confirms, using more biobased materials reduces the climatic impact of building, making them a strategy for climate mitigation. Moreover, with the transition towards biobased materials, the demand for primary materials

can be reduced (Oorschot et al., 2023). The cascade of biomass-derived goods, like wood, might improve this potential (Jørgensen et al., 2015). This is supported by Kayaçetin et al., 2022, who also note that bio-based designs perform better since end-of-life reuse and recycling reduce negative environmental effects. According to Oorschot et al. (2023) and Peñaloza (2017), the construction of biobased structures decreases embodied global greenhouse gas emissions and the embodied energy (Markström et al., 2016), however adverse effects are possible, especially given the sizable surface area required for wood production. According to Peñaloza (2017), additional initiatives, including increasing the use of low-impact concrete and renewable energy, need to be implemented together to maximise the potential for climate mitigation.

Thus, it is important and interesting to think about strategies to enhance the amount of biobased materials used in construction (Markström et al., 2016). Biobased products are as follows defined by the European Standard EN 16575:2014: “a product wholly or partly derived from biomass” (p. 5) and a product as: “substance, mixture of substances, material or object resulting from a production process” (p. 6). Markström et al. (2016) noted that wood and products made of wood, were the primary thought of products by the respondents, when thinking of materials for biobased construction. Markström et al. (2016) and Markström et al. (2018) concluded that architects have a positive view on biobased materials and engineered wood products (EWPs). “Everyone loves wood, so it is very popular.” (architect 4) and they predict that the use of EWPs will grow in the future.

According to Markström et al. (2018), it could be beneficial from a climatic standpoint to incorporate more wood products in buildings. Decreasing the proportion of non-biobased materials in buildings, “such as concrete and mineral wool, and increasing the proportion of sawn timber and other wood-based products, such as cross-laminated timber (CLT) and cellulose fibre insulation”, reduces the building's climate impact (Markström et al., 2018, p. 1) (Hurtado et al., 2016; Peñaloza et al., 2016; Schiavoni et al., 2016; Asdrubali et al., 2017; Guo et al., 2017; Rajagopalan and Kelley, 2017; Teh et al., 2017; Thiger et al., 2017). Moreover, the utilisation of wood gives the home a wholesome, vapour-open interior while also storing CO_2 from the atmosphere Oorschot and Asselbergs (2021).

In addition, there are numerous choices for cascading use of wood waste, which can further extend the useful life of the wood material and consequently its carbon storage, which is another benefit of utilising lumber in construction (Arm et al., 2016; Fraanje, 1997; Sommerhuber et al., 2015; Thonemann and Schumann, 2017). Given that it addresses actions to improve the utilisation of biomass, this approach has substantial overlap with circular economy concepts (Jarre et al., 2020). Caldas et al. (2020) mention a way wood waste can be used to result in climate change mitigation. Which is by recycling wood waste in wood bio-concrete, which helps as a CO_2 sink for a low-carbon building.

To conclude, not only the experts of consultancy firms (in the introduction) are positive about biobased construction, but also scientific literature shows how it fits the circular principals and could be a good option against the climate impact of the built environment.

4.1.5. Value system influence

With the transition from the linear to a circular economy, value also comes into play. For example, research done by Giorgi et al. (2022) shows that interviewees indicate legislation as an important trigger to cut back on the use of raw materials and landfilling. The Dutch 'Milieuprestatieberekening van gebouwen' (art. 5.8 and 5.9) legislation is an example to help achieve the transition to a circular economy (Giorgi et al., 2022). This legislation makes it mandatory for new homes and offices larger than 100 m^2, to report their environmental performance with a Life Cycle Assessment study. In addition, a maximum value has been established by legislation (Giorgi et al., 2022). Transition reasons could also be that stakeholders are anticipating future regulation, as the Dutch government wants to be completely circular and climate neutral in 2050 (Rijksoverheid, n.d.a and Rijksoverheid, n.d.b).

In addition, Torres-Guevara et al. (2021) also looked into reasons for implementing the circular economy. One of them they came up with was the commitment of the management team. Management commitment correlates with the management's motivation to shift to a CE and its principles. However, doing so demands commitment and willingness from the managers to make time and financial investments (Torres-Guevara et al., 2021).

The majority of self-initiated projects by developers are short-term focused (Rood, 2015). Their primary objective is to create a building and sell it for a profit. To keep succeeding in the market, developers will need to focus on the long-term strategy, according to van Mierlo (2010) and Grundemann (2010). Rood (2015) noted that developers allied to investors, came from financial institutions and part of businesses with a different core aspect such as NS and Schiphol are more aligned with the suggestion of Grundeman (2010) and Mierlo (2010), and therefore more long-term focused. Most of the developers who are currently involved in sustainable building did so because they anticipated the market shift towards this; the absence of legislation is the only reason it hasn't happened more yet (Utmani, 2021). All actors make room for it in their enterprises if those are in order. According to Utmani (2021), finance is a major element, but if new rules change the concept of "anticipated cost" or "average value," a new definition will emerge and be accepted as the norm. This led to a debate on how each stakeholder has a moral duty to individually integrate sustainable practices and decisions in their area of competence, even though there may be a "start point" (Utmani, 2021). As a result, preserving the planet will continue to advance without being mandated by law.

Currently, there are already organisations working towards the transition together with several other organisations and companies, for example “Club van Circulaire Ondernemers” and “Het Nieuwe Normaal”. Parties involved with these organisations already value the circular economy and are working to contribute to the CE shift with their businesses, because they do not only find the financial aspects important, but also value the environmental elements linked to their work. They see the need to become more sustainable, but note the financial aspect not being in order (Change Inc., 2023).

Literature makes clear that real estate developers must build more sustainably to still be able to create value in the future (Rood, 2015). However, as has been noted by a large group of circular entrepreneurs (‘Club van Circulaire Ondernemers’) and 10 partners that are closely

linked to the circular ecosystem (such as Copper8 and Change Inc.), that the current situation will not work to reach the climate goals of 2030 and 2050 (Change Inc., 2023). They claim that because it is impossible in the existing linear economy, it must be more ambitious, transparent, and encouraging for circular entrepreneurs. The government must establish circular business as the norm. Laws must be changed, and financial incentives must be offered, such as a tax shift that lowers taxes on labour in the circular economy while raising taxes on pollution and raw materials. A bigger goal of developing these favourable financial incentives for circular business models, is to level the playing field for circular entrepreneurs, who now have to put up more effort in their innovation. Strengthening the circular economy requires an understanding of and advocacy for circular behaviour (Change Inc., 2023).

To conclude, this paragraph has shown if developers value circular principles or want to incorporate it because of other reasons, it changes the usual way of working which is necessary to be more sustainable. However, according to practitioners, with the current way it will not be possible to do and reach the goals by 2030 and 2050. To understand this better, chapter 4.2 will examine how the real estate development process works.

4.2. Real estate development process

This chapter focuses on the real estate development process, what a real estate developer is/does, its business case and stakeholders.

4.2.1. Real estate developer

Peek and Gehner (2018, p. 41) describe a real estate developer as follows: “A project developer is a company that develops real estate projects for its own account and risk with the aim of making a profit.” Developers note on their websites that they also aim to develop beautiful, functional, affordable, sustainable homes and cities, accommodate people to help with the housing shortage, and a pleasant living environment (Synchroon, 2023; AM, 2023; BPD, 2023). Because each project developer has a different amount of equity, level of risk tolerance, and desired financial return, each business strategy differs. A project developer also uses one or more development strategies in addition to the business strategy. Deciding, phasing, and managing project-related risks, are done with the help of the development strategy (Peek & Gehner, 2018). Another characteristic according to Peek and Gehner (2018), is that a developer functions as the market party for the match between local demand for space and societal challenges, and that the work is done in a ‘project-based manner.’ Hedeman and Riepma (2017) define a project as “a set of activities to achieve a predefined result in a temporary organisation, within set conditions.” The ready-to-use building is in this case the result.

Furthermore, the activities for project development can be grouped in six core aspects (location, design and build, planning, use, ownership and financing), which result in the project being divided into phases to better coordinate them (Peek & Gehner, 2018). The phases are: initiative phase, feasibility phase, commitment phase and realisation phase (and exploitation phase). Several developers, such as Synchroon, are also area developers not only focused on the plots, but this thesis is focused on the buildings.

As shown in paragraph 4.1.3, developers experiment with innovations (in this case circularity), however this brings uncertainties along. The question is how to move from broad societal challenges to the local space market? Moreover, project development is characterised by high investments in land, advice and realisation (Peek & Gehner, 2018). These must take place before there are any proceeds. To get a better picture of this aspect, the next paragraph discussed the business case.

4.2.2. Business case

An important part of every project is its business case, what are the goals and deliverables from the project and do they align to the organisations' aims, what is the value or what are the advantages for the company, but another critical aspect is the financial feasibility of the business case. For real estate developers it is important that the business case is financially feasible and as discussed in the introduction, this is still a challenging part in the larger shift from the linear to circular developments.

According to Peek and Gehner (2018), a project can be developed if a new exploitation, such as the acquisition of an old industrial building, its destruction, and the creation and construction of new dwellings on that site, are less expensive than the sales earnings of the residences. Costs and earnings are the main considerations in deciding whether or not to develop. The return that the project developer may obtain on a project is heavily influenced by the profits from the use. Other interests, such as social, ecological, and cultural ones also come into play, as discussed in paragraph 4.1.5.

The financial parameters (costs and revenues) are an important element in a business case (together with the method of financing, the risks and the link with the planning). A business case is drawn up simultaneously with the concept for a project and is a document that describes an intended investment decision. The business case examines whether a project fits within the company strategy and is financially feasible (Peek & Gehner, 2018). It is not a static document, but is kept up to date and further refined during a project. Because the accuracy of information increases, the certainty of achieving the desired project return also increases (Peek & Gehner, 2018). Another important element for project developers is the profit-percentage, this is the difference between costs and earnings divided by the total investment costs and serves to determine the yield (Peek & Gehner, 2018). Besides a yield requirement, developers could als set criteria for the liquidity requirement on equity.

That the financial part of the project is an important element is also shown in other literature. Because, the financial aspect of the circular economy is one of the main barriers, as shown by several studies (literature reviews, interviews & surveys) investigating barriers in a circular economy in the built environment (Hart et al., 2019; Rizos et al., 2015; Rios et al., 2021; Guerra and Leite, 2021' Adams et al., 2017). Hart et al. (2019) describe five financial barriers. First, because the business and investment sector prioritises capital spending above operational expenditure, they are often criticised for functioning with "short-term blinkers" (Hart et al., 2019, p. 621). Moreover, they state that this tends to discourage initiatives with larger social and environmental goals but shorter financial payoffs in favour of transactional agreements rather than long-term partnerships. Second, for implementing CE strategies in the development projects, higher upfront investment costs are required (Hart et al., 2019; Rizos et al., 2015; Rios et al., 2021; Guerra & Leite, 2021). According to Hart et al.

(2019) these are needed e.g. for additional infrastructure supporting CE, certifications needed, but Rizos et al. (2015) also mention ‘hidden’ costs, such as the amount of effort and labour that enterprises need to invest for environmental improvements. In addition, the necessary knowledge is not always already available in the organisation and this could result in the need for hiring external consultants (Guerra & Leite, 2021). Because of the importance of the financial obstacle, having access to funds and finding the right sources of capital may be necessary to advance sustainability and/or introduce innovation in the project (Rizos et al., 2015). This limited funding is also one of the five points mentioned by Hart et al. (2019), which includes numerous common complaints regarding funding and finance access. Fourth, because there are uncertainties regarding value in the future, low costs for raw materials and even lower end-of-life values provide a significant barrier to CE (Hart et al., 2019; Kirchherr et al., 2018; Adams et al., 2017; Hopkinson et al., 2018). The fifth and last barrier mentioned by Hart et al. (2019) is about the weak business cases and mediocre case studies, which are often referred to.

Adams et al. (2017) also state that the unclear financial case is one of the biggest obstacles for implementing circularity strategies in building projects and that a clear business case is the most crucial enabler to have. According to interviewees from research of Guerra and Leite (2021) the business strategy of the developers may differ from the lifespan for which the building is intended. The developer's investment for a project is usually recouped far earlier than the end of the building lifetime, in a way that stakeholders are not concerned as much about the project's end-of-life (Guerra & Leite, 2021). Owners or stakeholders may find it challenging to understand a demand that extends beyond the time frame in which they are currently thinking. This calls for generating value not just for the corporation but also for a range of stakeholders (Leising et al., 2017).

Extra costs for circular building

Alba Concepts & Sweco (2022) conducted research and created a report called “Research into circular land and real estate exploitation” in which they a.o. investigated what the impact is on the direct building costs (figure 9) of building a home in a circular manner with biobased materials instead of in a traditional way. According to Alba Concepts and Sweco (2022), tackling the housing shortages is an important and relevant topic. However, they also state that it is not only important to build fast, but also to work on the transition to a circular economy to reduce CO_2 and nitrogen emissions and without the depletion of resources.

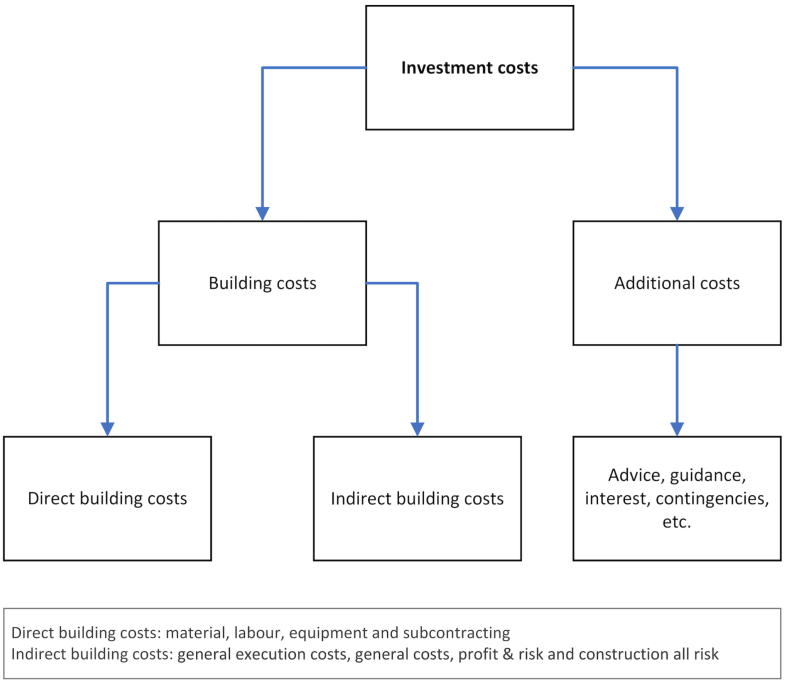

Figure 9, Investment costs and their different parts (adapted from: Alba Concepts & Sweco, 2022).

They took a MPG score of below 0,50 as a starting point for the circular building option in their research. According to Alba Concepts and Sweco (2022) to reach, materials with a low environmental impact are necessary like: biobased materials are necessary or materials with a proportion of secondary material. They used six different types of reference homes. Their results show a significant impact of MPG score improvement, of reduced CO_2 emissions and of increased direct building costs (tables 6 and 7 on the next page). Thus, currently extra investments are needed to reduce a building's climate impact.

Housing typology	**MPG-improvement [%]**	**Increase direct building costs [%]**
Home S (between)	-38%	+16%
Home M (between)	-38%	+24%
Home M (corner)	-41%	+24%
Home L (detached)	-43%	+23%
Residential building M	-28%	+32%
Residential building XL	-32%	+18%

Table 6, Impact of circularity on MPG score and direct building costs (green = positive impact, red = negative impact) (adapted from: Alba Concepts & Sweco, 2022).

Housing typology	MPG-improvement [%]	Decrease CO_2 emissions
Home S (between)	-38%	-52%
Home M (between)	-38%	-53%
Home M (corner)	-41%	-55%
Home L (detached)	-43%	-55%
Residential building M	-28%	-48%
Residential building XL	-32%	-42%

Table 7, Impact of circularity on MPG score and CO_2 emissions (green = positive impact, red = negative impact) (adapted from: Alba Concepts & Sweco, 2022).

From their results, they had several conclusions (Alba Concepts & Sweco, 2022):

- First of all, investors and social housing corporations are willing to pay (under conditions) extra for these developments. However, they can't permit themselves to spend (much) more on sustainability, instead of availability, affordability, quality of life, as their investment capacities are limited. In addition, financial benefits of sustainable housing are still not sufficiently embedded in current calculation models and construction costs are so high that project returns (IRR) cannot decrease much further. Nevertheless, a higher price of about 5 - 10% can be calculated in the exploitation of circular housing developments.
- Second, compared to building traditionally, the direct circular building costs were 15 - 30 % higher. This is partly because detachable design principles and circular materialisation are still more expensive than traditional building principles, there is not yet a mature market for recycled building products and materials, and building products made from biobased and renewable raw materials are still in full development.
- Thirdly, building following the CE principles pays off when CO_2 pricing will be included, as these developments score 40 - 55% lower (better). CO_2 pricing could help compensate for the additional costs for circular construction. As circular building materials get more commonplace, therefore reducing in price, and CO_2 pricing will therefore work in favour of circular building materials, because of their lower CO_2 emissions.

To conclude, the literature discussed shows that the financial feasibility of a business case is important, but often still a large obstacle in the transition from linear to circular building projects. The investments to improve the environmental footprint of buildings is higher, at the value side this helps reduce the climate impact, but the financial case stays unclear. Therefore, the subject of this thesis is useful to identify opportunities to make this possible in business cases for a larger scale or to determine if further research is necessary for certain identified possibilities. There are already a few circular buildings being built (or have been finished). Therefore, it is necessary to investigate if they were feasible, and if so, how they managed to do so.

4.2.3. Circular value creation

Scientific literature, as well as reports and research from institutes and organisations indicate that value creation is part of the circular economy. According to the definition by the Ellen MacArthur Foundation, the CE strives to create value in the form of economic value, social value, and environmental value (Rli, 2015; Karhu & Linkola, 2019). The value creation takes place when additional value is added, which can take place in these three areas (Rli, 2015; Vos, 2020). This is also according to Rios et al. (2021) the goal, to increase value and economic opportunities while promoting a low-carbon economy, reducing waste and using less resources that then can be used again (EMF, 2013). However, when these added values are taken into account, the business case changes drastically (Vos, 2020). The unclear financial case is according to Adams et al. (2017) one of the major barriers to circularity adoption in the built environment. In an ideal situation, a circular house would be worth more than a non-circular one (Vos, 2020). This could come from the value creation in the different areas (economic, environmental and social), through for example higher residual building value, reduced environmental impact (in terms of CO_2, NO_x, scarce materials etc.) and better indoor climate for users (Vos, 2020; Copper8, 2021; Karhu and Linkola, 2019; Rli, 2015).

According to Hart et al. (2019), it could help and be an enabler to measure the (added) value from the circularity of the building. For example ASN Bank together with Climate Cleanup developed a tool to calculate the amount of CO_2 a biobased/wood building saves (ASN Bank, 2021). However, Rood (2015) noted that participants in their study anticipated that because the circular economy neither improves user comfort nor adds functionality to the product with relation to the user and thus does not add any user advantages, the value of the product for the user would not change. In addition, the interviews and also scientific literature pointed out that to create this circular value, more costs need to be made in the current market situation. To make the CE shift and to fund innovative business models, change is needed by companies and the financial sector (Utmani, 2021).

A new topic is the storage of CO_2 in wood and the possibility to trade this for a certain value per ton CO_2. An example of an industry where this is already happening is the car industry. Tesla has created a cash flow with the so-called ‘regulatory credits.’ Several governments have created incentives for car manufacturers to produce electric vehicles or extremely low-carbon emitting vehicles in an effort to minimise carbon emissions (CNBC, 2021). Credits are awarded to automakers who make and sell eco-friendly cars. Automakers who build these vehicles will receive credits, with longer range zero-emission vehicles receiving more credits. These automakers must maintain a specific level of regulatory credits annually. If they fall short of the goal, they can purchase them from other businesses who have extra credits like Tesla, or otherwise get a heavy fine (CNBC, 2021).

EU Emission Trade System

Currently, the EU also has its own emissions trading system ‘EU ETS.’ The EU ETS is a ‘cap and trade’ system, which means that there is a maximum amount of emissions that the stakeholders in the system are allowed to emit and that the emission allowances can be traded by the stakeholders in the system (figure 10) (European Commission, n.d.). Each operator must hold itself to their emissions limit, otherwise it gets a heavy fine. If the operator is below their limit, it can keep the allowance for future needs or decide to sell them to others

that don't have enough (European Commission, n.d.). Another aspect is that the cap is lowered over time to reduce the total emissions and the limit of allowances makes sure they have a certain value. This system stimulates emission reductions, encourages investments to assist with this, and trading adds flexibility to ensure emissions will be reduced where it is less expensive to do so (European Commission, n.d.). The system recently (April 2023) got revised and tightened up to reform it and better steer on GHG emissions (European Parliament, 2023).

Province of Utrecht

Another example is from the province of Utrecht. They are the first Dutch administration to take the costs of climate change into account when making policy decisions (province of Utrecht, 2023). In contrast to the EU ETS system from the EU (which is an emissions levy on companies), the system used by the province of Utrecht is internal, not a real cash flow, and challenges other governments and market parties to follow. They followed the recommendation made by Klimaatverbond Nederland, which is also based on research from the German ministry for the environment. This led to a new fair CO_2 price of 875 euros per ton which includes its climate impact and social costs (province of Utrecht, 2023).

CO_2 pricing

Blankendaal (2022) also investigated another possibility: valuing CO_2 in real estate developments. According to him the problem is that the MPG does recognise CO_2 emissions, but not CO_2 storage, this and the absence of a fair CO_2 storages price results in market failure. Blankendaal (2022) investigated what the effect was of CO_2 pricing on the cost and income balance of developers and concluded that CO_2 pricing with a fair price has a significant influence on the financial driven return of sustainable real estate. According to his research, a price of, for example 50 euros per ton has nearly no influence, but a price of 800 euros influences for 65-98% (depending on two different reference homes) (Blankendaal, 2022).

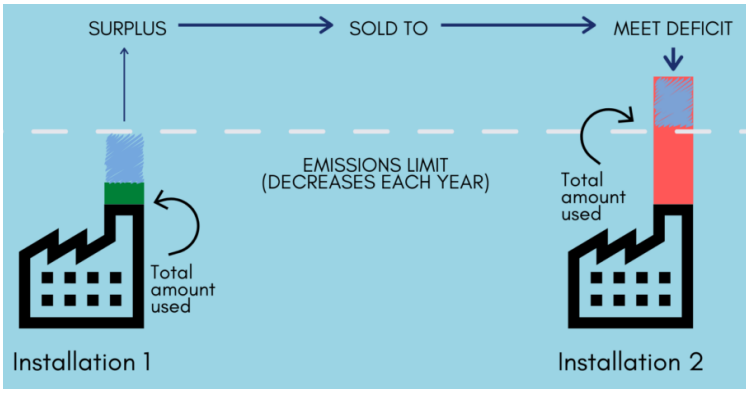

Figure 10, EU emissions trading system (Investigate Europe, 2020).

To conclude, this paragraph discussed that according to the literature, the circular economy should come with an added value in three areas. However, Rood (2015) noted that the consumer does not always want to pay extra for these. Currently, there are systems/parties putting a price on impact of for example CO_2 emissions, such as the province of Utrecht with their internal CO_2 price.

4.2.4. Stakeholders

A project developer is at the centre of the entire story for a real estate development. The developer engages in activities in several marketplaces and does business with the various stakeholders in these areas in order to realise a project (Gehner, 2008). This has been shown by Peek and Gehner (2018) in figure 11.

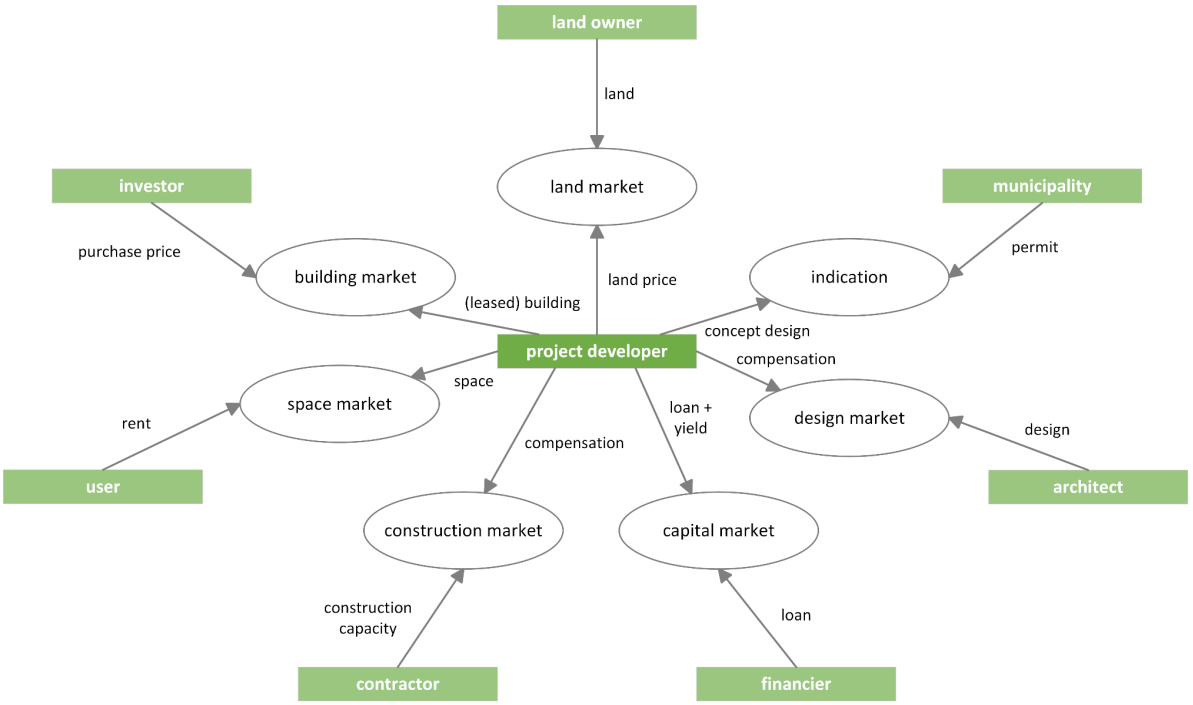

Figure 11, 'Project developer as a spider in the web of the different markets', (adapted from: Peek and Gehner, 2018).

This makes clear that a project developer works with many different parties. According to Acharya et al. (2018) and Guarra and Leite (2021) investors are one of three (together with policy makers and construction clients) stakeholder groups that have the most ability to influence decision-making for the shift to circularity. According to Hart et al. (2019), the stakeholders' behaviour and attitudes also need to change, because only technological and legal improvements will not be sufficient. Numerous circular strategies are described in the literature, however, their practical implementation also depends on external variables (Guerra & Leite, 2021) along with collaboration and synergies throughout the value chain among various stakeholders (Geldermans, 2016; Wells and Seitz, 2005). Costs, for instance, have a significant impact on whether to use circular methods or not (Kibert et al., 2001; Guerra et al., 2020). According to Zimmermann et al. (2016), to create a circular built environment, cooperation amongst stakeholders along the building value chain is crucial. Also according to Bocken et al. (2016), stakeholder collaboration is regarded as vital for the creation of circular value chains and innovation in a sustainable business model (Leising et al., 2018). Incentives may also safeguard and strengthen cooperation in the business model by intentionally incorporating the financial interests of stakeholders in the direction of the shared objective of a circular construction (Kraaijenhagen et al., 2016; Leising, 2016). The success of the group objective could for example result in financial rewards, necessitating the cooperation between the parties. Collaboration in the (Dutch) building sector and in the

supply chain could be improved by this, even for extended periods of time (Leising et al., 2018).

Other parties (not part of figure 11) indicated by Husgafvel et al. (2018), are the EU and the national government. According to them, their “public steering and sustainability considerations” are also of importance. They also concluded that for cascading of solid wood on a larger scale in Finland, inducements, legislative obligations or demands are necessary.

To conclude, according to the literature, stakeholders and collaboration among them are important in the shift to a circular economy in the built environment. During the empirical part of this research, also other stakeholders could be identified if they are important for the changes/solutions made in the business case.

4.3. Conclusion

The literature has helped create a better understanding about several topics discussed in the paragraphs. This short paragraph is focused on discussing the conclusions at the end of all the literature paragraphs, what can be concluded from this and how this contributes to the empirical research.

The literature showed that even though there are many circular economy definitions and strategies to help with the transition from the linear economy, developers are still struggling to implement these into their housing developments. Consultancy firms, developers and experts worked and are working on translating the more general definitions and strategies for the building industry, of which biobased is one on which all the parties involved are positive. This strategy helps get grip on a strategy to reduce the climate impact of the building industry. It was furthermore noted that the CE should come with an added value in three areas: economic value, social value, and environmental value, and that incorporating this changes the usual way of working. However, the circular economy neither improves user comfort nor adds functionality to the product with relation to the user and thus does not add any user advantages, the value of the product for the user would not change. In addition, the unclear and unfeasible business case still remains a significant barrier. Developers and their stakeholders are starting to value circular principles and starting to experiment with innovation. The collaboration between those stakeholders and developers was also noted as important for the transition.

There are already a few biobased buildings being built (or have been finished). Therefore, the results from the literature study are relevant for the investigation of these projects in the case studies. The literature conclusions help for the knowledge on the subject and with the questions for the interviews. Therefore, it is necessary to investigate what the problems, complications and differences were according to developers, if the business cases were feasible, and if so, how they managed to do so. This is relevant, because the literature showed that costs and feasibility are still a difficult and significant barrier. The role of the stakeholders was also found important, therefore this is also a relevant topic for the empirical research. Stakeholders which were important for or which are relevant to the adaptations could be further identified and spoken to. Moreover, the literature conclusions also serve a role in the final conclusions chapter of this research, to help compare and reflect on the results of the empirical research.

5. Results

This chapter entails the results from the empirical research. First the results from the case studies are discussed and then the stakeholder and expert interviews.

5.1. Results case studies

This part will discuss the findings from the case studies into circular housing developments using wood and biobased materials. The results will be discussed according to the sub research questions and the codes used in the interview transcripts. This results in the general aspects of the project and 5 topics related to: (1) business case (costs, solutions and differences), (2) the circular economy (importance/interest, requirement and circular method), (3) risks and complications, (4) important stakeholders and (5) related to the future of the built environment. An overview is created in table 8 which shows the topics the interviewees talked about and its occurrence.

	1 Xylino 1 (48)	2 Xylino 2 (49)	3 Swanladriehoek (56)	4 HAUT (50)	5 Horizons (58)	6 SAWA (56)	7 De Nieuwe Es... (57)	8 Zuiver Bosrijk (31)	Totals
Business case / project: Costs (57)	4	9	9	7	7	8	6	7	57
Business case / project: Difference traditional vs circular (42)	3	2	9	6	7	6	4	5	42
Business case / project: Solution (41)	5	6	5	8	3	8	2	4	41
Circular economy: Circular construction method (wood/biobased) (113)	10	10	13	16	18	15	19	12	113
Circular economy: Experience / familiar (21)	2	2	3	3	2	3	4	2	21
Circular economy: Importance (21)	1	5	4	2	2	3	2	2	21
Circular economy: Requirement (10)				2	2	2	2	2	10
Circular economy: Traditional construction method (steel/concrete/brick) (24)	2	3	3	4	5	4	3		24
Future (32)	6	6	2	6	4	2	4	2	32
Risks / complications: Government arrangement/policy (7)	1	3	1	1			1		7
Risks / complications: Guarantee / regulations etc. (35)	3	6	3	5	4	6	7	1	35
Risks / complications: Knowledge (13)	2		2	3	2	1	1	2	13
Risks / complications: Market / user reaction (11)			3		4		3	1	11
Risks / complications: Production / supply (17)	3	4	1	1	2	1	4	1	17
Risks / complications: Rising costs (12)	2	3	2	2	1	2			12
Risks / complications: Technical complications (26)		1		7	4	5	4	5	26
Stakeholders: Advisor (15)			4	1	5	3	1	1	15
Stakeholders: Architect (4)			1	1	1		1		4
Stakeholders: Contractor / supplier (21)	4	4	3	2	2	3	1	2	21
Stakeholders: Government (11)	1	2	1	2	1	2	2		11
Stakeholders: Help (16)	2	2		2	1	3	3	3	16
Stakeholders: Investor (8)		1		1	2	3	1		8
Stakeholders: Municipality (34)	3	3	1	6	6	3	6	6	34
Stakeholders: Project developer (17)	2	3	1	2	2	3	2	2	17
Stakeholders: Project establishment (8)	1	1	1	1	1	1	1	1	8
Stakeholders: Together (11)	3	2	1	2		3			11
Totals	60	78	73	93	88	90	84	61	627

Table 8, Code-document analysis of case study interviews (own work with Atlas TI, 2023).

It is important to note that the findings in these case descriptions come from the interviews done with developers/actors closely involved with the projects and (news)articles/websites about the project. Therefore, this shows what they encountered, see as complications and what in their eyes could be possible solutions. To stay critical, it is important to reflect these findings in the conclusion with the literature and interviews done with stakeholders of the mentioned solutions by the developers.

5.1.1. Case 1: Xylino

Xylino is a social housing development for the corporation Alliantie in Almere. Originally, it was supposed to be developed by Synchroon and built by Koopmans, however the parties came to an agreement that Alliantie would buy all the homes to close the business case. Which resulted in no homes left for Synchroon to sell in the market. Therefore, Synchroon withdrew from the project and booked their general costs as a loss, but they kept following the project to expand their knowledge.

Figure 12, Xylino (deAlliantieOntwikkeling.nl, n.d.).

The project started with the housing association, who had bought land in Almere and wanted to build in wood to get more experienced with this method. They came to an agreement with the municipality to build in wood at the location. The wood concept used for Xylino was ‘HOUTbaar’ from geWOONhout, which is a modular building concept which is interesting for Alliantie, as it is supposed to be fast, cheap and suits repetition. Interviewee 1 noted that the concept of Koopmans was important, because “You see that in many other projects, that the idea is there, but that no one can make it.”

The focus of the project was to build modular from wood, therefore the homes are demantable and reusable making it very circular according to interviewee 3. The concept uses renewable resources and the facade is also made from wood. However, due to regulations and requirements, the parking layer will be made from concrete and the gallery is also not completely from wood.

The close the business case, Alliantie also paid a bit more than in a concrete & bricks building and because the municipality found the circular building method important, they were willing to lower the land price. Interviewee 3 mentioned “I think the parties will be very happy if they can eventually realise this project without a loss.” which shows the financial barrier in this project. On the cost difference between the circular and traditional method, interviewee 3 mentioned “It has been suggested that you should assume approximately 10% more. [...] All parties simply wanted to build in wood and that was the starting point.”

Also costs related to fire resistance, sound transmissions and finishes to the wood casco, make wood constructed projects more expensive according to interviewee 1. But also because of technical risks related to tests and proving to the supervisor of the municipality or environmental service that the building method complied with the building code.

Both interviewees 1 and 3 think that circularity will be very important in the future of the built environment. Both see wood and biobased as important ways to build in a circular manner, but also that it won’t be the only option. Interviewee 3: “We have a huge task, which we cannot solve in wood construction alone.” Interviewee 1: “I think that wood construction will certainly play a major role, but I don't expect an all-determining role.” Both interviewees mentioned the importance and strength of concrete, which will still probably play a large role.

Interviewee 1 mentioned that it would be possible with the same budget, under the same agreements, which include the agreement with the municipality for a lower land price. But if the production of wood construction increases, the price should get more feasible. Governmental support is according to interviewee 1 needed for biobased products and the expansion of the national cadastre into including what a building is made of. Interviewee 3 mentioned that an incentive helps the building industry to become more sustainable, and that it is (temporarily) needed to get a more level playing field, as the market mostly looks at the cheapest option.

5.1.2. Case 2: Swanladriehoek

The Swanladriehoek is a housing development at the edge of Zevenhuizen. The circular ambitions to build with wood and biobased materials came from Synchroon, the municipality only set a very broad climate adaptive objective. Interviewee 2 mentioned that Synchroon had three vision points related to making the project circular, which were climate-adaptive, nature-inclusive and biobased construction. But also that they did not focus on a material passport or reusing materials, according to interviewee 2 you sometimes have to choose.

Figure 13, Swanladriehoek (Architectuur MAKEN, n.d.).

First, the aim was to develop the entire housing development in wood (casco's & facades), only the apartments would be built with a traditional casco. According to interviewee 2, the design team which included various advisors, the contractor and cost specialist were important. As they search not only for good options for the budget, but also for the sustainability goals. However, the business case would not allow this, as interviewee 2 mentioned: "At one point, it just turned out not to be possible. It is a bit how you calculate, but you can say that it costs about 40 thousand euros extra to build a house in wood instead of traditionally." (*note: this number is approximately and time/project/aspects specific and was an average for terraced housing)*. The material prices rose even more. Therefore, they chose to not build all homes with a wooden casco. The part they chose – the terraced housing in the first building phase – was because of the great repetition of the housing type, it was the easiest to build in wood, and gave the possibility to build more in wood in later phases.

Another complication to build everything in a biobased manner, was that the aesthetics committee wanted a transition between the existing homes and the new project. Therefore,

some houses had to have a traditional facade. Resulting in a lot of different homes, some with a traditional facade, others with a facade with materials from wood, some with a traditional casco, others with a CLT casco and there were the traditional apartments.

Interviewee 2 also notes the fire safety as an complication, this was the reason to use bamboo in the facade of the apartments (instead of wood), as it needed fire class B. Bamboo is also biobased, but comes from Asia. More research and design time was needed, and more explanations about the different housing types to the buyers. Moreover there was uncertainty about how buyers/the market would respond to a biobased home. Biobased isolation was also considered, however it turned out to be too expensive. It costs more per m^2 and more thickness was needed which resulted in less m^2 to sell.

Concerning the future, interviewee 2 mentioned: “I think this (constructing in biobased) is the future, and I also think we cannot do otherwise. I am really convinced that this sector really needs to change completely.” Moreover does interviewee 2 believe that the costs for biobased materials will reduce in the future, however governmental/municipal support is still (temporarily) needed. This could help promote and push the sector to build more circular to reduce the emissions and scarce materials currently used. Because according to interviewee 2, there is currently a strong lobby from the traditional sector/companies for building with concrete and in a traditional and industrial way.

5.1.3. Case 3: HAUT

HAUT is a high-rise housing development in Amsterdam, along the Amstel. The municipality of Amsterdam put out a tender for this plot with high sustainability requirements (with the BREEAM label). This building also had to become a prominent structure. Lingotto won the tender by coming up with a design that integrated the sustainability aspects in the design. Not only with installations, but also by choosing to build the structure in wood. It was important to have an experienced architect, but also experienced advisors were needed. Therefore, Lingotto worked together with ARUP, a large international engineering firm with already some knowledge about building in wood.

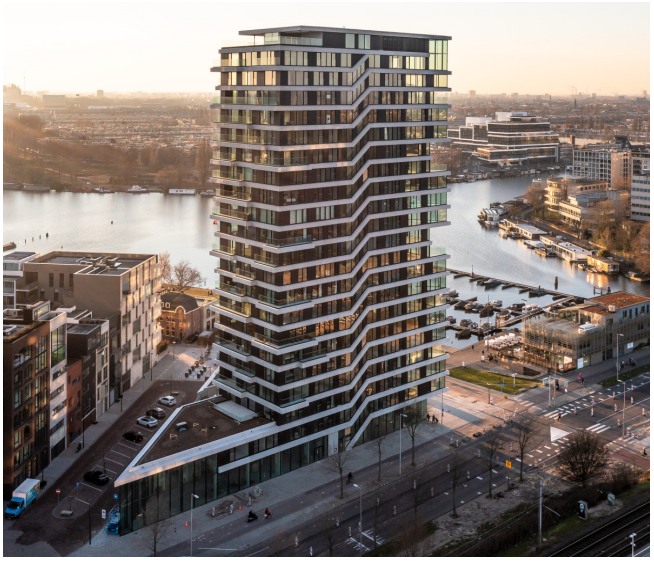

Figure 14, HAUT along the Amstel (jpvaneesteren.nl, n.d.).

With the use of wood (CLT) as a construction material, less scarce resources have been used and CO_2 is captured. Moreover, interviewee 4 noted that it makes it easier to disassemble the different elements after the lifespan of the building and the natural cycle of wood makes it circular. However, because of its height (73 m) and height and length/width (40 m by 16 m), it was not possible to only use wood. Steel elements were necessary to link the wood together and steel or concrete was needed against the wind. The plan was to use steel, however a concrete core turned out to be more CO_2 sustainable.

Lingotto managed to get the business case feasible during the project, even though they encountered a lot of extra costs. Interviewee 4 mentioned: “Well, look, we've been saved here by rising house prices. This was one of the last projects in Amsterdam that could be put on the market purely as private sector housing, and we had special homes here at a special location, which attracts a wealthy group of buyers.” To build HAUT in a circular manner with wood, the costs were higher than if chosen for a concrete & bricks building. Interviewee 4 mentioned that a calculation around 2019, 2020 and 2021, showed that it would cost around 200 - 250 euros more per square metre of gross floor area (*note: this number is time and project specific and for a housing high-rise building*).

These extra costs came from several compilations and risks such as acoustic and fire-resistant requirements, material prices, odd shape of the building plot, costs for testing and certifying the different hybrid building methods and the extra time needed for this and for getting the approval from the municipality which also results in cost for the advisors. Lingotto expected that the fire department would be an important stakeholder to be involved early on, but the extremely long procedure with the municipality was not expected according to interviewee 4.

Interviewee 4 stated on the question if it would be possible to realise this project again: “If we had put it on the market today, it would be a lot more complex, maybe impossible. I even expect impossible.” Therefore, to make these projects possible in the future, help from the municipality and/or government is needed according to interviewee 4. Interviewee 4 calls for reducing the land price to stimulate building in wood/biobased materials. Building in biobased and wood materials is more and more as an alternative by interviewee 4, but interviewee 4 believes that it will not take over the traditional way completely. The municipality/government can assist with this at the demand side, but interviewee 4 noted that it is also important for the building industry to develop together this new way of building further.

5.1.4. Case 4: Horizons

Horizons is a high-rise housing development in Amsterdam and also included a tender which was won by Ballast Nedam Development (BND). The procedure did not differ a lot compared to with a traditional project however, the municipality judged high on sustainability aspects (60-70% of the total score). The municipality measured these with the help of the MPG, BENG, MAT8 and BREEAM. Because sustainability was important and BND chose a relatively new building method, (more) advisors were acquired earlier on in the process than traditionally. This resulted in a larger design team and early contractor involvement. The municipality noted sustainability aspects as important, but kept the building method broad.

Figure 15, Horizons (horizonsamsterdam.com, n.d.).

Interviewee 5 mentioned that it was for the tender participants to decide how to get good scores on the requirement and that it soon became clear that circular materials help with this. Therefore, the structure will be mainly from wood (CLT), however interviewee 5 notes that concrete was still necessary for the parking structure, foundation and the core with the lift, therefore the wood building “stands on a concrete plateau”. BND also focused on the flexibility of the building itself in its design to change its use, as on this could be scored for the municipality requirements, and not on dismantability. There has also been looked at reuse of materials and reusable materials, however since the building has not started building yet, these numbers are not yet public.

The development process after the tender was very intensive according to interviewee 5, because it is a complex building and not a normal terraced house. Interviewee 5 also mentioned: “The principles and market conditions that we assumed at the time of the tender, when we won two years ago, are of course very different from now.” The business case is now feasible and they will start selling soon, so it is interesting to check the financial status at the next measurement moment, to see if they match the costs. Interviewee 5 stated that earlier in the process they calculated that building with wood/biobased materials was around 20% more expensive than if done traditionally. But it is not a problem if what the buyers pay matches the extra costs.

Other risks, complications and differences to a traditional project encountered in the project so far according to interviewee 5 were: acoustic, fire, water, stability and knowledge related. But, BND also checked if it would still be possible for the future users to get insurance, because it was not yet known how the insurance would work because of the biobased materials.

Regarding the future, interviewee 5 mentioned that it will probably be the future to build in a circular manner with biobased materials. However, interviewee 5 notes that modular standardisation will probably be the way to go. But concrete and steel will still be important according to interviewee 5, since the Netherlands is a “concrete country”, “It is a product that

we've optimised so much, both from a technical point of view and from a price/cost point of view." Therefore, interviewee 5 thinks that help from the government and/or municipality can definitely help with the transition. For example with the land price (if proportional to the costs), but another possibility is to stimulate it as has been done in Canada. The developments done from the government are all done in biobased/wood materials. This helped to kick start the biobased industry, by creating a large demand.

5.1.5. Case 5: SAWA

SAWA is a high-rise housing development in Rotterdam and did not start as a tender. When this project started, the municipality was still allowed to outsource one on one (under a certain limit). Therefore, Nice Developers went to the municipality of Rotterdam with an initiative to build SAWA, with what interviewee 6 called "the aim to add value to the society (shared value) and not shareholders value". Nice Developers found another developer, an investor and several advisors to help. Interviewee 6 also noted that the contractor and supplier for building in wood was very important, "So we thought, well, let's do some smart shopping, but that is not the case. In principle, there are only a few parties in the Benelux that can actually handle projects such as SAWA, and they are really busy. […] they decide for themselves which projects they use their energy and capacity for."

Figure 16, SAWA (mei-arch.eu, 2023).

The building is being made primarily from wood (CLT from Germany) to also store CO_2 and uses the 'open building principle', the columns and beams make large spaces possible. Gravel is also used instead of concrete on the floors where the pipes are. Interviewee 6 mentioned that this dry ballast can be easily reused and allows for better disassembly of the components. SAWA still uses steel in the connection nodes between the wood components and concrete in the ground floor, foundation, core and parking structure for stability of the building and for safety against possible electric car fires.

According to interviewee 6, it was very difficult to get a feasible business case, "during that period we had to deal with a huge increase in construction costs of an average of 25%. [...] For 1.5 years, it just was not possible." At the start the predicted building costs would be 22

million euros and according to interviewee 6, they ended with 34 million. Interviewee 6 mentioned that different stakeholders contributed to help. The municipality gave a (small) discount on the land price, because they found it important that the building would be made from wood. The investor was also important, they had to renegotiate the contract which resulted in the investor paying 1000 euro more per m^2 for a mid-rental apartment. But also the developers had to reduce their profit. Another new development as possible extra cash flow done in this project, is selling CO_2 storage from building in wood as credits to another party. In this case, according to interviewee 6, the ASN Bank paid 100 euros per ton of CO_2.

Other complications and differences to a concrete & bricks project had to do with extra advisors and research needed for fire safety, vibrations, acoustic, how to build in wood/circular materials and outdated building code. Interviewee 6 also notes the aversion of the contractor to innovation. But also mentioned: “That is also logical, because we only sell the land to the buyers via a purchase agreement, and the buyers enter into a building contract, [...] The construction industry will ultimately be held accountable if the building leaks, squeaks and creaks and that there is noise pollution, vibrations and things like that.”

Interviewee 6 believes that it is possible to do so again, as they acquired a lot of knowledge, but not always and not everywhere. It is also interviewee 6’s belief that this has to be the future and highlights the province of Utrecht using an internal CO_2 price of 875 euros per ton. But also notes that the government is setting the framework and that municipalities should add demands for this in their tenders, in which they can then loosen the (land) price a bit.

5.1.6. Case 6: De Nieuwe Es

De Nieuwe Es is a housing development of several low-rise houses of which four have been made with a modular biobased concept called HOUTbaar from geWOONhout. Interviewee 7 mentioned that a social housing corporation and the municipality owned the land and put out a tender, which was won by Koopmans. According to interviewee 8, in the original plan only traditional homes would be built, but in phase two of the project Koopmans pushed the developers of this project to include four of the HOUTbaar concept into the plan as a pilot project. Interviewee 7 notes that the municipality was very cooperative, as already submitted plans could be changed/supplemented.

Figure 17, HOUTbaar homes in De Nieuwe Es (houtbaar.nl, 2021).

HOUTbaar is according to interviewee 10 from geWOONhout a modular system completely from wood (LVL) with no concrete, which is made in a factory. They have several types, existing of types 4, 6 or 9 modules. Interviewee 10 notes that the homes are primarily meant for social housing or other cheap variants, and that they are also looking into modular apartments. According to interviewee 10, using LVL in these kinds of homes is better than CLT, as it saves a lot of unnecessary materials. However, for taller buildings, CLT would be the better option. Interviewee 10 noted that the factory is expanding, with the aim of reaching 8 modules a day. This will help with the production according to interviewee 10, but the price will probably not decrease immediately, as their investments have to be earned back. Currently the homes are around 25% more expensive, 10% is covered by the MIA subsidy, 10% by the corporations and 5% by geWOONhout. Interviewee 10 is expecting a CO_2 tax, which will help the biobased market and therefore believes biobased construction will (have to) be the future. But also mentioned the Dutch saying “what a farmer doesn’t know, he doesn’t eat.” If for example a MIA subsidy or interest from municipalities stops, it will be harder for this market to grow/continue in the near future, according to interviewee 10.

The business case for De Nieuwe Es worked out, the modular homes were significantly more expensive at the time (70-80%, currently around 30%), but were only a small part of the development. A reason for the extra costs according to interviewee 7 & 8 was that the municipality wanted a traditional look on the facade, therefore (expensive) clickable bricks were necessary. But also the higher price of wood and that not all buyers are willing to pay extra for biobased housing. They mentioned that social housing corporations are willing to pay a bit extra, as they have objectives imposed by the government about their CO_2 emissions.

Another risk and difference to traditional building was according to interviewee 7, 8 and 10 the planning and supply from the factory. Interviewee 10 notes that the difference with traditional construction (also from factory) is: “Traditionally, you don't build that fast. If you have a delay of a few days for example, it is usually less expensive, because then you assign the workers to other tasks for a while. [...] And when you work in a factory, you have to have a lot more material at once. You cannot assign the workers to another workstation, [...] your entire production comes to a standstill at once. [...] there's just a whole software system and a whole system built around it, so if you want to change it, it has many more consequences.”

Interviewee 7 & 8 think that for the future concrete will not be completely replaced, but that innovation for circular concrete will also improve. But also that biobased will increase in importance, as it stores CO_2 and is a renewable resource, but that (financial) impulses from the government/municipalities are needed. For example, a certain obligatory percentage of housing construction that should be biobased.

5.1.7. Case 7: Zuiver Bosrijk

Zuiver Bosrijk is a housing development consisting of 3 low building blocks. BPD won a tender put out by the municipality of Eindhoven in which building in wood/biobased materials was found very important according to interviewee 9. The municipality wanted something special for the unusual location between the trees and also wanted the parking underground.

Figure 18, Zuiver Bosrijk (nieuwbouw-bosrijk.nl, n.d.).

BPD chose to build the structure from sustainable, renewable resources: a combination of CLT, wood frame construction and bamboo, but also concrete for the parking and foundation. Interviewee 9 mentioned that CLT is stronger but more expensive, wood frame construction is better for parts with windows/openings and bamboo has a better fire safety score. The wood boards came from the south of Germany, where they were designed in BIM, then milled out and cut by a computer, after which they were transported to the building site where they were built as a building package.

Interviewee 9 notes that it was a struggle for a long time to get the project feasible, but also mentioned that the project did not consist of typical terraced homes. “We were really at 10-15% (extra costs compared to a traditional way) at first, but I think 'in the end' we managed to bring it back to about 5%.” The municipality played a significant role, as according to interviewee 9, the land price was lower compared to traditional tenders and the municipality focused more on sustainability than on price. The extra costs in this project (because the land price was low) had largely to do with the building costs, but also risks and complications related to fire safety, extra advisors to investigate several unknowns and other technical compilations played a role according to interviewee 9.

Biobased construction should be the future according to interviewee 9. Municipalities can certainly help with this, for example with the land price (“but only if it is used as a means and not as an end”). But this could depend on the municipalities, as interviewee 9 notes that it really is a ‘cash cow’ for some municipalities. Interviewee 9 also mentioned: “I do think that in the future, as a project developer, you should also be able to arrange things yourself.” As well as that this could be possible by more standardisation and ordering/making ‘building packages’.

Project	Building method	Differences (circular vs traditional)	Risks & complications	Extra building costs (circular vs traditional)*	Important parties (for success of the project)	Solution in project	Regarding the future of wood/biobased
Xylino - Almere - building phase - apartments	modular wood construction	- more expensive - strict grid - acquire technical evidence - fire safety - acoustic - user experience	- MIA regulation - uncertainty of reaction from regulatory/municipality supervisor - rising prices - knowledge	Not calculated, but it had been suggested that you should assume about 10% more	- municipality - housing - association - developer - contractor	- 1 party buys everything - less/no profit - lower land price - MIA Vamil regulation	yes, but (temporary) incentive/help from government/municipality needed, - more extensive cadaster needed - concrete and steel will still play a role - higher production needed for lower price
Swanladriehoek - Zevenhuizen - development stage - low-rise	traditional, wood and biobased construction and mix	- more different housing types - more expensive - acquire technical evidence - fire safety - acoustic - user experience - more advisors (for longer)	- market response - construction time - more consultation before decision - thickness biobased isolation - knowledge - aesthetic requirements	On average 40.000 euros more per home	- team (developer) - advisors	- less construction in wood - bamboo iso. wood - less profit - phasing	yes, but (temporary) push/help from government/municipality needed, still strong traditional push - higher production needed for lower price
HAUT - Amsterdam - finished 2022 - high-rise	hybrid construction with wood and concrete foundation & core	- more expensive - more advisors (for longer) - acquire technical evidence - long development phase - focus on sustainability aspects - acoustic - fire safety	- height of building in wood - wind & stacking wood - municipality wanting to confirm calculations themselve - rising prices - plot characteristics - knowledge	200-250 euros more per m2 gross floor area	- advisors - buyers - developer	- hybrid construction - saved by favourable market and selling in phases - only private sector housing - favourable location for wealthy buyers	yes, but (temporary) help/incentives from government/municipality needed - hybrid construction needed for high buildings - concrete and steel will still play a role - higher production needed for lower price
Horizons - Amsterdam - development stage - high-rise	hybrid construction with wood and concrete foundation & core	- focus on sustainability aspects - more advisors (for longer), larger design team, early contractor involvement - more expensive - checking the advisors - acoustic - fire safety	- market condition different compared to at tender - rising prices - general fear for water, fire, acoustic, stability - market reaction - insurance for users during exploitation - plot characteristics - knowledge	around 20% more	- advisors - contractor - design team	- hybrid construction - early involvement necessary stakeholders	yes, help from government/municipality will stimulate transition, it should be in proportion to requirements - probably modular and standardisation important - concrete and steel will still play a role - higher production needed for lower price
SAWA - Rotterdam - building phase - high-rise	hybrid construction with wood and concrete foundation & core	- municipality first wanted some proof that developer could live up to idea - more advisors (for longer), early contractor involvement - supplier selected developer - acquire technical evidence - more expensive	- knowledge - sprinklers not required, still added - 'MPG not up to date' - 2nd support structure needed - rising prices - renegotiation contracts - contractor reluctant for innovation - (in general) municipality having high requirements and wanting to earn a lot on land price	more expensive, but no precise answer on difference, average total building costs: 1750 euros per m2	- developer - investor - municipality - advisors - supplier	- hybrid construction - lower land price - new contract with investor (higher price) - passionate developer role - selling CO2 storage	yes, but (temporary) help/incentives/requirements from government/municipality needed - selling CO2 storage, using profit for sustainability - concrete and steel will still play a role
De Nieuwe Es - Hengelo - finished 2021 - low-rise	traditional and wood & biobased modular construction	- more expensive - monitoring the homes equipped with different installations - circularity advisor - convincing/showing/proving municipality - MIA regulations - more engagement with buyers	- market response - knowledge - aesthetic requirements - 'MPG not up to date' - acoustic & fire safety with apartments - rising prices - factory/production planning	for this project: 70-80% more, now around 25-30% more	- supplier/contractor - municipality - architect - developer	- spreading extra costs over traditional part of the project - more engagement with buyers and municipality - building 2nd factory (to better compete in the future) - MIA Vamil regulation	yes, but (temporary) help/incentives from government/municipality needed - aesthetic requirements possibly need to change - concrete and steel will still play a role
Zuiver Bosrijk - Eindhoven - building phase - low-rise blocks	hybrid construction with wood and concrete foundation	- more advisors (for longer) - acquire technical evidence - more expensive - focus on sustainability aspects, less on price in tender - acoustic - fire safety	- aesthetic requirements - knowledge - market response - CLT/bamboo/wood frame construction combination - stability	only CLT casco around 5-10% more, total around 10-15% more	- municipality - developer - contractor - advisors	- low land price - bamboo iso. wood - less profit - 'building package' from supplier	yes, but (temporary) help from government/municipality needed - concrete and steel will still play a role - possibly more standardisation and building packages needed

Table 9, Overview of the case studies and its findings (own work, 2023).

Table 9 shows an overview of the cases per housing developments and their findings categorised per topic. Important to note is that the extra building costs are project and time specific according to the interviewees.

5.2. Results stakeholder and expert interviews

This section presents the results from the interviews with experts and stakeholders relevant to the solutions mentioned and discovered in the case studies for discussing the future circular business case, results and the three possible monetary solutions (subsidies, discount in land price/tender and selling CO_2 credits). The different interviewees are shown in table 10. This table shows their main relevance and focus of the interview, but also the other topics were discussed in the semi-structured in-depth (expert) interviews.

Topic: / Interviewee:	(Decentralised) government aid	Selling CO_2 credits & valuing stored carbon	Biobased construction (opportunities, barriers & costs)
Built By Nature	✓	Main focus	Main focus
Klimaatverbond	Main focus	✓	✓
Province of Utrecht	Main focus	✓	✓
Climate Cleanup	✓	Main focus	✓
Biobased expert	✓	✓	✓
Graduate/developer	✓	Main focus	✓
Municipality of Amsterdam	Main focus	✓	✓
Municipality of Utrecht	Main focus	✓	✓
Triodos Bank	✓	✓	✓
Alba Concepts	✓	✓	Main focus

Table 10, Overview of interviewees and their main relevance (✓ = also discussed) (own work, 2023).

5.2.1. Interview Built By Nature

The first expert interview was with interviewee 11 from Built By Nature (BBN). BBN is a philanthropic foundation that aims at getting biobased construction to a higher level, to decarbonise the built environment and protect nature. According to interviewee 11, if the building industry constructs more in wood and by combining it with planting trees, then we try to stay within the Paris Proof targets. But this is a real change for the industry. According to interviewee 11, biobased construction has it all: flexibility, dismantability, circularity and sustainability. Also noted: “The building industry has something really interesting, on the one hand construction causes environmental problems, but construction also has the ability to solve them, to become part of the solution.”

All wood construction types should be able to exist next to each other and that you have to check for the best optimisation according to interviewee 11. For example a combination of CLT for the floors and wood frame construction for other parts of a terraced home. Mainly CLT could be more interesting for high-rise and that it still is an evolution that's not done in a day.

Interviewee 11 mentioned that the market still has to develop itself further and that there are still questions, but doesn’t see the total costs of a project and the production/supply as a large obstacle and that companies are already finding solutions. Interviewee 11 noted not to be a financial expert, but thinks that it should be possible to develop cheaper. For example by: using faster building techniques which result in less construction site costs and make it possible to receive rent earlier, not creating/inventing completely new homes every time and more standardisation. But also mentioned that it depends on the project (high-rise being more complex/costly than terraced housing).

Interviewee 11 also referred to an article which discussed scaling up biobased construction. Using more conceptual, modular and industrial construction and standardisation helps

increase the housing supply while decreasing the environmental impact (Fraanje, 2022). The link with the 'Trias Materia' was also made, which is focused on (1) use as little resources as necessary, (2) use reusable or renewable materials as much as possible, and (3) use unsustainable materials as efficiently as possible. Biobased materials suit point 2, by storing CO_2 safely for a long period of time, being renewable and better reusable by applying them in a circular manner (Fraanje, 2022).

Even though interviewee 11 doesn't see all the complications mentioned by the developers as large obstacles, interviewee 11 still believes that the three monetary solutions can help with the larger shift. Interviewee 11 mentioned: "The government can also steer CO_2 very well, [...] So that the government focuses on sustainability, if we all think sustainability is important, steer on it." A subsidy helps, but is limited, a discount in the residual land price/tender helps much more according to interviewee 11. The carbon credits is also something where interviewee 11 sees potential, "And you have that carbon storage paid for by investors who think it is important that CO_2 is stored." All these methods can bring a large capital to the industry which could also help with the housing shortage according to interviewee 11. Interviewee 11 did not mention a specific time span/duration for a credit system or discount, but was thinking of the first time the CO_2 gets captured in the material.

Interviewee 11 also noted that the CO_2 price needs to be higher. In the LCA (where also the MPG gets determined from and thus gets improved for wood/biobased materials), a ton of CO_2 is worth 50 euros, which is too low. The scientifically determined social costs by Klimaatverbond are now 875 euros. If governments start working with that, then you really have a steering tool (not a direct cash flow to support biobased) which means something according to interviewee 11. Interviewee 11 also mentioned that this should happen both on national and European level, and the government could also steer more by using the Global Warming Potential or CO_2 barometer as indicators according to interviewee 11.

5.2.2. Interview Klimaatverbond

The second interview was with Klimaatverbond Nederland (Climate Alliance Netherlands). Klimaatverbond is a national association of, for and by decentralised governments that is active in the field of climate mitigation and climate adaptation – and the intersection of both. Currently the Klimaatverbond is working in different application fields (figure 19) on CO_2 pricing. On the internal & real side, with for example funds. On the intern & fictitious side, with for example the advice to the province of Utrecht for a fair CO_2 price of 875 euros per ton in their social cost-benefit analysis and on the external & fictitious side, with for example looking into discounts in purchasing and tendering according to interviewee 12. They work less with the external & real side, which for example looks at taxes such as a EU ETS system, according to interviewee 12 this is more for the national and international context.

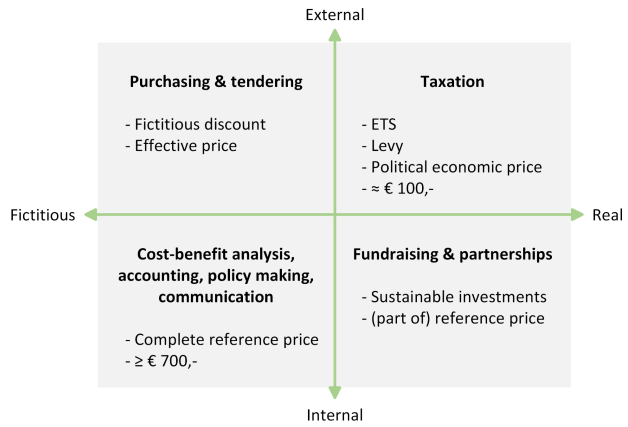

Figure 19, CO_2 pricing areas (adapted from: Klimaatverbond Nederland, 2022).

Interviewee 12 mentioned that the Klimaatverbond sees the market failure as one of the causes of the situation we are in now and that it is not only up to the market. Interviewee 12 thinks that governments can and should take a muchmore guiding and leading role in this. For example by setting up tenders differently, but also listening to and working better with the market to understand their capabilities. Fictitious discounts as part of the price for parties who have a relatively low-CO_2 offer, is seen by interviewee 12 as a solution which could work to help in the building industry. But also noted that to be able to determine if a plan has less CO_2 emissions and for determining a CO_2 price, it is necessary to know what the emissions are. Interviewee 12 was less enthusiastic about a credit system for wood, like with the EU ETS: “Because then of course all sorts of questions arise, how would you design something like that.” It could be more complicated than necessary as the previously mentioned solutions were better and more logical according to interviewee 12, who also mentioned not knowing a lot about a possible credit system for the building industry.

The Klimaatverbond came up with a price for the internal social cost-benefit analysis of the province of Utrecht, but interviewee 12 harder to say how much for example a discount in a tender or purchase should be. They have had research done for it, which concluded that it differs significantly per case and that there is therefore no straightforward answer for provinces and municipalities.

According to interviewee 12, it is easier said than done to have municipalities and other governments implementing CO_2 pricing in for example their tenders and purchases. You have to know the emissions, the limited number of employees and unwieldiness of the organisations all play a role. The Klimaatverbond keeps advocating for and informing about it and according to interviewee 12, it helps when for example a deputy makes him- or herself strong for it.

5.2.3. Interview province of Utrecht

Interviewee 13 works for the province of Utrecht and is part of a programme within the province focused on mitigating climate change. Interviewee 13 explained why they chose to adopt the internal CO_2 price of 875 euros per ton advised by Klimaatverbond Nederland (based on research by the German ministry for the environment). They concluded that the

social and environmental costs were much higher than the current usual 75 - 150 euros and that for the climate agreements from Paris, a higher price was needed.

Currently using this in their internal social cost benefit analyses is the start and interviewee 13 is convinced that implementing this in their purchasing and tendering should be done. For CO_2 pricing as well as fictitious discounts in a land price and/or tender. But that is only the final step and will take some time and might be a better tool for municipalities. Because according to interviewee 13, provinces and municipalities should and can help better with biobased construction, by stimulating but also by regulating: “I think we really need to play an active role in that. [...] We also need to have a real answer, ‘you can use this subsidy or you can use this incentive.”

Subsidies as incentive arrangements could and should also be used as another option according to interviewee 13. Interviewee 13 moreover thinks that these direct intervention/help methods are better than a credit system. The idea is okay, but it is more technical, maybe a bit greenwashing and the supply and demand aspect determining the price is not ideal.

According to interviewee 13, it is the view of (decentralised) governments to have these incentives temporarily, but notes that you should not make small sprints after which it fades away and to stay alert ofer maybe a bit longer period. Other important necessary steps to make according to interviewee 13 are, awareness within a wider range of people in governments but also combining themes so you create one face and one voice. National instruments for a price (discount), incentives, calculation methods and award criteria for CO_2 are necessary for clarity to all parties. The government, but also Klimaatverbond and experts/consultants can help with this. Lastly, interviewee 13 mentioned that the supporting ‘industry’ is also important: “You can prescribe that buildings must be built in wood in that percentage. But then it must be there, it must not be brought from China. We have to be able to provide that to a large extent ourselves.” Interviewee 13 notes the Dutch agriculture and farmers as a possibility to cultivate building ‘crops.’

5.2.4. Interview Climate Cleanup

The fourth stakeholder was interviewee 14 and works at Climate Cleanup. Climate Cleanup is an NGO focused on reversing global warming by stopping emissions and restoring excess carbon. They have already developed a calculation tool to calculate the amount of carbon stored in a wood and biobased building, and are currently working on a certification to accompany this. Interviewee 14 noted that not only calculations have to be made, but also a lot of criteria has to be developed for which they are running pilots and getting feedback with the aim to have the certification ready in March 2024.

Interviewee 14 mentioned: “We say: we do this as transition financing for construction. So we think, in hopefully 10 years, [...] is it just government policy that, for example, you can't use so much concrete or you have to store so much (carbon), you have to reuse everything, it has to be circular, etc. Until then, something has to get going now, [...] One way to do that now, is with cash flows.” This method is focused on the market and interviewee 14 also advocates/believes that the government/municipalities should contribute by guiding and steering. Interviewee 14 also applauds other possible real or fictitious cash flows as

stimulations, such as municipalities giving discounts in their land price or larger focus on sustainability and less on price in tenders and subsidies. As interviewee 14 states that these methods might be even better than a credit system.

Interviewee 14 also explained that this construction stored carbon credit system is different from the EU ETS system. Their aim is not to just stimulate wood construction by selling credits to for example Shell and BP. Therefore, they have created a framework called ONCRA (Open Natural Carbon Removal Accounting) with rules and principles to not just be a way for greenwashing and a cash flow, but also contribute to their climate goals. The framework means that it is transparent, natural, tangible and stored. Examples of rules and criteria for the buyers are:

- No fossil parties or with many fossil investments,
- Buyer is reducing its own emissions,
- Wants to compensate for its unavoidable or historic emissions.

Interviewee 14 also noted that they investigate what to include in the additionality of the certificate. For example, when the government/municipality makes a certain progress, that you receive less credits or that at a certain point when the cashflow is superfluous, the credit system stops. Interviewee 14 thinks that 10 to 20 years will do.

Interviewee 14 mentioned regarding the price, that it should go towards, or higher then, the price of 875 euro per ton CO_2, which includes the social costs. But also thinks that parties might not pay such an amount, therefore around 400 euros would probably be more reasonable. According to interviewee 14, there are many companies looking for new ways, compared to traditional emission credit systems. Which had scandals or doubts. A tangible carbon removal credit as in wood and biobased materials is a good solution to this according to interviewee 14, as it is a safe way for storage.

Regarding the future interviewee 14 noted that it is important that more requirements need to be made in module A in the LCA for the MPG about CO_2 storage and emissions reduction/reducing by the government. Which is hard because of the industrial parties with other interests. The European Commision is also important according to interviewee 14, as they are creating a new law regarding carbon removals and reduction. Which also notes the protection of European forests.

5.2.5. Interview biobased building expert

Interviewee 15 is working at the TU Delft and part of/working at several companies/institutes/foundations related to the biobased industry and sustainability, and also sees a lot of potential and advantages in wood and biobased construction. Interviewee 15 notes that all possible fictitious and real cash flows could help assist with the transition to construction with wood and biobased materials. But also explained that some incentives are better than otters according to interviewee 15. Interviewee 15 notes CO_2 pricing as a good and fair measure, as it counts for all materials, and sees this as something that could be permanent to steer more on CO_2 emissions and storage. The CO_2 price used by the province of Utrecht (875 euros per ton) is more realistic than for example the price the TU Delft is using (around 150 euros per ton). According to interviewee 15, the environmental

and social cost are way higher according to research and is therefore proponent of a higher price.

Implementing CO_2 pricing by decentralised governments in their purchasing and tendering is also something on which interviewee 15 is positive. This could be done for example through CO_2 pricing (long-term), but also by fictitious cash flows in a land price discount or shift of focus in a tender (from price, more to sustainability/CO_2) (temporary). Governments can steer and lead in this to help the transition, as interviewee 15 notes that wood material prices are still higher. Subsidies are also something which can definitely help and not hurt, but interviewee 15 sees subsidies more as something for the first threshold, which the wood industry has nearly taken, and notes that the industry should be able to do it in the end without subsidies. Interviewee 15 is also positive on selling CO_2 stored credits as a good temporary incentive. As in the method from Climate Cleanup with the ONCRA criteria, because: “Preconditions must be that you don't just continue to pollute and then buy it off. I would also reduce that at the source.”

In addition, interviewee 15 notes that the MPG must be adjusted in which CO_2 gets a larger role which helps stimulate wood and biobased materials. But also thinks that more and more investors are getting interested in buildings made with wood and biobased materials, as they are beginning to see traditional materials as a potential risk factor for their portfolio.

5.2.6. Interview graduate on CO_2 pricing / developer

The sixth interviewee was with interviewee 16, who is working as a developer at de Nijs and wrote a thesis about valuing CO_2 in the business case of developers. At the company, they are also investing and looking into biobased construction. They see the future heading in that direction, but currently one few biobased projects happen. For one of their projects, they calculated the price differences for a concrete and wood casco, wood turned out to be 6% more expensive according to interviewee 16. The CLT floors for example are more expensive than prefab concrete slab constructed floors.

Interviewee 16 mentioned that the circular economy plays a role when building with biobased materials, but “it is not the case that you immediately get an A everywhere in a project.” It starts with building in wood and next steps are looking into for example dismantability and reusing according to interviewee 16.

Regarding long-term thinking and solutions/changes to the business case, interviewee 16 noted that they are a developing builder and not an investing developer. They develop, build and then sell. What could play a role is if large investors are prepared to pay extra for the up front costs so the building could get more valuable in the future. The total cost of ownership and exit yield are then important according to interviewee 16, is the biobased home worth more for the investor at the end because it is better dismantlable and could have a higher residual value? But also mentioned that they are not an investor and can not/do not work with that long-term perspective, but do want to think along and help.

Governments can help with these developments and have a certain power according to interviewee 16, to give land price incentives for CO_2 storage. Moreover, a tool to measure the circularity is missing and the Building Circularity Index from Alba Concepts could help

with this. In addition, interviewee 16 think that CO_2 pricing will also in the end result in lower prices for biobased materials and scaling.

For CO_2 pricing, interviewee 16 notes it is important to note the different quadrants (figure 19), for example the market price and real social costs which are a lot higher, because the emissions do still damage a lot in 30 years. But it is also crucial to for example not value CO_2 storage several times so it becomes an 'obsession'.

Interviewee 16 further mentioned upscaling as an important for a future proof business case of these projects. But also immediately starting the design in wood and not start thinking in something else and later change it and sharing knowledge. Interviewee 16 also mentioned that when thinking about the long-term, you also have a transition theory to keep the business case going in the meantime, "maybe with subsidies?"

Lastly, interviewee 16 noted that it is important to keep different housing types in mind. Terraced housing is less complex with fire safety and vibrations than for high apartment buildings.

5.2.7. Interview municipality of Amsterdam

A sustainability advisor by the municipality of Amsterdam (interviewee 17) was interviewed next. Who focuses on monitoring their CO_2 and energy print and on CO_2 pricing. They recently chose to make it obligatory to make a fictitious CO_2 price for municipality investments above 1 million euros as extra information. For this they use a price of 418 euros per ton CO_2, which rises each year. According to interviewee 17, the alderman is interested to also use the same price as the province of Utrecht. In addition, CO_2 pricing could be something for even after 2050 according to interviewee 17. They are thinking of a next step to also implement this into their purchasing and tendering processes.

Interviewee 17 also mentioned that colleagues are working on pilots and looking into fictitious discounts in the land price for developments with low CO_2 emissions. But something which is already in use is the MKI (environmental cost indicator), to give fictitious discounts and also looks at other environmental effects. Interviewee 17 also mentioned: "Municipalities are not very popular as clients, so in my opinion, the more requirements we set, the more difficult it becomes to find suitable suppliers, so to speak." Moreover, interviewee 17 thinks that municipalities and the government can and must help to set out a CO_2 price and possible temporary subsidy incentives. But it is also important for different municipalities/governments to work in the same band width and not do things completely different.

Furthermore, interviewee 17 is more sceptical about a carbon credit system as EU ETS, "For example, building in wood, that you then make some kind of profit on it, and then exonerates others from not having to become more sustainable." But also because the municipality wants to focus on reduction instead of compensating.

Interviewee 17 also thinks that it is quite clear that the normal business case does not work for these circular developments, otherwise it would occur much more. As well as that the focus should be less on the short-term and more on the long perspective, for example with

developers using the total cost of ownership approach in which biobased will come out on top instead of concrete according to interviewee 17.

5.2.8. Interview municipality of Utrecht

Interviewee 18 works as a policy advisor for the municipality of Utrecht and is focused on sustainability (energy transition, circular economy, accessibility and climate adaptation). Currently they are also working on CO_2 pricing as a policy also for the built environment and are considering joining the province of Utrecht with the 875 price. But also mentioned that to reach the climate goals by 2050, an even higher price (1300 euros per ton CO_2) could be needed. Or/and that someone who pollutes should pay x euros to society and someone who stores or prevents should get x euros from society, therefore to subsidise biobased through a tax on the 'other side' (on non-sustainable/circular construction), but noted that this is very bluntly.

According to interviewee 18, they are trying and working on discounts for projects, not specifically on CO_2, but more on circularity and biobased materials. But interviewee 18 noted that "So much is piled up with ambitions, it is all pushed under the heading 'discount' on the land price, and that doesn't seem to work out." Interviewee 18 explained that the result is that the homes fall far outside the affordable categories. Therefore the discount does not work as intended and is overloaded. According to interviewee 18, it would be better to take it out of the award criteria and place it under the requirements. Then it could be that you actually receive a curtain amount per ton. One integrated tool is needed to make this practical instead of 5 different instruments. On government support interviewee 18 mentioned that it should be in a catalytic, stimulating way and not to just give money. Therefore, subsidies could also definitely help as an option for this, but an end should be kept in mind, as this is only temporary. Unless we all decide to pay extra tax to fund/stimulate this.

Interviewee 18 is more hesitant for trading carbon credits. There is potential, but the market is still not very pure and it is still on thin ice. For example, trees store CO_2 during their life and when used as construction, not when they are just taken out of the ground and not used.

The traditional business case is valid and functions according to interviewee 18, but it missed the climate and circular economy aspect. CO_2 pricing and approaches such as life cycle costing and the total cost of ownership can help to consider climate choices. Interviewee 18 mentioned that it is a matter how to add an assessment framework to the standard business case. As well as that it could be helpful to involve a party who will demolish/dismantle the building in the design phase, to help get an fictitious residual value/cash flow up front.

Lastly, interviewee 18 noted that recently published plans from the government showed their focus in the energetic side, also with subsidies. Which is good, but a significant error towards 2050 is made when we nullify all the tons in our buildings and materials. The national government can take a leading role with tools/instruments and not only "lame calculations as BENG and ENG."

5.2.9. Interview Triodos Bank

The next (ninth) interview was with interviewee 19 from the Triodos Bank, which was chosen as also a bank (ASN) was involved with the carbon trading in SAWA. Interviewee 19 finds CO_2 pricing an important and useful measure to help show how polluting the current building methods are and how much better it could be. It is also noted as a long-term tool (and not the goal) to help biobased construction.

Interviewee 19 found it difficult to answer questions about a carbon trading system and a CO_2 price, but noted that you should be careful that parties will not become too dependent on CO_2 cash flows. But a system as from Climate Cleanup, especially with the ONCRA framework, can support the transition, but should not become 'holy.' According to interviewee 19, it is crucial that governments and municipalities help and stimulate sustainable and circular construction. But also noted that the local agriculture is important for this to grow biobased resources. In addition, subsidies and fictitious/real land price discounts can help with the transition, but also mentioned: "But in the end, of course, this is not the way of working" and only temporary.

Regarding a non functioning business case, interviewee 19 thinks that it has to do with the transition and that biobased materials are undervalued. But also that it is a new way of working, which makes it now more expensive and thinks that it will in the end be cheaper. The question is according to interviewee 19, "How do you 'bite' through that and then ensure that it does not become more expensive."

A total cost of ownership and life cycle costing can help by also making the environmental impact visible. That perspective is needed, as it is also difficult to translate this into higher housing prices, as the market does not want to / can not pay that. Interviewee 19 also finds it important that more national knowledge, price, criteria, incentives sets/instruments are made, so municipalities do not have to create it all themselves which could differ among them.

Lastly, interviewee 19 mentioned that now is also a relevant and right time for working, steering and stimulating biobased construction and CO_2 pricing. Moreover noted the current agriculture discussions and the possibility for local renewable resources. According to interviewee 19, the MPG also needs to be improved, as it currently punishes biobased construction.

5.2.10. Interview Alba Concepts

The last interviewee (no. 20) was from Alba Concepts. Interviewee 20 noted of course contractors use a bit extra margin on the risks, but that that extra costs are mainly in the investment, in the direct building costs between standard concrete/sand-lime bricks, bricks & normal isolation and biobased materials. It was also mentioned that wood prices are currently rising less hard than other materials. However this does not mean that the current gap between (rising) costs and (lowering) housing prices decreases.

According to interviewee 20, construction with biobased materials fits the circular economy on the aspects of reducing climate impact and by using renewable resources from a

sustainable origin, that can also be reused. Which therefore makes it one of the important strategies to the circular transition.

Subsidies and land price discounts for biobased developments are seen as solutions by interviewee 20, but only temporarily, “But of course you would prefer to take a look at how you can get that business case done without a subsidy.” Interviewee 20 sees a carbon credit system as from Climate Cleanup also as a more long-term solution. Just as CO_2 pricing on emissions and material, but that will not be there tomorrow according to interviewee 20. Interviewee 20 believes that governments can help with the transition, but also notes: “If we wait for the government to impose stricter requirements. They will come, but that is actually more for the laggards than the frontrunners. That's also what the government always says.” Therefore, developers and investors can also make impact themselves and think about it.

Interviewee 20 also thinks that you can conclude that the traditional business case does not work for circular projects. But also notes that it is difficult for a developer, as he/she sells the product and therefore investors/housing corporations could be more interesting for this, to think more long-term and set up a different business case which connects more cash flows together and looks at the residual value. Total cost of ownership and life cycle costing approaches can help with this to make the investment side more interesting and create circular value for real estate.

Other important future steps according to interviewee 20 are, try these projects and work together with municipalities who are also interested. But also try to get the residual value on paper. In addition, the government should also improve the MPG for biobased materials and steer more on material usage criteria and dismantability with regulations. However, interviewee 20 questions if this will happen fast and sees it earlier happening in tenders. Biobased materials are therefore now more fitted to the circular economy in terms of being sustainable resources, storing CO_2 and having less environmental impact, and later probably also more in terms of dismantability and being reused according to interviewee 20.

	Land price discount/tender shift	Subsidies	Construction stored carbon credits	CO_2 pricing
Built By Nature	Positive, helps good	Neutral, helps, but is limited	Positive, sees good potential	Very important, but needs higher price
Klimaatverbond	Positive, impulse needed	Helps as additional push	Less enthusiastic, complicated	Good instrument
Province of Utrecht	Positive, tool for municipalities	Positive, not forever, but no short 'sprint'	Okay, but direct help is better	Important, good long-term tool
Climate Cleanup	Positive, best option, temporary	Positive, helps good, temporary	Positive, if well designed, temporary	Positive, needed, long-term
Biobased expert	Positive, good idea, temporary	Helps, can't hurt, temporarily	Positive, good incentive, temporary	Positive, long-term/permanent
Graduate CO_2 pricing/developer	Positive, good incentive	Positive	No clear opinion mentioned, but watch out for greenwashing	Positive, higher price needed
Municipality of Amsterdam	Positive	Positive, temporary	Sceptical, positive elements, doesn't like profit part on something which is/should be done nonetheless	Positive, long-term
Municipality of Utrecht	Notes risk of overloaded discount, but positive on temporary, catalytic function		Has potential, but is sceptical, thin ice	Positive, long-term, needs higher price
Triodos Bank	Tool to help transition, temporary	Temporary, not the future/right way of working	Positive, if done the right way, helps with transition	Positive, as a tool, not as a goal
Alba Concepts	Positive, so it can be done more, temporary	Positive, temporary, later should be done without	Positive, also interesting for the long-term	Positive, very important, long-term

Table 11, Summary of the views of the related stakeholders & experts on the solutions/adaptations found in the case studies (own work, 2023). (note: this has been derived from the interview transcripts as questions were asked about these adaptations to the interviewees, not all elements were discussed in an even amount of details with each interviewee. The views are further elaborated in the paragraphs of chapter 5.2)

During the stakeholder and expert interviews, the interviewees were asked for their view on the different adaptations and solutions found in the cases. This has been discussed in the previous paragraphs and a short overview is shown in table 11.

5.3. Conclusion

The results from the empirical research shows that the costs are indeed as described in the literature a significant barrier for circular biobased housing developments. The developers encountered higher direct building costs, which was also concluded in literature and by experts. Stakeholders and developers see the importance of biobased and believe it has an

important role for the future of the building industry. All the projects (2 have not been sold yet) were eventually financially feasible, however adaptations were found to make this happen, as was shown in table 9. The developers note that these adaptations could be solutions for the financial feasibility of these projects, to make it possible to develop with biobased materials over a wider width of all housing developments. But also to temporarily boost this construction method which could help lower the material prices as the production increases.

Moreover, it could be concluded that the stakeholders and experts relevant to the adaptations also see an important steer, lead and support role for (decentralised) governments to help with the transition. But, most of them were positive on land price discounts, more sustainability focus in tenders and subsidies. Their views were more divided on construction stored carbon credits. However, they noted that these solutions should be temporary with a catalytic function, and that the current business case is not working for the circular economy as these patch-up emergency measures are needed. They note CO_2 pricing as a more long-term tool to steer on this and mentioned the importance of a business case which is more long-term focused and which incorporates the CE better. There was also the idea to use the CO_2 pricing tax to subsidise biobased construction, to catalyse the market. They also note other adaptations not shown in table 11, such as total cost of ownership and life cycle costing approaches and better incorporating the residual value. More local production of the materials was also seen as important and a possibility to help with the Dutch farmers debate, but also more standardisation, repetitions and prefab building was noted which could help. However, how this could exactly be done or help change the business case for feasible circular biobased housing development was not known. Therefore, further research is required.

6. Conclusion

In this chapter the conclusions are drawn by answering the sub-questions and the main research question of this thesis. After that, recommendations for future research are discussed.

6.1. Conclusion literature study

The main literature study was done for answering sub-questions 1 and 2.

SQ 1: "*What does the circular economy entail, specifically within the built environment?*"

There are many definitions describing the CE and strategies for its transition. The most well-known one being from the Ellen MacArthur Foundation (2013). The definitions of the CE come in short down to an economic system that minimises waste, pollution and the use of scarce resources by using sustainable and reusable resources and keeping them in use for as long as possible. Examples of strategies for this are shown in the R-strategies and the ReSOLVE framework. These strategies are meant to help achieve the transition from a linear to a circular economy and go from 'take-make-waste' to 'design-use-recover' systems. Reports from organisations, companies, consultants and experts show that they are working on an unambiguous language, definitions and strategies for the built environment to implement the circular economy and lower its climate impact. Construction with biobased materials is seen as one of the strategies by the consultants/experts and scientific literature that fits this aim and the circular economy. Biobased materials can significantly contribute to reducing the climate impact of construction through storing carbon in a building which was captured while growing, being a renewable resource and thus not using scarce resources which also pollute more during production and use, and offering better reuse and cascading options. Therefore helping the building industry go from being part of the problem, to offering part of the solution to reduce climate impact.

SQ 2: "*How does a developer and its business case for a real estate development work?*"

Developers function as the market party for the match between local demand for space and societal challenges, and are often short-term focused with self-initiated projects with the habit to create a building and then sell it to another party. The business case differs for each project and among developers, as the amount of equity, level of risk tolerance, desired financial return and other goals/objectives differ. The most important parameters, whether to develop, are the costs and earnings in the business case, but also other interests/goals such as social, ecological and cultural factors come into play. The business case examines if a project fits within the strategy of the company and is financially feasible. It is drawn up simultaneously with the concept for a project and is kept up to date along the way. Moreover, the unclear and unfeasible financial case is one of the biggest obstacles for implementing circularity strategies in building projects. It also became clear that the business strategy of developers differs from the lifespan of a building, the investment is usually recouped earlier than the lifetime of a building. Therefore can be concluded that the circular economy and the long-term perspective for the building is currently missing in the business case.

6.2. Conclusion case studies

The aim of the case studies was to answer sub-questions 3 and 4 and to get a better understanding about the current developments and their business cases, and to identify stakeholders of the used solutions and made adaptations.

SQ 3: ***"How are biobased housing projects currently being developed?"***

Different methods are currently chosen to construct housing with biobased materials. According to the interviewees, CLT is better suited for high-rise construction, but also possible for low-rise. Modular building concepts or the use of wood frame construction is chosen for low-rise or apartments with few levels. Modular concept homes are moreover more attractive for social housing developments, as they tend to be cheaper than the alternatives and have more repetition. Bamboo was also used, often because of the better fire safety qualities than other wood materials. Apart from the modular concept homes, the high-rise and low-rise buildings still used concrete because of costs, familiar effective method, strength, fire safety and sound/vibrations. The developers realised the larger environmental impact, but noted the qualities of concrete and that it was necessary for these parts to create a sound building. It can be concluded that the analysed biobased developments primarily fit the circular economy because they used natural/renewable resources which have a much lower impact on the environment, unlike scarce resources. Strategies from the literature such as dismantability, reusability and flexibility were also mentioned in several interviews on how the projects were made circular. However, some interviewees also noted that dismantability for example was not always the aim, as this was not a criteria to score on in the tender of the municipality or because they aimed for a long lifespan for the building and did not have the intention to dismantle it in the near future. The emissions and kind of materials were therefore more focused upon to reduce climate impact and score in the tender.

Another connection with the literature can be made with the values and reasons to choose for a circular strategy. One of them, found in most cases, was management commitment and motivation from the developers and clients to use biobased materials, as biobased construction was often not a specific requirement by the municipality. Anticipating the market shift can also be confirmed as another similarity with the literature, developers see biobased construction becoming important in the near future and want to learn more about it. In addition, clients and other parties with certain objectives regarding their CO_2 budget or sustainability, such as the social housing corporations and municipalities, were also found important for choosing biobased materials. Furthermore, the projects are built with feasible business cases, but several solutions/adaptations were found to make this happen (shown in table 12). Parties such as municipalities, investors, contractors, advisors and developers themselves together with their (design)teams were found to have an important role in the feasibility and possibility of the investigated housing developments.

Project: → / Monetary aid: ↓	Xylino	Swanladrie hoek	HAUT	Horizons	SAWA	De Nieuwe Es	Zuiver Bosrijk
Lower land price	yes	no	no	no	yes	no	yes
Investor/ buyer paid more	yes	not sold yet	yes	not sold yet	yes	not discussed in interview	yes
Cut in (own) profit	yes	not sold yet	yes	not sold yet	yes	yes	yes
Other	MIA subsidy	not all homes biobased	-	-	sold construction stored carbon credits	not all homes biobased & MIA subsidy	-

Table 12, Overview of financial 'solutions'/adaptations in business cases (own work, 2023).

SQ 4: *"What is the influence of these implementations on the business case?"*

The reason why the changes and solutions in the business case were needed, was because the implementation of biobased materials as a circular strategy influenced the financial feasibility of the business case negatively. The cases show that monetary help was needed for the projects to be developed. Developers noted that this was necessary, as the upfront investment costs were higher than when using traditional/standard materials such as concrete and bricks. This was shown in higher material and construction costs, and because more expenses were made for advisors, research and explanations to buyers and proof for municipalities. Once parties have gained more experience with biobased construction, cost for advisors and research for the building code will reduce. These obstacles correlate with findings in the literature study, this showed that the financial aspect is a barrier in the business case for implementing circular strategies and research also concluded that the direct building costs for circular biobased construction are higher. The different adaptations found to this were: (1) a lower land price / discount on the land price from the municipality for the project, or more focus on sustainability and less on price in the tender (as they also found the building method important). (2) Investors paying extra than first agreed or compared to a project without biobased materials. Or paying for construction stored carbon credits. (3) Reduce profit margins of developers and other involved stakeholders. (4) Using a subsidy (MIA Vamil). (5) Mixed construction, not building all homes in the project with biobased materials. The circular implementation also influenced and limited the supplier and contractor options, especially for the more difficult higher buildings, which also resulted in higher costs. Also other construction differences and complications such as fire safety, detailing and vibrations were mentioned. However, obtained knowledge about these will help with future projects. Therefore, several parties were important as mentioned in the previous paragraph.

A stakeholder which reoccurs several times, is the municipality because they determine the land price and have the power to allow adjustments, and allow for changes to be made with an already submitted plan. The contractor and supplier were also mentioned as important,

as their knowledge was also seen by the developers as crucial and not always already available in the team. The advisors were also more important and used than traditionally according to the interviewees. The investors and buyers were also mentioned by several interviewees. For example with SAWA, where the investor agreed to pay a significant additional amount per m^2 and where the ASN Bank bought carbon credits. Several interviewees also noted themselves or their team as important. For example with Xilino, where the parties and developer wouldn't profit much or probably anything at all. But interviewees also mentioned that they found the project and new way of building important, even though it resulted in less profit than traditionally. Their dedication and eagerness for wanting to make a wood and biobased project possible was also mentioned by several interviewees, which also applied to the stakeholders they worked with.

Moreover, from the case studies and interviews with developers it can be concluded that the traditional business case does not work for the biobased implementations and is not fitted for the circular economy. The influence of the implementation results in developers needing to use emergency measures and patch-ups for the business case to counter the extra costs and be financially feasible. According to the developers, help is needed to boost the transition and get it scaled up in the near future with the identified real and fictitious cash flows: (1) subsidies (as for example the MIA Vamil regulation), (2) a lower land price or less focus on the price and more on sustainability requirements in a tender by municipalities and (3) selling construction stored carbon credits. Developers and experts also noted that the building methods need to change and that more standardisation, repetition and prefabricated elements/building packages can help with lower costs. They also thought that the real and fictitious cash flows could help with the upscaling of the biobased industry which will lead to an increase in production and supply and lower the costs after which the measures are less/not needed anymore. Therefore, currently biobased is getting more and more seen as an alternative, but because of the higher costs, not yet possible on a large scale.

6.3. Conclusion stakeholder interviews

Sub-question 5 aimed at discussing the identified adaptations/solutions with its stakeholders and experts. To understand their view and opinion on them and for possible other future proof adaptations.

SQ 5: "*To what extent are the changes made in the business case a solution?*"

The previous paragraph noted the changes made in the biobased developments to make them feasible, and that the developers mentioned that these help with the transition and the financial barrier. But also that this means that the traditional business case is not suited for circular strategies, as 'aid cash flows' are needed. From the interviews with stakeholders and experts linked to these cash flows (shown in table 11) can be concluded that they do not all have the same view on all the possibilities, and also note other measures. Overall, they were positive on (decentralised) governments helping the market by leading, steering and supporting the transition. For example with a lower land price for biobased construction and subsidies. But also by CO_2 pricing to 'punish' building methods with larger environmental impacts. The opinions were most divided on construction stored carbon credits, some interviewees saw more/better potential in direct governmental aid with real/fictitious cash flows, others did see potential but noted the importance of a well designed system against

greenwashing and other ‘frauds’. These measures could function as an enabler for economic value creation as described in the literature study to choose for this circular strategy. Most stakeholders and experts saw the opportunities/solutions as something for the short-term, to boost and help with the transition, but all agreed that CO_2 pricing was something for the long-term. Literature concluded that for CO_2 pricing to be of real influence and to translate in the actual cost of CO_2 emissions, a higher price is needed than currently often used. This was also mentioned in the interviews, as well as that the MPG needs to be updated for biobased materials. Stakeholders and experts also saw the traditional business case not working for the circular economy as these temporary solutions and emergency measures are needed, and came up with other possibilities not mentioned by the developers. Some interviewees mentioned more future thinking with approaches such as the total cost of ownership and life cycle costing as possibilities to help with this in the business case of developers and to better be able to include the climate impact. So it could also be possible to involve the residual value better with fictitious cash flows in the beginning. It was also noted that this could be (more) interesting for investors, as developers often sell the homes. Therefore, the found adaptations are not a future proof business case solution, as they are patch-ups. However, how the other approaches noted by stakeholders and experts could help/turn out exactly was not mentioned/known.

6.4. Main research question

Now all sub-questions of the subs-studies have been answered, it is possible to turn to the main research question of this thesis.

MRQ: “*How are business cases adapted in order to create financially feasible and circular biobased housing developments?*”

Based on the findings of this research in the three sub-studies (literature review, case studies and stakeholder & expert interviews) and the answers on the sub-questions can be concluded that the business cases themselves were currently not drastically changed to fit the circular strategy. It was concluded that biobased construction as a circular strategy fits the circular economy, but several differences and complications came along with choosing to build housing with biobased materials. The extra costs were the most significant one as a barrier and limitations for the wider necessary transition. Adaptations in the business case for biobased housing developments were temporary patch-up measures to make the project possible and financially feasible, these were: less profit for the parties involved, investors paying extra, selling construction stored carbon credits, lower the land price or more focus on sustainability and less focus on price by municipality, using subsidies and building only partly with biobased materials and partly in a more traditional/standard manner with concrete and bricks. Future real or fictitious cash flows such as subsidies, construction stored carbon credits, land price discounts/shift from price to sustainability requirements in tenders, and also using a CO_2 pricing tax to subsidies biobased construction definitely help the financial feasibility of the business case for biobased housing, because the costs and yields are an important prerequisite in a business case. They allow the projects to happen and could boost the transition, despite the current higher (rising) direct building costs and lowering housing prices. However, they are not the solution in a healthy circular business case. These solutions are still emergency measures and patch-ups to the business case of circular biobased housing developments. Therefore, the traditional business case is not suited for

circular construction, otherwise the patch-ups would not be needed and it could be done more standard with more projects. This is not the case and also contributes to why the larger circular shift stays out.

Developers are willing to limit and work on their environmental impact, and stakeholders of the used solutions are also open and working on ways to help with real and fictitious temporary cash flows for the transition. But the views differ, while developers see opportunities with the fictitious and real cash flows to support biobased and boost production and supply to help lower the prices. Stakeholders and experts note that also changes need to be made to the business case and/or building methods to allow for the circular economy and long-term focus to be incorporated with for example approaches such as the total cost of ownership and life cycle costing, as it does not work in the traditional business case. This shows a gap between their views, therefore an answer for the problem is not simple. Moreover, not only changes to the current business case of developers are needed, but also adaptations in the building methods, such as more conceptual, modular and industrial construction and standardisation could help the financial feasibility of biobased housing. In addition, the long-term thinking approaches and better being able to incorporate the residual value are also relevant for investors to value these projects more. Therefore, the changes should be done/help in the input and/or output of the business case for circular biobased housing developments. Either it has to become cheaper in the business case to construct or the proceeds need to be higher to cover the extra costs.

In addition, not all the temporary solutions are in the short-term available on a larger scale to immediately boost the wider necessary transition. Municipalities are working on internal and external CO_2 pricing and discounts for biobased/sustainable developments, but wider (decentralised) government support could take some time. Moreover, national sets and instruments are needed for this. For the near future it is currently expected that the certificate of Climate Cleanup for construction stored carbon credits will be finished around March 2024.

To conclude, the business cases were currently not drastically changed and the found adaptations are more emergency and patch-up measures. Even though the adaptations could help as a catalyst in the transition, they do not make a solid healthy business case. Subsidies and other temporary incentives are a finite process, something you can not build a future business case on. Therefore, other adaptations are necessary, but further research is necessary to investigate how, if and to what extent possible discovered adaptations in the business case and building methods help lift circular biobased housing to the necessary level.

7. Discussion

This chapter includes the discussions, research limitations and recommendations for future research and for practice.

7.1. Discussion

This research for this thesis has shown that the circular economy is upcoming in the building industry, there is a paradigm shift in the building industry. Not only researchers but also developers, clients and other stakeholders are realising that changes have to be made to reduce climate impact. This thesis' focus was on biobased as circular strategy. Although it is a paradigm shift in materials used in the building industry, the CE is a sub part of the wider economy (focused on material usage). The current economic model is still aimed at perpetual growth. This thesis started with the aim to investigate how circular biobased housing development could be made financially feasible, but this turned out to be even more complex than first anticipated. The focus shifted to investigating and understanding differences and complications of current business cases of these projects compared to more traditional/standard concrete and brick projects.

The results show the urgency and problems with the immediate wider transition to circular biobased housing. It is concluded that this is not possible within the current business case and values, because the costs are higher but there are no direct advantages for the owner/user, except for the broader societal impact. Therefore, except from his/her ethical values cannot or will not pay more money. This shows that something has to change, but the ideas about this differ. Developers believed that the temporary solutions could help scale up the biobased industry and help lower the prices, by now making it more attractive and possible for more housing developments. Stakeholders noted that these are only temporary measures, and that the business case themselves should also be adapted to better incorporate the circular economy and sustainability with a more long-term perspective and approaches such as the total cost of ownership and life cycle costing.

However, discussions with a developer made clear that they have questions with long-term ownership and thinking, and do not believe in total cost of ownership and life cycle costing approaches. It was noted that the aim of (developing) investors is more on the yields and compared to 'normal' developers, have less room for sustainability. But also that keeping buildings in their ownership limits their budget to develop significantly and that others are coming up with these ideas, without calculating them through. In addition, it was noted that the residual value at the end of the building's lifespan is small. Moreover, giving a commitment for something which only happens over ± several decades is difficult. This was also discussed with another graduation student, who investigated how to quantify circular values for the point of view of investors (Zwueste, 2023). She noted approaches such as the TCO and LCC not working for developers in the current economic system, as this makes it too hard to be competitive in the market with other investors and shares. The market does not accept a different time frame.

Therefore, the changes should be done/help in the input and/or output of the business case for circular biobased housing developments. Either it has to become cheaper in the business

case to construct or the proceeds need to be higher to cover the extra costs. Zwueste (2023) suggests for investors to change the calculation of the exit yield after an initial investment period with a time horizon of 10 years. Now 1 year is used in the exit yield, and the suggestion is to change this to 10 years. This helps include capital expenditures in the calculation, making circular developments more valuable. This could help on the output side. For the input this research suggests for the future to investigate and invest more in the production, supply and building methods (conceptual, modular and industrial construction and more standardisation) for circular biobased housing developments. However, more research is needed to build on the findings of this thesis to help with the transition to a circular economy and reduce the climate impact of the building industry.

7.2. Limitations

The first limitations of this research has to do with the restricted amount of time. All planned methods have been carried out, but a more extensive literature study for example, could lead to new findings and reasons for additional interviews with other people. The time also restricted some data of certain projects, not all developments were already built and sold. Therefore, those projects missed some data about the proceeds, market reaction and final financial feasibility.

The second limitation has to do with the stakeholder interviews. The plan was to also interview someone from the ASN Bank, who was involved with the construction stored carbon credits in the SAWA project. However, this turned out not to be possible. Therefore someone from the Triodos Bank was interviewed, but this interviewee did not have the same knowledge/insights about SAWA. Moreover, it could have been beneficial to also have interviewed other investors, to discuss findings, adaptations and their views. This had not been done as it did not fit the research timeline.

Another limitation was with the case studies, the internship helped significantly with connections to the interviewees and with scoping the research, but might also have restricted the information gathered in the case studies. It would have been interesting to receive more precise data on the business case of the circular biobased housing developments, in terms of actual numbers/costs for example. However, this data could be seen as sensitive and a secret for other competing developers. The literature as well as stakeholder interviews, helped gain more knowledge about this.

This research was also limited to use of qualitative research methods and focused on biobased housing developments. In practice, other circular strategies for housing and biobased construction for other building types such as offices could also help reduce climate impact of the built environment. This research did not investigate which strategy is necessary to what extent, but did conclude that immediate significant action is required and that biobased housing developments can contribute to this.

The last limitation could have to do with the investigated cases and interviewed developers, stakeholders and experts. Views differed on adaptations and solutions, but all interviewees were positive about biobased construction. No interviewees were spoken who were negative about biobased materials, therefore this perspective is not present in this thesis.

7.3. Recommendations

During the research for this thesis, several recommendations for future research and for practice were mentioned during the interviews with developers and stakeholders, or identified during the analysis. These are described in this paragraph.

7.3.1. Recommendations for future research

This research focused on looking into the current business case of biobased housing developments and into the adaptations/solutions found in these projects. But future research should also look closer into this business case and with approaches such as the total cost of ownership and life cycle costing as possible options for developers and investors to fit the circular economy strategies better. To investigate how and if these can indeed help with this, have a limited impact or not at all work for the building industry and other changes might be needed. In addition could be investigated if and how the found temporary solutions could be useful in the transition while not making the business cases dependent on them.

As currently more biobased housing developments are realised, it could be interesting to investigate the experience of the residents. How is their comfort in these homes, for example compared to living in a home with normal concrete and bricks or do they have negative experiences?

Other recommendations are to investigate how and what biobased materials can be grown more locally. But also how these can be used in more innovative building methods such as conceptual, modular and industrial construction and more standardisation in housing. Lastly could be investigated if and how investors could value circular biobased housing differently, so values change/increase.

7.3.2. Recommendations for practice

For practice it is recommended to further investigate and invest in innovative circular biobased building materials to help reduce the costs in the long-term. Therefore taking a more involved role in the setup at the front of the process, and working together with Dutch agriculture. To take a role to supply and produce local biobased materials and implement this in the business cases on a longer timeframe.

Furthermore, should be looked more into innovative building methods like conceptual, modular and industrial construction and more standardisation. Just as with geWOONhout and the prefab construction method of Zuiver Bosrijk and other projects. To also invest in this on a long-term perspective to reduce costs.

Lasty, the temporary measures such earnings from construction stored carbon credits should not only be used for current circular biobased projects, but also to help the investments and make shift stick in the future business cases to realise this on the necessary scale.

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Appendix

Appendix A: Data plan

0. ADMINISTRATIVE QUESTIONS

1. Name of data management support staff consulted during the preparation of this plan.

My faculty data steward, Diana Popa, has reviewed this DMP on 25-01-2023.

2. Date of consultation with support staff.

25-01-2023

I. DATA DESCRIPTION AND COLLECTION OR RE-USE OF EXISTING DATA

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Qualitative interview recordings	.mp3 / .mp4	By recording the interviews with a recording device, either online (Microsoft Teams) or offline (smartphone). Recording devices are encrypted, password protected and files will be deleted once transcripted and transferred to safe storage.	To enable the researcher to make transcripts and listen back to analyse the data	TUDelft Project Data Storage	Project team: Arthur Knibbe Supervisor TU Delft: Hilde Remøy Supervisor internship: Maaike Perenboom
Qualitative interview transcripts	.docx	By writing a transcript of the interview after the interview has been done, with the help of the recording	To allow the researcher to code the transcripts in certain software to analyse the data	TUDelft Project Data Storage	Project team: Arthur Knibbe Supervisor TU Delft: Hilde Remøy Supervisor internship: Maaike Perenboom
Qualitative interview transcripts anonymized	.docx	By writing a transcript of the interview after the interview has been done, with the help of the recording, but this version is made anonymous	This is the same data as the in the previous row, but it's made anonymous, this way it's possible to share this data	TUDelft Project Data Storage	Project team: Arthur Knibbe Supervisor TU Delft: Hilde Remøy Supervisor internship: Maaike Perenboom

Qualitative interview analysis	Atlas TI output: .pdf / xlsx / jpeg / png / other	By collecting, grouping, ordering and coding the results from all the interviews in Atlas TI (analysing the transcripts)	To allow the researcher to draw conclusions from the data to answer the research questions	TUDelft Project Data Storage	Project team: Arthur Knibbe Supervisor TU Delft: Hilde Remøy Supervisor internship: Maaike Perenboom
Qualitative case study documents	.pdf / .docx / .xlsx / jpeg / png / other	By collecting relevant data at the internship company	To enable the researcher to search for the information to answer the research questions	TUDelft Project Data Storage	Project team: Arthur Knibbe Supervisor TU Delft: Hilde Remøy Supervisor internship: Maaike Perenboom
Qualitative case study analysis	.docx / .xlsx / jpeg / png / other	By collecting, grouping, ordering and coding the results from the case study documents	To allow the researcher to draw conclusions from the data to answer the research questions	TUDelft Project Data Storage	Project team: Arthur Knibbe Supervisor TU Delft: Hilde Remøy Supervisor internship: Maaike Perenboom
Master thesis end document	.pdf	End result of the research, with anonymized data	To share the results of the research	repository.tudelft.nl	public access

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. DOCUMENTATION AND DATA QUALITY

5. What documentation will accompany data?

- Methodology of data collection

III. STORAGE AND BACKUP DURING RESEARCH PROCESS

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- Another storage system - please explain below, including provided security measures
- OneDrive
- Project Storage at TU Delft

The data will be stored in the Project Storage at the TU Delft, working documents will be stored in OneDrive and on my laptop. When finished they are moved to the Project Storage at the TU Delft. But

also the personal hard drive (laptop) will be used for working documents. The security measure for the personal hard drive: encrypted, password protected and with no automatic cloud backup.

IV. LEGAL AND ETHICAL REQUIREMENTS, CODES OF CONDUCT

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

- Yes

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

- Yes, data related to competitive advantage (e.g. patent, IP)
- Yes, confidential data received from commercial, or other external partners

Data that could lead to this / could contain, could come from the interviews and case studies. For example when discussing a companies (financial) strategy or financial calculations. It could occur that the interviewee or company in question, wants this out of the interview transcript or only for me to understand the situation/context. Therefore, this data could come from the interviews (in transcripts), but also from the case studies (in documents).

9. How will ownership of the data and intellectual property rights to the data be managed?

During the research, the data won't be openly accessible for the public. Only to the project team and the supervisors. The intellectual property rights of the internship company won't be shared to the public. Only the final master thesis report with the anonymized data and conclusions will be available in the TU Delft repository. The data will be safely stored as shown in the table in point 3.

10. Which personal data will you process? Tick all that apply

- Data collected in Informed Consent form (names and email addresses)
- Signed consent forms
- Photographs, video materials, performance appraisals or student results
- Access or identification details, such as personnel number, student number
- Email addresses and/or other addresses for digital communication
- Names and addresses

11. Please list the categories of data subjects

Employees of the internship company. Business case stakeholders (other real estate developers, experts, (decentralised) governments, NGO's, foundations, organisations, investors).

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

All study participants will be asked for their written consent for taking part in the study and for data processing before the start of the interview. Moreover will this consent form ask for the permission to record the interview.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Personal research data will be destroyed after the end of the research project

23. How long will (pseudonymised) personal data be stored for?

- Other - please state the duration and explain the rationale below

Personal data will be destroyed at the end of the research project. Pseudonymised results used in the master thesis document, will be stored in the TU Delft repository, according to its policy.

24. What is the purpose of sharing personal data?

- No personal data will be shared

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

In the consent will be explained how the data will be used and its purpose. Participants can withdraw at any moment from the study. This can be done freely and without consequences. Their data will be destroyed and not used or shared.

V. DATA SHARING AND LONG-TERM PRESERVATION

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- No other data can be publicly shared - please explain below why data cannot be publicly shared

No data will be publicly shared separately, only the data used in the final master thesis report. This data will be anonymized.

29. How will you share research data (and code), including the one mentioned in question 22?

- No data can be publicly shared - please explain below

The master thesis report (which makes use of the (anonymized data) will be uploaded to the TU Delft repository.

31. When will the data (or code) be shared?

- At the end of the research project

VI. DATA MANAGEMENT RESPONSIBILITIES AND RESOURCES

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

The TU Delft is the leading institution in this project in collaboration with the internship company.

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

My supervisor will be responsible for the data: Hilde Remøy (h.t.remoy@tudelft.nl)

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

The TU Delft repository is able to archive the master thesis free of charge for all TU Delft graduates. Moreover, the project team will make sure the data is managed correctly during the research.

Appendix B: Informed consent form

Geachte heer/mevrouw,

Verschillende studies tonen aan dat het afval en de emissies die ontstaan in de bouwsector significant zijn. Er heerst momenteel een lineaire economie met het principe ‘take-make-waste’ die er ook voor zorgt dat de schaarste van materialen toeneemt. De circulaire economie wordt gezien als een oplossing voor deze problemen. Door het (onder)houden van materiaal en componenten in continue lussen en het tegengaan van afval en uitstoot van schadelijke stoffen. Hierbij hoort het principe ‘design-use-recover’. Een van de circulaire methodes die momenteel toegepast wordt in enkele woningbouwprojecten is het gebruik van biobased materialen. Het zijn hernieuwbare grondstoffen, slaan CO_2 op en kunnen makkelijker worden hergebruikt.

Echter is het voor veel projectontwikkelaars nog lastig om de circulaire bouwprojecten financieel rond te krijgen. Daarom richt mijn onderzoek zich op de businesscase van circulaire bouwprojecten. Bij de circulaire economie komt namelijk ook het behouden van de economische levensvatbaarheid aan bod. Voor mijn onderzoek kijk ik naar enkele circulaire woningbouwprojecten die al uitgevoerd zijn, nog in aanbouw zijn of nog worden ontwikkeld, om te onderzoeken of en hoe het daar wél gelukt is om tot bouwen te komen. Het onderzoek wordt uitgevoerd door Arthur Knibbe, afstudeerstagiair bij Synchroon en afstudeerstudent Management in the Built Environment, een Mastertrack binnen de MSc Architecture, Urbanism and Building Sciences aan de TU Delft.

Het interview wordt gedaan door Arthur Knibbe. Het interview duurt ca. 30-60 minuten. Graag zou ik het interview willen opnemen om het achteraf uit te kunnen werken. De opname wordt uitsluitend gebruikt voor de analyse van het interview middels het maken van een transcriptie. Vanuit de universiteit (TU Delft) wordt geacht om nog eens apart te vragen of u mee wilt doen aan het onderzoek en of u het goed vindt om dit interview op te nemen. U mag ook nu zeggen dat u liever niet meedoet. U kunt u ook later nog bedenken en uw deelname intrekken zonder opgave van reden. U mag iedere vraag die gesteld wordt weigeren te beantwoorden.

Als u meedoet, dan vraag ik u om uw handtekening onderaan deze brief te zetten en een **pdf** aan mij te **retourneren**. Ook mijn handtekening staat onderaan, zodat u zeker weet dat er vertrouwelijk omgegaan wordt met uw gegevens en antwoorden. De resultaten worden geanonimiseerd, als uw woorden worden aangehaald, dan zal het niet duidelijk zijn wie dit gezegd kan hebben. Uw naam- en contactgegevens worden meteen in de interview transcriptie geanonimiseerd. Verder wordt de data die uw gegevens bevatten, aan het eind van het onderzoek vernietigd.

Als u vragen heeft over dit onderzoek, kunt u contact opnemen met: Arthur Knibbe (telefoon ……, email ……). Ook kunt u contact opnemen met mijn stagebegeleidster: Maaike Perenboom (email ……).

Als u mee wilt doen aan dit interview, zou u dan de onderstaande verklaring kunnen invullen, ondertekenen en retourneren?

Met vriendelijke groet,

Arthur Knibbe

In te vullen door de geïnterviewde & de interviewer

Ik verklaar op een voor mij duidelijke wijze te zijn ingelicht over de aard, methode, doel en belasting van het onderzoek. En mijn vragen zijn naar tevredenheid beantwoord.

Ik begrijp dat het geluids- en/of beeldmateriaal (of de bewerking daarvan) en de overige verzamelde gegevens uitsluitend voor de analyse, de presentatie en publicaties van het afstudeeronderzoek zullen worden gebruikt.

Ik behoud me daarbij het recht voor om op elk moment zonder opgaaf van redenen mijn deelname aan dit onderzoek te beëindigen.

Ik heb dit formulier gelezen of het formulier is mij voorgelezen en ik stem in met deelname aan het onderzoek.

Aangeven als van toepassing (om deze reden verleen ik toestemming om mijn naam- en contactgegevens tot het eind van het onderzoek te bewaren):

_____Graag ontvang ik de interview transcriptie als deze gemaakt is.

_____Graag geef ik zelf eerst goedkeuring op de transcriptie, voor het gebruikt wordt in de analyse.

_____Graag ontvang ik het onderzoeksresultaat aan het einde van het onderzoek.

Plaats:

Datum:

_____

(Volledige naam, in blokletters)

_____

(Handtekening deelnemer)

‘Ik heb toelichting gegeven op het onderzoek. Ik verklaar mij bereid nog opkomende vragen over het onderzoek naar vermogen te beantwoorden.’

[locatie & datum interviewer]

[naam interviewer]

[handtekening interviewer]

Appendix C: Interview protocol developers

It is important to note that this is a general interview protocol for the case studies with developers and that the interviews were semi-structured in depth interviews. Therefore, the questions were not limited to the ones shown in this protocol. It also differed slightly for example for a finished project or if it had not been sold yet.

Interview protocol

Cases: circulaire biobased woningbouwprojecten
Interviewer: Arthur Knibbe
Afstudeeronderzoek master track Management in the Built Environment binnen de MSc Architecture, Urbanism and Building Sciences aan de TU Delft. Samen met een afstudeerstage bij Synchroon.

Dit interview protocol is opgesteld ter ondersteuning van de interviews die voor dit onderzoek zullen worden afgenomen. Het onderzoek wordt uitgevoerd om te begrijpen hoe en of circulaire business cases voor woningbouwprojecten financieel haalbaar kunnen worden gemaakt. Daarom worden enkele case studies uitgevoerd met behulp van semi-gestructureerde interviews die gericht zijn op beschrijven van al uitgevoerde of in aanbouw van circulaire woningbouwprojecten. Met als doel om te onderzoeken hoe die tot bouwen zijn gebracht, of het financieel rond gekregen is en zo ja, op welke manier en met welke stakeholders.

Dit interview protocol leidt de onderzoeker door het interview, onder meer door een gedetailleerd script voor het openen en sluiten van het interview, gebaseerd op tips van Jacob & Furgerson (2012). Andere tips die gegeven worden zijn gebaseerd op de volgorde van de vragen. Het is echter belangrijk om tijdens het interview open te staan voor eventuele spontane aanpassingen aan de vragen als men denkt dat dit de redenering van het antwoord op de onderzoeksvraag zou ondersteunen.

Voor het begin van de interviews, moet ervoor gezorgd worden dat de technologie volledig werkt en dat alles klaar staat voor gebruik. Enkele zaken om rekening mee te houden zijn:

- Zorg ervoor dat het gebruiksprogramma werkt (Teams, Zoom, etc.), doe een testgesprek,
- Test of hoe de functies voor het opnemen en transcriberen van het interview in het gebruikersprogramma werken,
- Zorg ervoor dat ook een tweede apparaat klaar ligt om het interview op te nemen (bijvoorbeeld een telefoon),
- Zorg ervoor dat de opname en data veilig opgeslagen kunnen worden na het interview (TU Delft Project Data Storage),
- Zet de transcribeer optie in de juiste taal (Nederlands)
- Zoek een rustige omgeving op (geen afleiding, achtergrondlawaai, enz.)
- Houd een oplader in de buurt
- Houd een back-up vergadering klaar voor gebruik wanneer het programma niet goed werkt

Het tweede element van dit protocol zijn de openings- en sluitings scripts. Door het openen en sluiten kan de interviewer de relevante informatie over het onderzoek en de details van de geïnformeerde toestemming delen. Het script is als volgt:

Opening interview:
“Voordat ik begin, wil ik u nogmaals vragen om uw toestemming om dit interview op te nemen en of u officieel deel wilt nemen aan dit interview. De informatie die u in dit interview verstrekt, wordt alleen gebruikt voor mijn onderzoek zoals net beschreven. [*reactie afwachten ja/nee*].

Dan zal ik vanaf nu het gesprek opnemen. Welkom '*naam deelnemer*' fijn dat u deel kan en wilt nemen aan dit interview en mijn onderzoek. Ik ben Arthur Knibbe en doe onderzoek voor het afstuderen van de mastertrack Management in the Built Environment aan de TU Delft, naar de businesscase van circulaire woningbouwprojecten. Mijn focus ligt op biobased projecten en of dat op grotere schaal door projectontwikkelaars gerealiseerd kan worden, daarvoor kijk ik eerst naar voorbeeldprojecten om daar te onderzoeken wat knelpunten waren en hoe het daar gelukt is om tot bouwen te komen. Dan is het nu tijd voor de eerste vraag."

Sluiting interview:
"Dat was de laatste vraag. Ik wil u nogmaals hartelijk bedanken voor uw tijd. Dit interview helpt erg met mijn onderzoek. Mocht u op dit moment geen vragen meer hebben, wil ik dit interview zo afsluiten. Mocht u zich later nog bedenken of vragen hebben, mail of bel mij dan gerust. Wilt u de interview transcriptie nog ontvangen om te lezen of te corrigeren, voordat ik het ga analyseren? [*reactie afwachten ja/nee*]. En/of wilt u het eindresultaat van mijn onderzoek ontvangen? [*reactie afwachten ja/nee*]. Dank nogmaals voor uw deelname en fijne dag nog."

Na de opening van het interview volgens het protocol worden onderstaande interviewvragen aan de geïnterviewde gesteld. Volgens Jacob & Furgerson (2012) is het belangrijk om te beginnen met basisvragen over iemands achtergrond. Dit helpt om vertrouwen op te bouwen en ervoor te zorgen dat de deelnemer zich meer op zijn gemak voelt bij het interview. Daarna worden de vragen gesteld die relevant zijn voor het onderzoek. De vragen zijn gerangschikt van minst moeilijk tot moeilijk te beantwoorden. Dit helpt ook om het vertrouwen bij de geïnterviewden op te bouwen en te voorkomen dat deelnemers zich terugtrekken (Jacobs & Furgerson, 2012).

Interview vragen:

Vraag 1: Zou u uzelf kort voor kunnen stellen met uw achtergrond binnen (bedrijfsnaam)?

Vraag 2: Zou u kort kunnen omschrijven hoe het project en de verhoudingen met de andere partijen (gemeente, beleggers, kopers, aannemers etc.) in het project in elkaar zitten.
→ Hoe zijn het project en de verhoudingen tot stand gekomen?
→ Hoe verhouden deze zich tot een 'traditioneel' project?

Vraag 3: In hoeverre bent u bekend met de circulaire economie wat betreft de bouwindustrie?

Vraag 4: Hoe is het project circulair gemaakt? Ik las dat het (korte omschrijving van bouwmethode volgens gelezen (online) documenten) gebouwd gaat worden, is het project nog op meer manieren circulair?
→ Waarom is er voor deze circulaire manier gekozen?

Vraag 5: Hoe circulair is het project? Hebben jullie daar kwantitatieve data over en berekeningen voor gemaakt? (MPG, percentages biobased/herbruikbaar/los-maakbaarheid etc.)

Vraag 6: Is het gelukt om de business case zowel vooraf aan de bouw van het project als bij de oplevering financieel rond te krijgen?

Vraag 6B (als antwoord op 4 **'nee'** is)**:** Wat heeft ervoor gezorgd dat dit niet gelukt is?
→ Was dit ook in de 'traditionele' situatie gebeurd?

Vraag 7: Waren er partijen cruciaal om dit voor elkaar te krijgen?

→ Zo ja welke?
→ En op welke manier?

Vraag 8: Kunt u aangeven wat de omvang ongeveer is van de kosten vergeleken met als het project traditioneel was uitgevoerd?
(Was het duurder/goedkoper?, aan welk(e) percentage/getallen moet ik denken?)

Vraag 9: Aangezien circulair bouwen relatief nieuw is, komen er andere risico's bij kijken tijdens het project vergeleken met een 'traditioneel' project?
→ Zo ja, hoe is daar mee omgegaan?

Vraag 10: Kunt u uw ervaring met vergelijkbare projecten omschrijven, of bent u nog niet veel met circulaire woningbouwprojecten betrokken geweest?

Vraag 11: Zijn er (nog andere) (grote) verschillen in de business case van een traditioneel en een circulair woningbouwproject?
→ Wat kwam er bij het project nog meer kijken, wat niet bij een 'traditioneel' project aanbod was gekomen?

Vraag 12: Als ik u nu precies hetzelfde budget zou geven als beschikbaar was voor het project, zou u het dan nog een keer kunnen uitvoeren in de huidige markt/situatie?
(Of alleen onder bepaalde voorwaarden van ook andere partijen?)
→ Wat zou er moeten veranderen in de toekomst om het wel te laten lukken als dit niet het geval is?

Vraag 13: Denkt u dat houtbouw en andere biobased materialen de toekomst zouden kunnen zijn in de bouwsector?
→ Of ziet u een andere circulaire bouwstrategie als meer succesvol?
→ Zo ja, welke?
→ Of is daar volgens u nog meer hulp bij nodig?
→ Zo ja, op welke manier?

Afsluitende vraag: Heeft u zelf nog toevoegingen naar aanleiding van de antwoorden die u hebt gegeven, of ben ik misschien iets belangrijks vergeten?

Het is belangrijk dat de onderzoekers deze vragen tijdens het interview vrij kunnen aanpassen of nieuwe vragen kunnen toevoegen. De duur van dit interview moet echter rond de 30-60 minuten blijven, en niet veel langer (aangezien dit vooraf is afgesproken). Wanneer de interviewer het gevoel heeft dat de deelnemers te lang antwoorden, moet men overwegen om naar de volgende vraag te gaan.

Na het interview dient de onderzoeker de transcripties van het interview te controleren op juistheid en waar nodig aan te passen. Aangezien het verslag van dit onderzoek bovendien geanonimiseerd is (zoals vermeld in het toestemmingsformulier), zullen de geïnterviewden ook geanonimiseerd zijn. De volgende stappen zullen zijn om deze transcripties te analyseren en te vergelijken met behulp van de software Atlas TI.

Bronnenlijst
Jacob, S. A., & Furgerson, S. P. (2012). Writing Interview Protocols and Conducting Interviews: Tips for Students New to the Field of Qualitative Research. The Qualitative Report, 17(2), 1-10.

Appendix D: Interview protocol stakeholders & experts

It is important to note that this is a general interview protocol for the stakeholder interviews and that the interviews were semi-structured in depth interviews. Therefore, the questions were not limited to the ones shown in this protocol. Most questions/subjects were discussed with all interviewees, but it also differed slightly for each stakeholder, because some knew more about topic A and others more about topic B. The protocol below includes the prepared questions for three different stakeholders: Alba Concepts, Climate Clean up and the municipality of Utrecht.

Interview protocol

Interviews met stakeholders (experts, adviesbureaus, overheden etc.)
Interviewer: Arthur Knibbe
Afstudeeronderzoek master track Management in the Built Environment binnen de MSc Architecture, Urbanisme and Building Sciences, aan de TU Delft. Samen met een afstudeerstage bij Synchroon.

Dit interview protocol is opgesteld ter ondersteuning van de interviews die voor dit onderzoek zullen worden afgenomen. Het onderzoek wordt uitgevoerd om te begrijpen hoe en of circulaire business cases voor woningbouwprojecten financieel haalbaar kunnen worden gemaakt. Daarom worden enkele case studies uitgevoerd met behulp van semi-gestructureerde interviews die gericht zijn op beschrijven van al uitgevoerde of in aanbouw van circulaire woningbouwprojecten. Met als doel om te onderzoeken hoe die tot bouwen zijn gebracht, of het financieel rond gekregen is en zo ja, op welke manier en met welke stakeholders. Dit interview richt zich op het spiegelen van de resultaten uit de interviews met projectontwikkelaars met andere stakeholders, zoals experts, adviesbureaus, overheden etc. Met als doel om te onderzoeken hoe zij tegen de genoemde belemmeringen en mogelijke oplossingen aankijken.

Dit interview protocol leidt de onderzoeker door het interview, onder meer door een gedetailleerd script voor het openen en sluiten van het interview, gebaseerd op tips van Jacob & Furgerson (2012). Andere tips die gegeven worden zijn gebaseerd op de volgorde van de vragen. Het is echter belangrijk om tijdens het interview open te staan voor eventuele spontane aanpassingen aan de vragen als men denkt dat dit de redenering van het antwoord op de onderzoeksvraag zou ondersteunen.

Voor het begin van de interviews, moet ervoor gezorgd worden dat de technologie volledig werkt en dat alles klaar staat voor gebruik. Enkele zaken om rekening mee te houden zijn:

- Zorg ervoor dat het gebruiksprogramma werkt (Teams, Zoom, etc.), doe een testgesprek,
- Test of hoe de functies voor het opnemen en transcriberen van het interview in het gebruikersprogramma werken,
- Zorg ervoor dat ook een tweede apparaat klaar ligt om het interview op te nemen (bijvoorbeeld een telefoon),
- Zorg ervoor dat de opname en data veilig opgeslagen kunnen worden na het interview (TU Delft Project Data Storage),
- Zet de transcribeer optie in de juiste taal (Nederlands)
- Zoek een rustige omgeving op (geen afleiding, achtergrondlawaai, enz.)
- Houd een oplader in de buurt
- Houd een back-up vergadering klaar voor gebruik wanneer het programma niet goed werkt

Het tweede element van dit protocol zijn de openings- en sluitings scripts. Door het openen en sluiten kan de interviewer de relevante informatie over het onderzoek en de details van de geïnformeerde toestemming delen. Het script is als volgt:

Opening interview:
“Voordat ik begin, wil ik u nogmaals vragen om uw toestemming om dit interview op te nemen en of u officieel deel wilt nemen aan dit interview. De informatie die u in dit interview verstrekt, wordt alleen gebruikt voor mijn onderzoek zoals net beschreven. [*reactie afwachten ja/nee*].
Dan zal ik vanaf nu het gesprek opnemen. Welkom ‘*naam deelnemer*’ fijn dat u deel kan en wilt nemen aan dit interview en mijn onderzoek. Ik ben Arthur Knibbe en doe onderzoek voor het afstuderen van de master track Management in the Built Environment aan de TU Delft, naar de businesscase van circulaire woningbouwprojecten. Mijn focus ligt op biobased en houtbouw projecten en of dat op een grotere schaal door projectontwikkelaars gerealiseerd kan worden, daarvoor heb ik eerst naar enkele voorbeeldprojecten gekeken om daar te onderzoeken wat knelpunten waren, hoe het daar gelukt is om tot bouwen te komen, welke partijen daarvoor belangrijk waren en wat zij als oplossingen zien om dit een impuls te geven en aantrekkelijker te maken voor de toekomst. Mijn vervolgstap is de bevindingen uit deze interviews te bespreken met experts van bijvoorbeeld adviesbureaus en ook met gemeenten of overheden, over hoe zij tegen die complicaties aankijken, maar ook over hoe zij over de genoemde oplossingen denken of zelf nog andere mogelijkheden zien. Daarom ben ik erg blij met uw deelname aan dit interview. Dan is het nu tijd voor de eerste vraag.”

Sluiting interview:
“Dat was de laatste vraag. Ik wil u nogmaals hartelijk bedanken voor uw tijd. Dit interview helpt erg met mijn onderzoek. Mocht u op dit moment geen vragen meer hebben, wil ik dit interview zo afsluiten. Mocht u zich later nog bedenken of vragen hebben, mail of bel mij dan gerust. Wilt u de interview transcriptie nog ontvangen om te lezen of te corrigeren, voordat ik het ga analyseren? [*reactie afwachten ja/nee*]. En/of wilt u het eindresultaat van mijn onderzoek ontvangen? [*reactie afwachten ja/nee*]. Dank nogmaals voor uw deelname en fijne dag nog.”

Na de opening van het interview volgens het protocol worden onderstaande interviewvragen aan de geïnterviewde gesteld. Volgens Jacob & Furgerson (2012) is het belangrijk om te beginnen met basisvragen over iemands achtergrond. Dit helpt om vertrouwen op te bouwen en ervoor te zorgen dat de deelnemer zich meer op zijn gemak voelt bij het interview. Daarna worden de vragen gesteld die relevant zijn voor het onderzoek. De vragen zijn gerangschikt van minst moeilijk tot moeilijk te beantwoorden. Dit helpt ook om het vertrouwen bij de geïnterviewden op te bouwen en te voorkomen dat deelnemers zich terugtrekken (Jacobs & Furgerson, 2012).

Interview vragen Alba Concepts:

Vraag 1: Zou u uzelf kort voor kunnen stellen met uw achtergrond binnen (bedrijfsnaam)?

Vraag 2: Ik heb al meerdere mensen gesproken die mooie kansen zien bij woningbouw om dat in houtbouw of met biobased materialen uit te voeren. Daarmee gebruik je natuurlijke grondstoffen die makkelijker hergebruikt kunnen worden dan bijvoorbeeld beton, minder uitstoot hebben tijdens de verwerking, tijdens de productie zelfs CO2 opneemt en dat ook nog voor een langere tijd kunnen opslaan in een gebouw. Hiermee zou de bouw mogelijk als deel van het probleem naar de oplossing kunnen. Uit mijn interviews met projectontwikkelaars bleek dat ze momenteel nog wel hogere kosten ondervinden met dit soort projecten, nu las ik ook in jullie City Deal rapport (Onderzoek naar Circulaire grond- en vastgoedexploitatie) dat dat iets is dat jullie ook ondervonden. Kunt u daar iets meer over vertellen, waar die extra kosten dan precies in zitten?

Vraag 3: Hoe past volgens jullie hout en andere biobased materialen binnen de circulaire economie?
- Wat maakt het circulair?

- Of is het alleen een verkooppraatje bij dit soort projecten?

Vraag 4: Uit de projecten die ik onderzocht heb en wat ontwikkelaars aangeven, is dat ze graag hulp krijgen bij het rondmaken van hun business case met bijvoorbeeld subsidies, een lagere grondprijs, focus op duurzaamheid en minder op prijs in een tender of bijvoorbeeld met het verhandelen van construction stored carbon credits. Hoe kijken jullie hier naar?
- Zien jullie dit als oplossingen voor de langere termijn of alleen als korte oplossing?

Vraag 5: Hoe denkt u dat CO2 beprijzen een rol speelt bij dit soort projecten? Ik kan me voorstellen dat daarmee andere opties duurder worden, maar het bouwen met hout niet meteen goedkoper?
- Is dit iets voor de langere termijn?
- Door vragen…

Vraag 6: Vindt en/of denkt u dat overheden kunnen en/of moeten helpen met het aantrekkelijker maken van een duurzame en circulaire manier van bouwen door hier een leidende rol in te nemen en dat er dus momenteel bijvoorbeeld sprake is van marktfalen, of dat dit alleen tijdelijke oplossingen zijn en het meer aan de markt om dit op te lossen?

Vraag 7: Zou je kunnen concluderen dat de traditionele business case niet werkt voor dit soort circulaire projecten, aangezien ze dus fictieve en reële hulp geldstromen nodig hebben om dit op een grotere schaal toe te passen?

Vraag 8: Uit jullie onderzoek, maar ook van andere adviesbureaus, blijkt dat het duurder is, wat ook de ontwikkelaars dus aangeven. Maar hoe kijken jullie naar de toekomstige business case van dit soort circulaire woningbouwprojecten met hout en andere biobased materialen?
- Waar zitten / wat zijn oplossingen?

Vraag 9: Wat denkt u dat er verder nodig is voor een business case die wel toekomstbestendig is? Zou een ontwikkelaar dan juist bijvoorbeeld meer zelf op de langere termijn moeten denken en dus de standaard business case moeten wijzigen?
- Dat ze bijvoorbeeld meer werken met een total cost of ownership, LCC benadering?
- Hebben jullie een idee hoe dat dan moet?
- Welke (andere) partijen zijn belangrijk?

Afsluitende vraag: Heeft u zelf nog toevoegingen naar aanleiding van de antwoorden die u hebt gegeven, of ben ik misschien iets belangrijks vergeten?

Interview vragen Climate Cleanup:

Vraag 1: Zou u uzelf kort voor kunnen stellen met uw achtergrond binnen (bedrijfsnaam)?

Vraag 2: Ik sprak vorige week (contactpersoon Built By Nature) en hij/zij ziet mooie kansen bij woningbouw om dat in houtbouw of met biobased materialen uit te voeren. Daarmee gebruik je natuurlijke grondstoffen die makkelijker hergebruikt kunnen worden dan bijvoorbeeld beton, minder uitstoot hebben tijdens de verwerking, tijdens de productie zelfs CO2 opneemt en dat ook nog voor een langere tijd kunnen opslaan in een gebouw. Hij/zij noemde al dat hiermee de bouw als deel van het probleem naar de oplossing kan. Uit mijn interviews met projectontwikkelaars bleek dat ze momenteel nog wel hogere kosten ondervinden met dit soort projecten en denken dat mogelijke fictieve of reële geldstromen kunnen helpen met het aantrekkelijker maken en een impuls kunnen geven aan deze nieuwe bouwmethode. Hoe kijkt u hier naar?

Vraag 3: Vindt en/of denkt u dat overheden kunnen en/of moeten helpen met het aantrekkelijker maken van een duurzame en circulaire manier van bouwen door hier een leidende rol in te nemen en dat er dus momenteel bijvoorbeeld sprake is van marktfalen, of is het meer aan de markt om dit op te lossen?

Vraag 4: Zou u misschien iets kunnen vertellen over hoe het zo ver is gekomen om bij SAWA gebruik te maken van construction stored carbon credits, die vervolgens gekocht zijn door de ASN Bank voor ongeveer 100 euro per ton CO2?

- Hoe is het tot stand gekomen?

Vraag 5: Uit eerder interviews met ontwikkelaars kwamen drie mogelijke geldstromen naar voren, waarvan ik net al begon over een daarvan, namelijk het verhandelen van CO2-opslag in hout. Hoe kijkt u hiernaar, denkt u dat dit een mogelijkheid zou kunnen worden zoals bijvoorbeeld het EU ETS systeem? Of ziet u het meer voor u dat een ontwikkelaar dan bijvoorbeeld zelf een partij moet zoeken die hier aan mee wilt werken?

Vraag 6: De prijs van een ton CO2 bij het ETS systeem ligt momenteel net boven de 100 euro, ik begreep dat de ASN Bank zo'n 100 euro heeft betaald per credit. Momenteel gebruikt de provincie Utrecht een prijs van 875 euro per ton CO2, dat volgens het Klimaatverbond een eerlijke prijs is. Hoe kijkt u aan tegen dat verschil?

Vraag 7: De provincie Utrecht gebruikt momenteel een CO2 prijs van 875 euro per ton in hun MKBA's, hoe kijkt u er naar om CO2 ook zwaarder mee te laten nemen in bijvoorbeeld inkoop en aanbesteding van gemeenten en provincies als tweede mogelijke geldstroom, bijvoorbeeld met een fictieve korting in de grondprijs of met meer focus of duurzaamheidseisen en minder op de prijs in een tender?

Vraag 8: Als derde mogelijke geldstroom voor dit soort projecten, kwamen subsidies of regelingen zoals de MIA / Vamil regeling naar voren, om dit soort projecten te helpen. Hoe kijkt u hier tegen aan?

Vraag 9: Zouden dit soort externe fictieve/reële kortingen, subsidies en een credits systeem, voor een onbepaalde of bepaalde tijd moeten duren? Om het dus alleen tijdelijk aantrekkelijker te maken en te boosten of voor een langere tijd te helpen?

- Zijn er nog andere belangrijke voorwaarden of dingen waar rekening mee gehouden moet worden?
- En is CO2 beprijzen dan meer voor de langere termijn?

Vraag 10: Wat is er verder belangrijk of nodig om bijvoorbeeld het verhandelen van CO2 credits mogelijk te maken, of dat overheden CO2 zwaarder gaan meewegen in hun inkoop en aanbestedingen / tenders en mogelijke fictieve kortingen geven? Of om dichter bij een CO2 opslag handelssysteem te komen voor hout en biobased materialen?

- Zijn daar nog bepaalde partijen belangrijk voor?

Afsluitende vraag: Heeft u zelf nog toevoegingen naar aanleiding van de antwoorden die u hebt gegeven, of ben ik misschien iets belangrijks vergeten?

Interview vragen gemeente Utrecht:

Vraag 1: Zou u uzelf kort voor kunnen stellen met uw achtergrond binnen (bedrijfsnaam)?

Vraag 2: Is de gemeente Utrecht momenteel al bezig met het beprijzen van CO2 in inkoop en/of aanbesteding?

- Denkt u dat CO2 beprijzen wel iets is dat zich verder gaat ontwikkelen en dan niet alleen intern maar ook bij externe aanbesteding bij gemeenten?
- Verder sprak ik vanochtend iemand van de gemeente Amsterdam en daar hebben ze de mogelijkheid, die niet verplicht is, om 418 euro per ton CO2 te hanteren voor dit jaar en die dan vervolgens elk jaar oploopt. Momenteel gebruikt de provincie Utrecht al 875 euro per ton CO2, op aanraden van het Klimaatverbond dat zich mede baseert op Duits onderzoek. Kunt u iets zeggen over dat verschil?

Vraag 3: Ik sprak laatst (naam) van Built By Nature, een expert op het gebied van biobased en circulair bouwen, maar ook andere mensen, en die zien mooie kansen bij woningbouw om dat in houtbouw of met biobased materialen uit te voeren. Daarmee gebruik je natuurlijke grondstoffen die makkelijker hergebruikt kan worden dan bijvoorbeeld beton, minder uitstoot hebben tijdens de verwerken, tijdens de productie zelfs CO2 opneemt en dat ook nog voor een langere tijd kunnen opslaan in een gebouw. Uit mijn interviews met projectontwikkelaars bleek dat ze momenteel nog wel hogere kosten ondervinden met dit soort projecten en denken dat mogelijke fictieve of reële geldstromen kunnen helpen met het aantrekkelijker maken en een impuls kunnen geven aan deze nieuwe bouwmethode. Hoe kijken jullie er naar om CO2 ook zwaarder mee te laten nemen in jullie inkoop en aanbesteding? Bijvoorbeeld met een fictieve korting in de grondprijs of met meer focus op duurzaamheidseisen en minder op de prijs in een tender?

Vraag 4: Momenteel worden ook voor sommige projecten, met name dan voor sociale huurwoningen, bijvoorbeeld een subsidie gebruikt zoals de MIA Vamil regeling, om daar een beetje tegemoet te komen qua kosten. Zijn subsidies ook misschien iets waar jullie als gemeente van denken: dat zouden we ook kunnen inzetten om dit soort projecten op een bredere schaal aantrekkelijk te kunnen laten maken?

Vraag 5: Vindt en/of denkt u dat overheden kunnen en/of moeten helpen met het aantrekkelijker maken van een duurzame en circulaire manier van bouwen door hier een leidende rol in te nemen en dat er dus momenteel bijvoorbeeld sprake is van marktfalen, of dat dit alleen tijdelijke oplossingen zijn en het meer aan de markt om dit op te lossen?

Vraag 6: Een derde mogelijke geldstroom voor ontwikkelaars zou bijvoorbeeld een verhandelbaar creditsysteem voor CO2-opslag in hout/biobased materialen kunnen zijn, zoals het EU ETS systeem. Wat vind u van dit idee?

Vraag 7: Zouden dit soort geldstromen, zoals de externe kortingen, subsidies en een creditsysteem, voor een onbepaalde of bepaalde tijd moeten duren? Om het dus alleen tijdelijk aantrekkelijker te maken en te boosten of voor een langere tijd te helpen? En dan misschien CO2 beprijzen wel voor de langere termijn?

- Zijn er nog andere belangrijke voorwaarden of dingen waar rekening mee gehouden moet worden?
- Wat is er verder nog nodig om hier stappen in te zetten? Nationale sets aan instrumenten, voor gunningscriteria, CO2 prijzen, kortingen etc.

Vraag 8: Hoe kijkt u dus naar de business case voor dit soort circulaire woningbouwprojecten met biobased materialen? Zou je kunnen concluderen dat de traditionele business case niet werkt voor dit soort circulaire projecten, aangezien ze dus fictieve en reële hulp geldstromen nodig hebben om dit op een grotere schaal toe te passen?

Vraag 9: Wat denkt u dat er verder nodig is om stappen te zetten naar een business case die wel toekomstbestendig is? Zou een ontwikkelaar dan juist bijvoorbeeld meer zelf op de langere termijn moeten denken en dus de standaard business case moeten wijzigen?

- Dat ze bijvoorbeeld meer werken met een total cost of ownership benadering?
- Hebben jullie een idee hoe dat dan moet?
- Welke partijen zijn belangrijk?

Afsluitende vraag: Heeft u zelf nog toevoegingen naar aanleiding van de antwoorden die u hebt gegeven, of ben ik misschien iets belangrijks vergeten?

Het is belangrijk dat de onderzoekers deze vragen tijdens het interview vrij kunnen aanpassen of nieuwe vragen kunnen toevoegen. De duur van dit interview moet echter rond de 30-60 minuten blijven, en niet veel langer (aangezien dit vooraf is afgesproken). Wanneer de interviewer het gevoel heeft dat de deelnemers te lang antwoorden, moet men overwegen om naar de volgende vraag te gaan.

Na het interview dient de onderzoeker de transcripties van het interview te controleren op juistheid en waar nodig aan te passen. Aangezien het verslag van dit onderzoek bovendien geanonimiseerd is (zoals vermeld in het toestemmingsformulier), zullen de geïnterviewden ook geanonimiseerd zijn. De volgende stappen zullen zijn om deze transcripties te analyseren en te vergelijken met behulp van de software Atlas TI.

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Appendix E: Personal study targets

This appendix includes my personal study targets made at the beginning of my graduation process.

For me personally I have several study targets during my thesis. First of all I would like to get more knowledge about the subject, as it is a relevant and important topic for future developments. The discussion about climate change is getting louder and louder and I believe that the built environment can play a key role in this. Another objective is to build connections in practice with developers and to learn more from the practical side during an internship. This can be useful for after my graduation, because you get to know more people in the area I might want to work in and they get to know you. But I am also very interested in this topic, because I am curious about the answers of my main- and sub-questions. In addition, an important reason for writing this thesis is the aim to graduate from the master track Management in the Built Environment at Delft University of Technology.

Appendix F: Reflection

This appendix includes the reflection on my research results, design and process of this thesis.

Personal reflection on the process and outcome

It was not easy to find a relevant and interesting graduation topic I wanted to investigate for my thesis. My interests were with the circular economy, but I had difficulties making the subject concrete. Especially around the P1, my topic was not certain and not concrete enough. Literature, my graduation supervisor and supervisors from the university helped me with finalising my topic and making it concrete. After my P2 I received useful feedback which resulted in me changing my research questions and methods to be more critical and make it more scientific. Moreover, I struggled with the aims of the graduation company and the objectives of the university. As I first had the idea to investigate how the business case could be made financially feasible. The scientific and critical perspective was missing in this setup. After the P3, I also realised that I had to look from a different perspective to my preliminary results. Feedback from the P4 helped make the conclusion and discussion of my thesis go a step further. The cohesion was missing a bit in the conclusion, and the discussion could use improvements, and ideas about future directions/solutions.

Something I could have done better but find difficult is probably more often checking with others, students and supervisors, about my methods and progress to receive feedback on possible changes/improvements. I now see similarities with the design courses during my bachelor's. During these courses I also wanted to make my design and then show the end results and not only small unfinished parts, but it is better to discuss it along the way and improve it. This is probably also one of the reasons why I preferred exam courses or where you handed in a document in the end, instead of the design courses. This shows an area to improve myself.

Changes made after the P2 helped with the setup of the research, but if I could have done something differently, then I would have maybe also interviewed experts and/or advisors before the interviews with the developers. That could maybe have helped to ask them even better questions. Discussions with another graduation student helped understand the perspective of investors, and made me realise that this perspective and their knowledge is missing a bit in my stakeholder interviews. But as the time was limited, investor interviews could have been possible if for example 1 less case study was done, and for example if 1 municipality instead of 2 was interviewed.

Relation between graduation project and master programme

The management part of the MBE master track is related to the management of development projects and between the actors involved with business cases. If this process changes and becomes more circular focused, other aspects of the master programme such as the architects will also be challenged to learn more about the new way of working/designing. In practice, the knowledge of the different aspects of the broad MSc AUB master programme needs to be combined to get a good final project and working industry. Therefore, a transition towards biobased housing influences different stakeholders from different backgrounds with the broader building industry in which collaboration is crucial.

Relation between research, design and recommendations

The research started with a literature study which formed the basis of the thesis. This helped determine the scope and made it possible to reflect and compare findings from the empirical research. The literature helped gain insights into the CE, strategies and barriers for the building industry, this was used in the case studies and interviews. Recommendations for research and practice were made after analysing the results and making conclusions. These are made based on the research, and help go further in depth on certain aspects, but also wider in different related areas. There were also recommendations for the research process in this thesis, which came from my supervisors and helped to make it more critical and scientific. But also helped during the beginning of the research with the setup of the topic, and with improvements and feedback for the final part of the process.

Approach and methods

The approach was a bit bumpy, as described earlier, I did not immediately have a concrete topic in mind with the right research questions. It could have been useful to have spoken to more people in practice about the subject earlier on, but other courses also required time and energy. The chosen methodology however, worked well in my opinion. The qualitative methods of case studies and semi-structured interviews allowed for investigating the topic within, but not limited to a certain framework of questions as it is a relevant and developing/new topic. Moreover, the literature study formed a useful framework for the empirical research. The internship at a developer helped me well with making the subject more concrete, making connections to interviewees, and giving feedback on the report, but might also have steered me without realising for (wanting) certain conclusions when analysing the results. The P3 helped me notice this.

Interviewing different developers from different projects and companies helped gather a view on their current opinions of the situation and the future. This helped me learn about ways how the developers made the business case feasible, which gave me a better understanding of which stakeholders and experts needed to be interviewed next to discuss these found solutions. But also to check and verify if they were good or bad solutions or if the other stakeholder thought that the market themselves could or should solve it. This is also how I translated feedback from my mentors in my method, not just developments from 1 developer, but check if the problem occurs elsewhere and talk with relevant stakeholders, how they think about the answers/problems/solutions form the developers.

Although there is still room for improvements, I also learned to be more critical during interviews with the stakeholders. As well as how to reach interviewees, which sometimes can be difficult. But also speaking to different parties allowed me to better understand the different views which helps to be more aware of them during other interviews. Therefore I do think that the approach worked, but only with the changes made after the P2 and P3. After the P3 I realised that I had to change my conclusion, as something became clear from my results which I first did not see as a conclusion of my research.

Values and implications

This graduation project has value on different fronts. This thesis not only helps inform and bring more attention to the climate crisis, but also shows and informs about a circular strategy for the building industry to reduce its environmental impact. This research furthermore helps explore and discuss current practice and barriers from the perspective of

developers, in addition to views of stakeholder and experts relevant to the made adaptations. Furthermore, recommendations for further research and for practice are given. Thus, the results are relevant to academics, practice and society, because climate change has an effect on all of us, and more research is needed to help with the transition.

The ethical aspect went quite well during my empirical research. First, the interview protocol was tested and discussed together with the informed consent form, with the first interviewee of the internship company. This interviewee gave feedback for improvements and ethical aspects. An issue occurred that not all interviewees returned the informed consent form before the interview, therefore I also always informed them about the research context and aim, asked them in the interviews if it was ok if I recorded the interview, if they wanted the transcript and if they wanted to approve it. Moreover did I have the responsibility as researcher to inform them about this and use the (personal) data as intended and keep it safe.

Project results and transferability

By interviewing several different developers the results from those interviews could give a clear and well representation. Also several stakeholders have been interviewed, but not several of the same type. That is also something which could not be possible in all cases, as there is only one Klimaatverbond for example. For the housing developments, several different types of projects were investigated, but one has to be careful with generalisation of the outcome. Especially since building costs and housing prices are project, time, and location specific. The process and research methods have been explained in this report, which makes it possible to do again or add to this research. Furthermore, the appendix includes the informed consent form and interview protocols, which make it also more transferable.

Appendix G: Advice report

This appendix contains the short advice report as the main deliverable of this thesis.

Advice report

On

The circular business case

Exploring the role of the business case in creating financially feasible and circular biobased housing developments

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Recap

The construction industry has a significant environmental impact, consumes a large amount of scarce resources, generates a lot of waste and causes a lot of emissions such as CO_2, which contribute to global warming and are all reasons of great concern. A significant portion of these negative environmental impacts are caused by the building sector and attendant linear construction process. Developments with biobased materials as a circular strategy help encounter this. Real estate developers are seen as a crucial party to initiate the circular economy, because of their connection and role between supply and demand. However, this implementation is still lacking in the building industry and the linear to a circular economy transition is still in the early stages. Moreover, real estate developers are struggling to make their business cases for circular projects financially feasible, as the extra costs for implementing circular strategies in housing developments are a significant barrier. Immediate action is required to stop global warming. Therefore, the research in the thesis focused on investigating and understanding how current circular biobased business cases are adapted and if they are future proof or use temporary measures. With the aim to go from the linear economy to a circular economy with not only a few experimental housing developments, but in the full width, which uses less scarce resources and produces less harmful emissions to reduce climate impact. This short advice report is the main deliverable for the research done for this thesis and entails a short description about the research methods, the main findings and recommendations. For a more detailed insight into the methods, literature, findings, conclusion and the references, it is advised to also read the thesis report.

Methodology

The main research question used in the thesis to contribute to this research was: *How are business cases adapted in order to create financially feasible and circular biobased housing developments?*

To answer this question, several sub-questions were investigated. This was done with a literature study to examine the current knowledge about the topic, with case studies investigating recent biobased development projects, and by interviewing developers, (indirect) stakeholders and experts. These methods were used in the qualitative exploratory research with the aim to understand if and how the current business cases allowed to include the circular economy via biobased construction, and if complications occurred in the business case for these projects and how the business case dealt with it. To understand if these are solutions for the future or if the traditional business case needs to change and to come up with advice for the developers on the business case of circular biobased housing developments. The objective of this research was therefore to contribute to the wider necessary shift from a linear to a circular economy in the building industry to reduce its environmental impact.

Findings

Biobased as circular strategy

First of all, it was concluded that construction with biobased materials is seen as one of the strategies by the consultants/experts and scientific literature that fits this aim and the circular

economy. Biobased materials can significantly contribute to reducing the climate impact of construction through storing carbon in a building, being a renewable resource and thus not using scarce resources and offering better reuse and cascading options. Therefore helping the building industry go from being part of the problem, to offering part of the solution. The case studies showed that the analysed biobased developments primarily fit the circular economy investigated in the literature study because of the use of natural/renewable resources which have a much lower impact on the environment and store CO_2, unlike when using scarce resources. Strategies from the literature such as dismantability, reusability and flexibility were also mentioned in several interviews on how the projects were made circular. However, some interviewees also noted that dismantability for example was not always the aim, as this was not a criteria to score on in tenders by the municipality or because they aimed for a long lifespan for the building. The emissions and kind of materials were therefore more focused upon.

Building methods

The case studies show that currently different methods are chosen to construct housing in wood or with other biobased materials. According to the interviewees, for high-rise, CLT is the better option, but it is also possible for low-rise housing. Modular building concepts or the use of wood frame construction was chosen for low-rise or apartments with few levels in the social housing sector. This option tends to be cheaper than the alternatives, have more repetition and are designed for this sector in combination with the MIA Vamil subsidy. Bamboo was also used, often because of the better fire safety qualities than other wood materials. But apart from the modular concept homes, the high-rise and low-rise buildings still used concrete for the foundation, underground garages and the core of the higher buildings. The interviewees realised the larger environmental impact, but noted the qualities of concrete and that it was necessary for these parts.

Figure 1, Zuiver Bosrijk (bolwerkweekers.nl, 2022). Figure 2, De Nieuwe Es (houtbaar.nl, 2021).

Costs

The projects are built with feasible business cases, but several solutions/adaptations were found to make this happen. The case studies showed that monetary help was needed for the projects to be developed. Developers noted that this was necessary, as the upfront investment costs were higher than for traditional/standard (concrete and bricks) projects. This was shown in higher material and construction costs, and because more expenses were made for advisors, research and explanations to buyers and proof for municipalities that it complies with the building code. This correlates with findings in the literature study, which showed that the financial aspect is a significant barrier in the business case for

implementing circular strategies. Research from for example Alba Concepts also concluded that the direct building costs for circular biobased construction are higher compared to more traditional/standard building methods such as with concrete and bricks. The circular implementation also influenced and limited the supplier and contractor options, especially for the more difficult higher buildings, which also resulted in higher costs. “Smart shopping” was not an option. But also other construction differences and complications such as fire safety, detailing and vibrations were mentioned. However, obtained knowledge about these will help with future projects.

Found adaptations

The different solutions/adaptations in the biobased developments compared to traditional projects found in the case studies were:

- A lower land price / discount on the land price from the municipality for the project, or more focus on sustainability and less on price in the tender.
- Investors paying extra than first agreed or compared to a project not with biobased materials. Or paying for construction stored carbon credits.
- The use of a subsidy (MIA Vamil).
- Reduce profit margins of developers and other involved stakeholders.
- Not building all the homes in the project with biobased materials.

Several parties had an important role in these adaptations/solutions, such as municipalities, investors, contractors, advisors and developers themselves. The implementation of biobased materials as a circular strategy influenced the financial feasibility of the business case negatively, therefore the changes and solutions were needed. The developers also thought that the measures (temporary additional real/fictitious cash flows) could help with the upscaling of the biobased industry (production and supply) which will lead to lower costs. Developers and experts also noted that the building methods need to change and that more standardisation, repetition and prefabricated elements/building packages through more industrial construction can help with lower costs. Together with when the production and supply of biobased materials increases.

Stakeholders & experts

The stakeholders and experts linked to these measures did not all have the same view on all the possibilities, and also noted other measures. Overall, they were positive on (decentralised) governments helping the market by leading, steering and supporting the transition with a lower land price and subsidies for biobased construction. But also by CO_2 pricing to ‘punish’ construction with larger environmental impacts. The opinions were most divided on construction stored carbon credits, some interviewees saw more/better potential in direct governmental aid with real and fictitious cash flows, others did see potential but noted the importance of a well designed system against greenwashing and other ‘frauds’. Most interviewees saw the adaptations as something for the short-term, to boost and help with the transition, but all agreed that CO_2 pricing was something for the long-term. They also noted the traditional business case not working for the circular economy as these temporary solutions and emergency measures are needed. But also that a higher CO_2 price is required and they agreed with developers that the MPG needs to be updated for biobased materials. They also came up with other possibilities not mentioned by the developers, such as the total cost of ownership and life cycle costing as possibilities to help with this in the business case of developers and better being able to include the climate impact. To also

involve the residual value with fictitious cash flows better in the beginning. It was also noted that this could be interesting for investors, as developers often sell the homes. How the approaches could help exactly was not mentioned/known.

Conclusion

Based on the findings can be concluded that the business cases themselves were not drastically changed to fit the circular strategy. The investigated projects showed that several differences and complications came along with choosing to build housing with biobased materials, of which the extra costs were the most significant one. This results in the limitations of a wider necessary circular transition. The adaptations and solutions made/found in the business cases are options to help and boost the transition, but are still emergency measures and patch-ups to the business case of circular biobased housing developments. Even though the adaptations could help as a catalyst in the transition, they do not make a solid healthy business case. From this can be concluded that the traditional business case is not fitted for biobased construction as a circular economy strategy, which also contributes to why the large shift to such strategies stays out. Developers are willing to and working to limit their environmental impact, and stakeholders of the used solutions are also open and working on ways to help with real and fictitious temporary cash flows for the transition. But the views differ, while developers see opportunities with the fictitious and real cash flows to support biobased and boost production and supply to help lower the prices. Stakeholders and experts note that also changes need to be made to the business case and/or building methods to allow for the circular economy and long-term focus to be incorporated with for example approaches such as the total cost of ownership and life cycle costing, as it does not work in the traditional business case. This shows a gap between their views, therefore an answer for the problem is not simple.

Moreover, not only changes to the current business case of developers are needed, but also adaptations in the building methods, such as more conceptual, modular and industrial construction and standardisation could help the financial feasibility of biobased housing. In addition, the long-term thinking approaches and better being able to incorporate the residual value are also relevant for investors to value these projects more. Therefore, the changes should be done/help in the input and/or output of the business case for circular biobased housing developments. Either it has to become cheaper in the business case to construct or the proceeds need to be higher to cover the extra costs.

In addition, it became clear that not all temporary solutions are in the short-term available on a larger scale. Municipalities are working on internal and external CO_2 pricing and discounts for biobased/sustainable developments, but wider (decentralised) government support could take some time. Moreover, are national sets and instruments needed for this. But it is currently expected that the certificate of Climate Cleanup for construction stored carbon credits should be finished around March 2024.

Recommendations

The conclusion showed a.o. that the traditional business case is not fitted for the circular economy. Approaches such as total cost of ownership and life cycle costing were mentioned as possibilities by experts and stakeholders to better incorporate future thinking, the circular economy and the residual value of a building. However it was not yet known or mentioned

how this could exactly help or should be done and it was noted as also a possibility for investors instead of developers. Therefore, more research is needed into how the business case should change for this and if this actually is a solution. Moreover, the temporary measures identified in this research could still help in the transition and their role should also be included in future research.

For practice it is recommended to further investigate and invest in innovative circular biobased building materials to help reduce the costs in the long-term. Therefore taking a more involved role in the setup at the front of the process, and working together with Dutch agriculture. To take a role to supply and produce local biobased materials and implement this in the business cases on a longer timeframe.

Furthermore, should be looked more into innovative building methods like conceptual, modular and industrial construction and more standardisation. Just as with geWOONhout and the prefab construction method of Zuiver Bosrijk and other projects. To also invest in this on a long-term perspective to reduce costs.