Improving knowledge about circularity in the definition phase

How circular design strategies can help project managers advise clients on circularity of construction projects in the definition phase

de Kwaasteniet, Nicole

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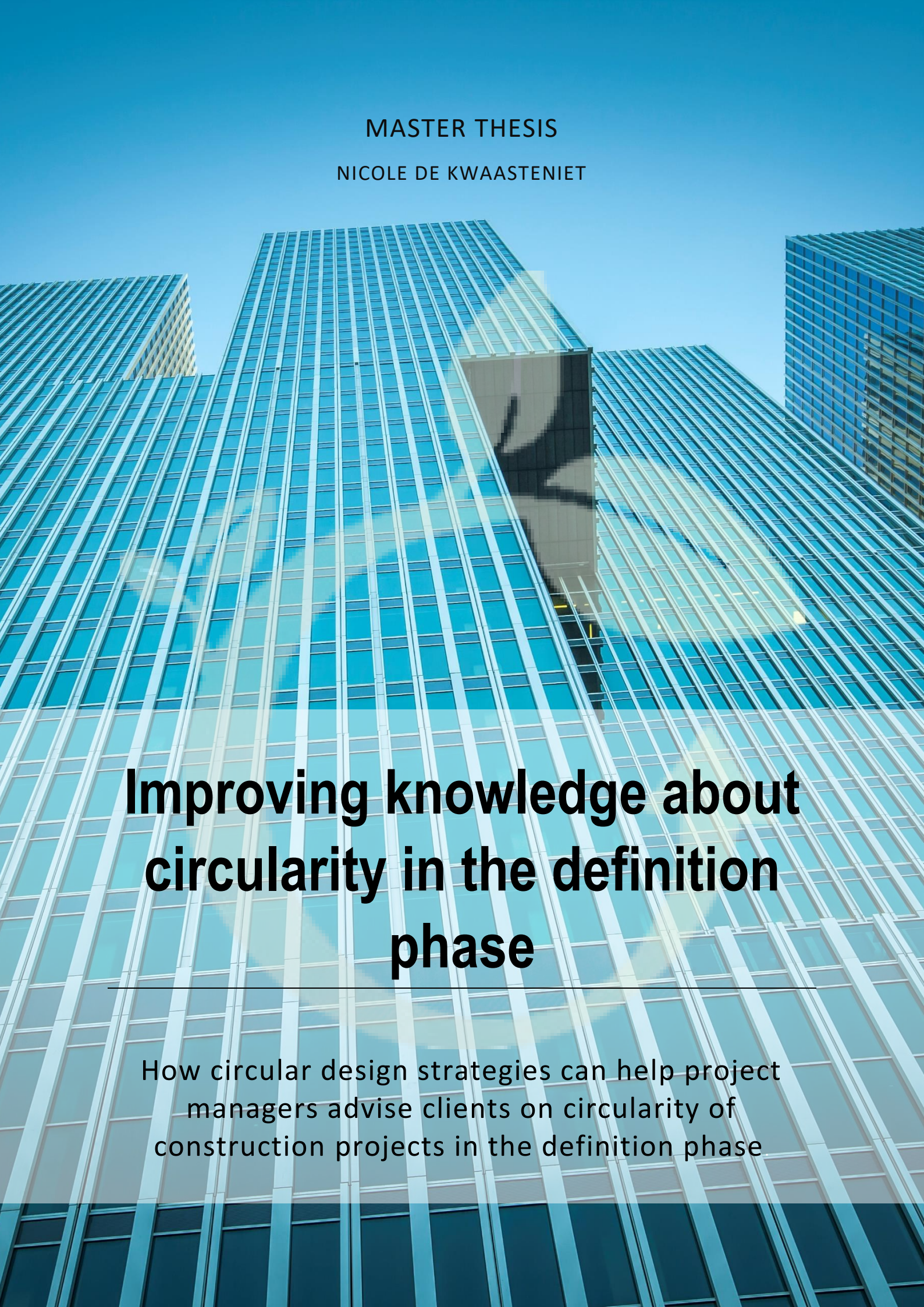

MASTER THESIS

NICOLE DE KWAASTENIET

Improving knowledge about circularity in the definition phase

How circular design strategies can help project managers advise clients on circularity of construction projects in the definition phase

REPORT

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AUTHOR
N. (Nicole) de Kwaasteniet
Student no.: 1510207
Email: n.d.kwaasteniet@student.tue.nl
Phone number: +31630624908
University: Eindhoven University of Technology
MSc program: Construction Management and Engineering

GRADUATION COMMITTEE
Prof. Dr. Ir. B. (Bauke) de Vries
Chairman
Department: Department of the Built Environment
Chair: Information Systems in the Built Environment (ISBE)
E-mail: b.d.vries@tue.nl

Dr. Ir. Q. (Qi) Han
1st University supervisor
Department: Department of the Built Environment
Chair: Information Systems in the Built Environment (ISBE)
E-mail: q.han@tue.nl

Dr. Ir. B. (Bob) Walrave
2nd University supervisor
Department: Department Industrial Engineering and Innovation Sciences
Chair: Innovation Technology Entrepreneurship & Marketing (ITEM)
E-mail: B.Walrave@tue.nl

Ir. M. (Menno) Meulebeek
Company supervisor/external advisor
Company: Brink Management / Advies B.V.
Position: Senior consultant
E-mail: M.Meulebeek@brink.nl

Ir. D. (Denise) Huizing
Company supervisor/external advisor
Company: Brink Management / Advies B.V.
Position: Senior consultant
E-mail: D.Huizing@brink.nl

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PREFACE

Dear reader,

Six and a half years ago I chose to study Built Environment at the University of applied sciences of Utrecht. After four years, I was not finished with studying and I wanted to develop myself further in project management of the built environment. Therefore, I started the pre-master and master of Construction Management and Engineering at the Eindhoven University of Technology. After having followed the master's degree in Construction Management and Engineering for 2 years, the big moment is almost there.

The last six and a half years have been a rollercoaster of new challenges and developments. From the more practical side of HBO to the more research-oriented thinking of the University. I have learned how much passion I have got for the built environment and I have discovered my ambition to make the built environment more sustainable. Finding a topic for my graduation thesis was therefore not difficult. My interest in sustainability and circularity made me realize that the construction sector has to change drastically. The question arose of how I could contribute to accelerating this change.

This thesis is the masterpiece of six and a half years of studying. I'm very glad and proud that I could perform research that is close to the topics I'm interested in. After months of research, I believe I have found an interesting way to give project managers the right information about circular design strategies. This could help them to advise clients in making circular choices for the construction project by using circular design strategies in the definition phase, which hopefully can act as input to practice to make steps forward to a circular economy.

This master thesis wouldn't be there without a lot of people. I am grateful to the people around me who have helped me to get the most out of my research. To begin, I would like to thank my graduation committee of the TU Eindhoven for their help and ideas throughout the process. A special thanks to my first supervisor, Qi Han, for her excellent guidance and support during this process. Additionally, to my second supervisor, Bob Walrave, for his helpful feedback and ideas on my research. Also, thanks to my company supervisors, Menno Meulebeek and Denise Huizing, for the motivational meetings and I appreciate your effort and time to provide me with good feedback and ideas.

Second, I would like to thank all colleagues at Brink Management/Advies for showing a lot of interest and for the fun moments during office hours. I also would like to thank all colleagues for opening their network for me. A special thanks to the members of the 'vernieuwen groep duurzaamheid en circulariteit' who provided me extra information and examples.

Furthermore, many thanks to all interviewees. The interviewee's input has been of great value to the results of my research and gave me a lot of insight into the practice and the construction sector. Finally, I would like to thank my friends and family for the unconditional support they gave me throughout this journey.

I am very proud to share my master thesis with all who are interested.

Enjoy reading!

Nicole de Kwaasteniet

Eindhoven, March 2022

SUMMARY

There is a big need for change in Architecture, Engineering, and Construction (AEC) industry because, at the moment, the construction sector is the world's largest consumer of raw materials and accounted for 25-40% of global carbon dioxide emissions. The construction-related CO2 emissions continue to rise and it is expected that the emissions will double by 2050. To overcome the contradiction between economic and environmental prosperity, change is a necessity. The circular economy must now be accelerated. The role of the built environment, therefore, is crucial, due to its high environmental impact. Whereas the concept of circular economy is getting global momentum, the knowledge and tools for bringing it into practice still largely need to be developed.

The complicating factors of the implementation of circularity in the AEC industry are different barriers. From the literature review, the barriers with a lot of impacts are the lack of awareness, lack of knowledge, and resistance to change. Bringing awareness to the detriment caused by the construction industry's linear economic model is cited as a first step to enable the adoption of a circular economy model in the AEC industry. If the public sector and AEC stakeholders understand the circular economy and its value, the obstacle will be reduced and it will be easier to shift. Another enabler for the adoption of a circular economy model in the built environment is access to transparent data to make easier, faster, and more informed decisions. By reducing these obstacles, there will be less resistance to circularity in the AEC industry and the transition will be faster. A construction project is managed throughout the entire process at least on the management aspects of cost, time, and quality. By providing more insight into circularity in these aspects, better considerations can be made for certain choices and circularity can be controlled throughout the project. It is important to make all parties in the right phase aware of circularity and the action points which go along with circularity. There is a role for the project manager in steering on and raising awareness of circularity, as early as possible, in a construction project. To realize the structural changes in the system and provide AEC stakeholders with the right transparent information, it is important to translate circularity into circular design strategies. By using circular design strategies, more knowledge can be developed and disseminated.

Circular strategies can enable economically viable ways to continually reuse products and materials, using renewable resources where possible. In the AEC industry, circular design strategies can be used in the design of projects. Prior to the design, comes the process of arriving at the right circular design strategies or the right combination of these strategies. Six circular design strategies are discussed in this research, which can be used separately or in a combination: 'designing for prevention', 'designing for the reduction of life cycle impact', 'designing for future-proofing', 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials'. Circular design strategies provide insight into the changes in the characteristics of the built environment as a result of circular construction. This must make the adoption of the circular economy easier. Every construction project is unique and requires a tailor-made strategy based on the project-specific parameters. The group of six circular design strategies can also be used to develop a tailor-made strategy. To clarify when which circular design strategy can best be applied, more relevant information is needed. This research closed the research gap by giving more information about the different circular design strategies on the management aspects of cost, time, and quality to help project managers advise and encourage clients to opt for circular design more often. The main research question this thesis answers arises from this gap in academic knowledge and reads:

How can a project manager advise clients in making circular choices by using circular design strategies in the definition phase for the construction project?

By answering this question, this thesis strives to help clients to take the next step in the move from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies to advise clients in this process. To reach this goal, design science research has been conducted by using several methods. First, a literature study has been performed to deliver the theoretical background on circular design strategies, the characteristics of the circular design strategies, what circular economy and the circular design strategies entail for the built environment, and which project parameters consist in the built environment. The literature review has offered a good starting point for design science research. The design science research aimed at getting a deeper understanding of which project parameters are used in practice to categorize construction projects, what influence the parameters have on the aspects of cost, time, and quality, what the consequences are of the project parameters on the choice of circular designs strategies and for the three management aspects. Also getting a deeper understanding of how the project manager can interpret and use the outputs of this research to advise clients. To achieve these goals, explorative interviews and Delphi research, which include expert interviews and surveys, have been conducted. The synthesis of all collected data has resulted in a model that the project managers can use when advising the clients.

Based on the explorative interviews with project managers, the project parameters from the literature were verified and supplemented. The explorative interviews have resulted in a definitive list of project parameters, which are parameters that take into account when talking about circularity and have an influence on the three management aspects. The definitive list with project parameters has been further used in the research. The interviews and surveys indicate that most of the respondents experience many changes in the management aspects of cost, time, and quality in a construction project when applying circularity. The respondents agreed that the choice of circular design strategies can vary per project and that it is difficult to map out in advance. Based on the previously established list of project parameters, the respondents were asked about their experiences with the effects of applying circularity on the management aspects and about their experience with which circular design strategy or a combination of the circular design strategies they will apply to the construction project. This shows that for certain project parameters, circularity has a positive effect, has a negative effect, or remains neutral. The interviews gave insight into what influence the project parameters have on the management aspects and showed which circular design strategies can best be applied to each project parameter. The interviews provided the condition of when a project parameter has a positive, neutral, or negative effect and gives insight into the reason why circular design strategies can best be applied to a construction project with the given project parameters. Consensus about the results of the interviews was achieved through the round of surveys wat was held.

The synthesis of the findings included combining all results into an overview. By combining all data, it shows per project parameter what the consequences are for the choice of circular design strategies and what the effects are on the management aspects. To reach the objective of this research, the framework with the synthesis of all data has been converted into a model. By processing the results in a model, it has been made user-friendly for the project manager. By entering only the project parameters for the particular project, the model shows the recommended circular design strategies and the effects on the management aspects. By having this information mapped out in advance, it can also be taken into account in the construction project in advance. By starting this early in the project, circularity can still be favorably included in the construction project. By using the model, the project managers can arrive at the optimal option for the construction project and can advise the client in making circular choices for the construction project by using circular design strategies in the definition phase.

SAMENVATTING

Op dit moment is er een grote behoefte aan een verandering in de AEC-industrie, omdat de bouwsector 's werelds grootste verbruiker van grondstoffen is en goed is voor 25-40% van de wereldwijde uitstoot van carbon dioxide. De CO2-uitstoot gerelateerd aan de bouw blijft stijgen en de verwachting is dat de uitstoot in 2050 verdubbeld zal zijn. Om de tegenstelling tussen economische en ecologische welvaart te overwinnen, is er verandering nodig. De circulaire economie komt op dit moment in een stroomversnelling. Met een cruciale rol voor de gebouwde omgeving, vanwege de hoge milieu-impact. Terwijl het concept circulaire economie wereldwijd momentum krijgt, moet de kennis en tools om het in de praktijk te brengen nog voor grotendeels worden ontwikkeld.

Wat de implementatie van circulariteit in de AEC-industrie op dit moment complex maakt, zijn verschillende obstakels. Uit het literatuuronderzoek blijkt dat de volgende obstakels veel impact hebben: het gebrek aan bewustzijn, gebrek aan kennis en weerstand tegen verandering. Om de invoering van een circulaire economie in de AEC-industrie mogelijk te maken, wordt bewustwording als belangrijke eerste stap gezien. Obstakels worden verminderd zodra de publieke sector en de AEC-industrie de circulaire economie en de waarde ervan begrijpen. Een andere factor die de invoering van een circulaire economie mogelijk maakt, is toegang tot transparante gegevens om gemakkelijker, sneller en beter geïnformeerde beslissingen te kunnen nemen. Door de obstakels weg te nemen, zal er minder weerstand zijn tegen circulariteit in de AEC-industrie en zal de transitie sneller gaan. Een bouwproject wordt gedurende het gehele proces gemanaged op onder andere de managementaspecten kosten, tijd en kwaliteit. Door circulariteit in deze managementaspecten mee te nemen, kunnen betere afwegingen worden gemaakt en kan er op circulariteit door het gehele project gestuurd worden. Het is belangrijk om alle partijen in de juiste fase bewust te laten worden van circulariteit en de actiepunten die daarbij horen. Er ligt een rol voor de projectmanager bij het zo vroeg mogelijk sturen en bewust maken van circulariteit in een bouwproject. Om de structurele veranderingen in het systeem te krijgen en de AEC-industrie te voorzien van de juiste transparante informatie, is het belangrijk om circulariteit te vertalen in circulaire ontwerpstrategieën. Door gebruik te maken van circulaire ontwerpstrategieën kan er meer kennis ontwikkeld en verspreid worden.

Circulaire strategieën kunnen het economisch haalbaar maken om producten en materialen voortdurend her te gebruiken. Voorafgaand aan het ontwerp, speelt het proces om te komen tot de juiste circulaire ontwerpstrategieën of de juiste combinatie van circulaire ontwerpstrategieën. In dit onderzoek zijn zes circulaire ontwerpstrategieën besproken, die afzonderlijk en in combinatie kunnen worden gebruikt: ontwerpen voor preventie, ontwerpen voor het verminderen van de impact op de levenscyclus, ontwerpen voor toekomstbestendigheid, ontwerpen met hergebruikte objecten, ontwerpen met secundaire grondstoffen en ontwerpen met hernieuwbare grondstoffen. Circulaire ontwerpstrategieën maken de veranderingen in de kenmerken van de gebouwde omgeving inzichtelijk, als gevolg van circulair bouwen. De circulaire ontwerpstrategieën moeten de adoptie van de circulaire economie makkelijker maken. Elk bouwproject is uniek en vraagt om een strategie op maat. Om duidelijk te maken wanneer welke circulaire ontwerpstrategie het beste kan worden toegepast, is meer informatie nodig. Dit onderzoek heeft de onderzoek kloof gedicht, door meer informatie te geven over de effecten van de verschillende circulaire ontwerpstrategieën op de managementaspecten kosten, tijd en kwaliteit, om projectmanagers te helpen bij het adviseren en aan moedigen van opdrachtgevers om vaker voor circulair ontwerpen te kiezen. De onderzoeksvraag die dit proefschrift beantwoordt, komt voort uit de kloof in academische kennis en luidt:

Hoe kan een project manager opdrachtgevers adviseren bij het maken van circulaire keuzes voor het bouwproject door gebruik te maken van circulaire ontwerpstrategieën in de definitiefase?

Door de onderzoeksvraag te beantwoorden, streeft dit onderzoek ernaar om klanten te helpen om de volgende stap te zetten in de overgang van circulaire ambities naar circulaire project eisen, door projectmanagers een model te bieden met de nodige informatie over circulaire ontwerpstrategieën om klanten in dit proces te kunnen adviseren. Om dit doel te bereiken, is er wetenschappelijk onderzoek uitgevoerd met behulp van verschillende onderzoek methodes. Eerst is er een literatuurstudie uitgevoerd om de theoretische achtergrond te geven over circulaire ontwerpstrategieën, de kenmerken van de circulaire ontwerpstrategieën, wat circulaire economie en de circulaire ontwerpstrategieën inhouden voor de gebouwde omgeving en welke projectparameters er zijn in de gebouwde omgeving. Het wetenschappelijk onderzoek is gericht op het verkrijgen van een dieper inzicht in welke projectparameters in de praktijk worden gebruikt om bouwprojecten te categoriseren, welke invloed de parameters hebben op de managementaspecten, wat de gevolgen zijn van de projectparameters op de keuze van circulaire ontwerpstrategieën en voor de drie managementaspecten. Er is ook dieper inzicht verkregen over hoe de projectmanager de resultaten van dit onderzoek kan interpreteren en kan gebruiken om klanten te adviseren. Om deze doelen te bereiken, zijn verkennende interviews en een Delphi-onderzoek uitgevoerd. De synthese van de verzamelde data heeft geresulteerd in een model dat de projectmanagers kunnen gebruiken bij het adviseren van de opdrachtgevers.

Uit de interviews en enquêtes bleek dat de respondenten de meeste managementaspecten bij het toepassen van circulariteit op een project anders ervaren. De respondenten zijn het erover eens dat de keuze voor circulaire ontwerpstrategieën per project kan verschillen en dat het moeilijk is om vooraf te bepalen. Op basis van de opgestelde lijst met projectparameters is er aan de respondenten gevraagd naar hun ervaringen met de effecten van het toepassen van circulariteit op de managementaspecten en naar hun ervaring met welke circulaire ontwerpstrategie of een combinatie van de circulaire ontwerpstrategieën zij zouden toepassen op het bouwproject. Hieruit blijkt dat circulariteit bij bepaalde projectparameters een positief effect geeft, een negatief effect geeft of neutraal blijft. De interviews hebben inzicht gegeven in het invloed dat de projectparameters hebben op de managementaspecten en lieten zien welke circulaire ontwerpstrategieën het beste kunnen worden toegepast bij elk projectparameter. De interviews gaven ook de voorwaarde wanneer een projectparameter een positief, neutraal of negatief effect heeft en geven inzicht in de reden waarom een bepaald circulair ontwerpstrategie het beste toegepast kan worden op een bouwproject met de gegeven projectparameter. Door middel van de enquêteronde is overeenstemming bereikt over de resultaten van de interviews.

De synthese van de resultaten omvatte het samenvoegen van alle resultaten tot één overzicht. Door alle data te combineren wordt per projectparameter weergeven wat de consequenties zijn voor de keuze voor circulaire ontwerpstrategieën en wat de effecten zijn op de managementaspecten. Om het doel van dit onderzoek te bereiken, is het raamwerk met de synthese van alle data omgezet in een model. De resultaten zijn verwerkt in een model, waardoor de resultaten gebruiksvriendelijk zijn gemaakt voor de projectmanager. Door alleen de projectparameters voor het betreffende project in te voeren, geeft het model de aanbevolen circulaire ontwerpstrategieën en de effecten op de managementaspecten weer. Door vooraf deze informatie in kaart te brengen, kan dit ook vooraf in het bouwproject worden meegenomen. Circulariteit kan voordeliger worden meegenomen in het bouwproject, door hier eerder in het project mee te beginnen. De projectmanager kan doormiddel van het model tot de optimale optie komen en kan de opdrachtgever adviseren bij het maken van circulaire keuzes voor het bouwproject door gebruik te maken van circulaire ontwerpstrategieën in definitiefase.

ABSTRACT

To reduce the pressure on the planet, there is a need for a fundamental shift from a linear economy to one that closes the material cycle. The construction sector plays a pivotal role in the realization of a more sustainable and circular environment. At the moment, there are often high circular ambitions at the start of a construction project, but the further the project progresses, the circular ambitions of the project often decrease. Because of the lack of knowledge in workable practices, the re-thinking process into a circular built environment is not yet made by all construction parties. To get the structural change into the system, it is important to translate circularity into circular design strategies. The study aims to help clients by taking the next step in the process from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies. The aim is achieved by conducting design science research, consisting of a literature review, explorative interviews with project managers, and a Delphi research including expert interviews and surveys by experts with knowledge about circular design strategies. Based on the synthesis of the results, project managers can advise clients in making circular choices for the construction project, by providing a model with the necessary information about circular design strategies. By filling in the project parameters of the relevant construction project in de model, it becomes clear which circular design strategy can best be applied to the project and what the effects are on the management aspects when these circular design strategies are applied. The research suggests that these circular design strategies that emerged from this research can in a further step be translated in advance in the Program of Requirements. It also becomes clear in advance what the effects are on the management aspects. By having this information mapped out in advance, this can be taken as soon as possible into account in the construction project. Besides, the project managers can use this model in the conversations with the clients in the initiative/definition phase. By using the model, the project managers can arrive at the optimal circular option for the construction project and can advise the client.

KEYWORDS

Circular building projects, Project management, Circular design strategies, Management aspects, Definition phase

LIST OF GLOSSARY

Refuse - Make a product/object redundant by abandoning its function or by offering the same function with a radically different product.

Reduce - Increase efficiency in product manufacture or use by consuming fewer natural resources and materials.

Re-use - Re-use by another consumer of discarded product/object which is still in good condition and fulfills its original function.

Recycle - Process materials to obtain the same (high grade) or lower (low grade) quality.

Lifespan - The length of time for which a material/product/object functions or are normally expected to function.

Life cycle - The series of stages in form and functional activity through which a material/product passes between successive recurrences of a specified primary stage. From concept and design to production, distribution, maintenance, and retirement (end of lifecycle).

Flexibility - The ability to be easily modified. Flexibility refers to the ability of a building to continuously adapt its space layout and even its structure to evolving needs.

Adaptability - The capacity to be modified for a new use or purpose. A building/object/product is adaptive if parts are accessible and physically independent of each other.

Detachable - Deconstruction of the building's objects/products, which can be repaired or reused in other buildings or directed for recycling. Connections of objects/products should be detachable.

Product - A thing that is the result of an action or process. Products are processed, finished items that are offered for sale. They have manufactured combinations of materials and perhaps other products, processed to create items such as doors, windows, light fittings, and so on.

Material - Materials are raw, unprocessed substances such as sand, salt, and so on

Compostable - Materials are biodegraded within a composting time frame and the mineralization process starts within the period required for biodegradation of biowaste.

Renewable raw materials - Renewable raw materials are grown, naturally supplemented, or naturally cleaned. It is materials that can be renewed sustainably within relatively short periods.

Secondary raw materials - Materials which can be identified as materials/products/objects which can be used as raw materials by simple re-use or via recycling and recovery

Object (instead of elements) - A material thing that can be seen and touched. Objects include buildings and structures. In this research are objects a part of the building.

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CHAPTER 1.

INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1. PROBLEM DEFINITION / OBJECTIVE OF THE THESIS

Sustainability in construction projects is a vast and complex subject that must be considered from the very earliest stages as the potential environmental impacts are very significant. Construction projects play a pivotal role in the realization of a more sustainable and circular environment, and the concept of circularity has more recently also been linked to project management. The emerging literature on this topic provides strong indications that considering circularity impacts project management processes and practices. However, according to Schipper and Silvius (2014), the standards for project management fail to address the sustainability/circularity agenda.

The circular economy is about fundamentally shifting the production logic from one that is linear (i.e. take-make-dispose) to one that closes the materials cycle by e.g. reusing and recycling materials. Achieving this fundamental change, it has been argued, is only possible if organizations and firms radically transform their processes to become circular (M. Venselaar, 2019).

There are often high circular ambitions at the start of a construction project, from both the client and the developer. The further the project progresses, the circularity of the project often decreases. To prevent this, circular ambitions for a project needs to be used from the start until the end of the project, in all the layers of the project. This means from the client, project manager, advisors to the contractor of the project. Otherwise, the ambitions of clients dilute, or decisions are made by clients on other arguments because it might be easier, cheaper, better known, or more reliable (Versteeg Conlledo, 2019). Ultimately, the project is usually built with a much lower circularity than the client's ambition was in advance.

One of the largest problems is that there is a lack of knowledge and standardization on the circular economy implementation strategies or the experiences with implementing circular economy in the built environment, so far, according to Versteeg Conlledo (2019). A circular building is often perceived as a high-risk project because each construction project is unique and there is too little knowledge about the impact of choosing a circular building on the management aspects cost, time, and quality. Because of the lack of knowledge in workable practices, the re-thinking process into a circular built environment is not yet made by all construction parties.

To get the structural change into the system, it is important to translate circularity into circular design strategies, according to Voorend (2021). In this study, circular design strategies refer to the strategies that can be used in the design of the project. The focus of the circular design strategies will be on the process of material/product use in the AEC industry. Everyone involved in the project must understand the consequences of opting for a certain circular design strategy. In this way, all decisions and considerations throughout the chain can be made according to the tailor-made circular design strategy.

To help project managers by advising the clients it is important to know which consequences the circular design strategies have on the management aspects of money, time, and quality of the construction project. In this way, project managers can prepare their organization for this and well-founded estimates can be made for the opportunities and risks of the project. At the moment there are no standard processes for what impact the determined circular design strategies have on the different management aspects of a construction project. Therefore, the objective of this research is:

"To help clients by taking the next step in the move from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies to advise clients in this process."

1.2. RESEARCH QUESTIONS

A main question and sub-questions have been drawn up as a guideline for the research. The following main question has been prepared to achieve the above-mentioned research objective.

How can a project manager advise clients in making circular choices by using circular design strategies in the definition phase for the construction project?

To answer the main question, several sub-questions have been formulated.

1. Which circular design strategies are there for the built environment and which characteristics do the circular design strategies have?
2. Which parameters are there to categorize the construction projects and what influence do the project parameters have on the aspects of cost, time, and quality?
3. What are the consequences of the project parameters for the choice for one or a combination of circular design strategies and for the three aspects of cost, time, and quality?
4. How can the project manager interpret and use the outputs of this research to advise clients in making circular choices in the definition phase for the construction project?

1.3. RESEARCH DESIGN

To realize the research objective and to answer the research questions, the following research framework is formulated (see Figure 1). The method that is used for the research is a design study, based on design science methodology. The research will be carried out in seven steps. First, a literature review will be done to answer sub-question 1 and a part of sub-question 2. After completing the literature review, the theoretical background is available on circular design strategies, the characteristics of the circular design strategies, what circular economy and the circular design strategies entail for the built environment, and which project parameters there are in the built environment. After the literature review, the theoretical framework and the interview protocols are established. To answer sub-question 2, the project parameters found in the literature review are validated through explorative interviews. After the project parameters have been finalized, the data will be collected through interviews. The effects of the parameters on the management aspects cost, time, and quality will emerge from the interviews. Sub-question 3 will also be answered by means of the interviews. The interviews will show which circular design strategies can best be applied for the various parameters. In order to obtain consensus about the collected data, a survey will be conducted among the same respondents as those of the interviews. The last phase will be the development phase to answer sub-question 4. A model will be made in which all data is processed and which can be used in the discussions between the clients and the project managers in the definition phase. To validate the model, project managers will be asked to assess the model and to give recommendations. In the end, conclusions will be drawn and recommendations will be made for practice and further research.

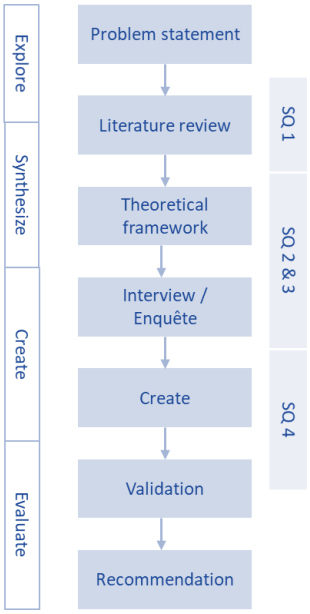


Figure 1: Research framework

1.4. THE PRACTICAL/SOCIAL RELEVANCE

In the 1990s, the construction, operation, and maintenance of buildings were responsible for 40% of the materials used by the world economy and for about a third of energy consumption, according to Rees (1999). Two decades later, the construction sector is still the world's largest consumer of raw materials and accounts for 25-40% of global carbon dioxide emissions, while only an estimated 20-30% of these materials are recycled or reused at the end of life of a building (WEF, 2016). At the moment, construction-related CO2 emissions continue to rise, with the International Energy Agency (IEA) suggesting that emissions will double by 2050 (International Energy Agency (IEA), 2013). A new paradigm, circular economy, is now gaining momentum, with the help of the Ellen Mac Arthur Foundation, and it promises to overcome the contradiction between economic and environmental prosperity, according to Pomponi and Moncaster (2017). The role of the built environment, therefore, is crucial, due to its high environmental impacts, which also conversely offer significant opportunities for reductions in energy use, greenhouse gas emissions, and waste production.

The circular economy presents huge potential for global economic growth while accelerating society towards a sustainable future, according to Thelen et al. (2018). Several definitions of the circular economy have been proposed, but in this research, the definition of the Ellen Mac Arthur Foundation (2013) will be used: “A Circular Economy is an economic and industrial system where material loops are closed and slowed and value creation is aimed for at every chain in the system”. The circular economy, as opposed to the current linear economy, is seen as a sustainable economic system where economic growth is decoupled from resource use, through the reduction and recirculation of natural resources (Corona et al., 2019). Whereas the concept of circular economy is getting global momentum in politics, business, and academia, the knowledge and tools for bringing it into practice still largely need to be developed. This is especially true for the building sector, where innovation diffuses rather slowly and where the focus has been on issues like energy use and energy efficiency (Leising et al., 2018).

With a global economy that is only 9.1% circular, there is a massive circularity gap. Closing the gap will not only be a matter of reducing material input and cycling more, it will also be crucial to optimize and extend the lifetime of what has already been built. Then the world is moving from a linear to a circular economy. This change affects all characteristics for the built environment and applies to all layers of a building, according to Thelen et al. (2018). For clients, advisors, project management and construction companies that have only recently heard of the term circular economy, adopting a circular economy is quite a challenge. Nazareth (2019) asked the following question in his research: how does a company meet a customer's requirements if a) it doesn't understand what's involved b) what are the new processes c) what the technologies within the value or supply chain could be or d) how to deliver it?

There is a lack of information about the benefits and the approach of the circular economy. The development of the circular economy further is challenged by the lack of good examples and broad experience with circular solutions (Thelen et al., 2018). Designers recognize their responsibility, over the years, environmental philosophies have evolved from green design to design for sustainability and, more recently, design for circularity or circular design (Moreno et al., 2016a). More and more companies are researching circular design strategies to find examples and experience with circular solutions (Moreno et al., 2016a). Circular design strategies cover a range of strategies that could be adopted to design for a circular economy, as in some cases, it takes a more holistic and radical approach towards product development. The advances in circular design strategies according to Moreno et al. (2016) were that they provided the most complete and up-to-date description of design considerations for a circular economy.

Can the advances of circular design strategies help clients and project managers adopt a circular economy? Clients do have the ambition to build circularly, but often these ambitions are diluted or decisions are taken by clients on other arguments because it might be easier, cheaper, better known, or more reliable, according to Versteeg Conlledo (2019). There can be a role for the project manager in this to inform the client about circular options and to adhere to the circular choices the client made. As mentioned before, a circular building is often perceived as a high-risk project because there is too little knowledge about the impact of choosing a circular building on the management aspects cost, time, and quality (Versteeg Conlledo, 2019). By creating more knowledge about circular design strategies, according to Versteeg Conlledo (2019), a circular building project becomes a less risky project. Everyone involved in the project must understand the implications of the chosen circular design strategy so that everyone knows what they are opting for, especially the client.

Circular design strategies make clear the changes in the characteristics of the built environment caused by circular construction. This must make the adoption of the circular economy easier. Can provide more information to clients while making circular choices for the construction project ensure that clients opt for circular construction more often? This research closed the research gap by giving more information about the different circular design strategies on the management aspects of cost, time, and quality to help advise clients and to encourage clients to opt for circular design more often.

1.5. READING GUIDE

This thesis is structured such that more information about circular design strategies to advise clients in making circular choices for the construction project are given bit by bit. The final result of the thesis will be a model which helps project managers by advising the clients in this process. Chapter 2 aims to give fundamental knowledge about circular economy in the AEC industry, circular design strategies, and project parameters which are essential for advising clients in making circular choices for the construction project by using circular design strategies in the definition phase. To obtain this knowledge, a literature review has been conducted. After creating a theoretical base, the methodology of the research will be explained in Chapter 3. This chapter will indicate the different methods which have been used to answer the research question and the sub-questions. Chapter 4 presents the result of the explorative interviews and the Delphi research. It aims to give more insight into the influence the project parameters have on the management aspects of cost, time, and quality and what the consequences are of the project parameters on the choice of circular designs strategies. It explains how the synthesis of the results ensures that project managers can advise clients in making circular choices for the construction project in the definition phase, by providing a model with the necessary information about circular design strategies. In order to measure the accuracy of the model, the results are validated twofold. First, the model is validated by a focus group that is part of a construction project in the definition phase. In the second session, circular example cases that have already been performed are tested in the model to gain insight into whether the results of the model are related to the practice. In chapter 6 the research is critically discussed and the limitations of the research are drawn up. Chapter 7 closes the research with a conclusion. It emphasizes both the scientific and societal relevance of the research and ends with recommendations for further research.

CHAPTER 2.

LITERATURE REVIEW

CHAPTER 2. LITERATURE REVIEW

Fundamental knowledge about circular economy in the AEC industry, circular design strategies, and project parameters are essential for advising clients in making circular choices for their construction project in the definition phase by using circular design strategies. To obtain this knowledge, a literature review has been conducted. First, the consequences of the circular economy on the AEC industry and the obstacles that the circular economy entails in the AEC industry are being discussed. In order to map out in which phase of the project and who is involved in the obstacles that circular economy entails, the life cycle of building and the important management aspects are discussed. Afterward, the literature review will focus on the circular design strategies, after which the characteristics of the circular design strategies were drawn up based on the literature. Last, to be able to distinguish between construction projects later in the research, project parameters are discussed. Finally, a summary is given of the literature review, conclusions have been drawn, and the literature framework is presented.

2.1. NEED FOR A CHANGE

There is a big need for a change in de AEC industry because, at the moment, the construction sector is the world's largest consumer of raw materials and accounted for 25-40% of global carbon dioxide emissions (WEF, 2016). As discussed in de introduction, the construction-related CO2 emissions continue to rise, with the International Energy Agency (IEA) suggesting that emissions will double by 2050 (IEA, 2013). To overcome the contradiction between economic and environmental prosperity, the circular economy is now gaining momentum (Pomponi & Moncaster, 2017). More and more international, national and regional authorities have set high ambitions regarding the circular economy. The role of the built environment, therefore, is crucial, due to its high environmental impacts. Whereas the concept of circular economy is getting global momentum, the knowledge and tools for bringing it into practice still largely need to be developed (Leising et al., 2018).

2.1.1. CIRCULAR ECONOMY

The circular economy is based on a shift from a linear model to a new model that examines the role of value conservation and resource efficiency for economies and the environment. The transition from a linear to a circular economy is shown in Figure 2. The linear model, of take-make-dispose, moves from top to bottom through the center of the diagram. In the circular model (in the shape of a butterfly), the core is formed by sources such as the sun, wind, tides, biomass, and the heat of the earth. The two wings are models for reuse and renewal. All materials belong to two building material cycles: the biological building materials (renewable raw materials) such as the soil, plants, and animals, and technical building materials (non-renewable raw materials) such as plastic, synthetic materials, and metals (Boon-Bart, 2020). Applying the circular model makes it possible to produce a product in a resource-saving manner, to extend its lifespan, and to reuse the residual materials after use, which makes it capable to cope with the challenges presented in the introduction. According to the paper of Sariatli (2017), the collection of concepts composing the circular economy enables reducing the waste by incorporating reusing components of goods by design via a closed-loop and cascaded approaches, containing the dependence of the economy on material and energy inputs, increasing the resilience of the economic system, the preservation of the environment, supplying the growing demands of the ever more populated planet and increasing the operation ability and cost efficiency of production.

Currently, the AEC industry is very traditional and conservative (Kovacic et al., 2020). The transition from a linear economy to a circular economy is, therefore, a major challenge for the AEC industry. On the one side, the issues are quite complex as the lifetime of buildings is hard to manage, they might have multiple uses that evolve through time. Indeed, a great part of the existing building stock was not

designed for disassembly and resource recovery. As discussed in the introduction, very few buildings have been designed taking into account their entire lifecycle and end-of-life treatment. As such, a great part of construction materials ends up as waste during the building's end-of-life, which increases environmental costs and creates a risk of resource scarcity (Guerra & Leite, 2021a). On the flip side, the circular economy provides different sets of strategies that might lead to better use of resources. This set of strategies also leads to trade-offs, lock-ins, and potential rebound effects.

A circular economy is complex. It is necessary to understand the causal structure leading to the visible effects: high consumption of material, high level of emissions, etc. Only by understanding the effects of adding circularity in the AEC industry and mapping the effects of the obstacles leading from circularity in the AEC industry at the moment, a circular built system can be designed that adapts the sources of complexity for the AEC industry. In the next section, the circularity in the AEC industry and the obstacles currently encountered are mapped out.

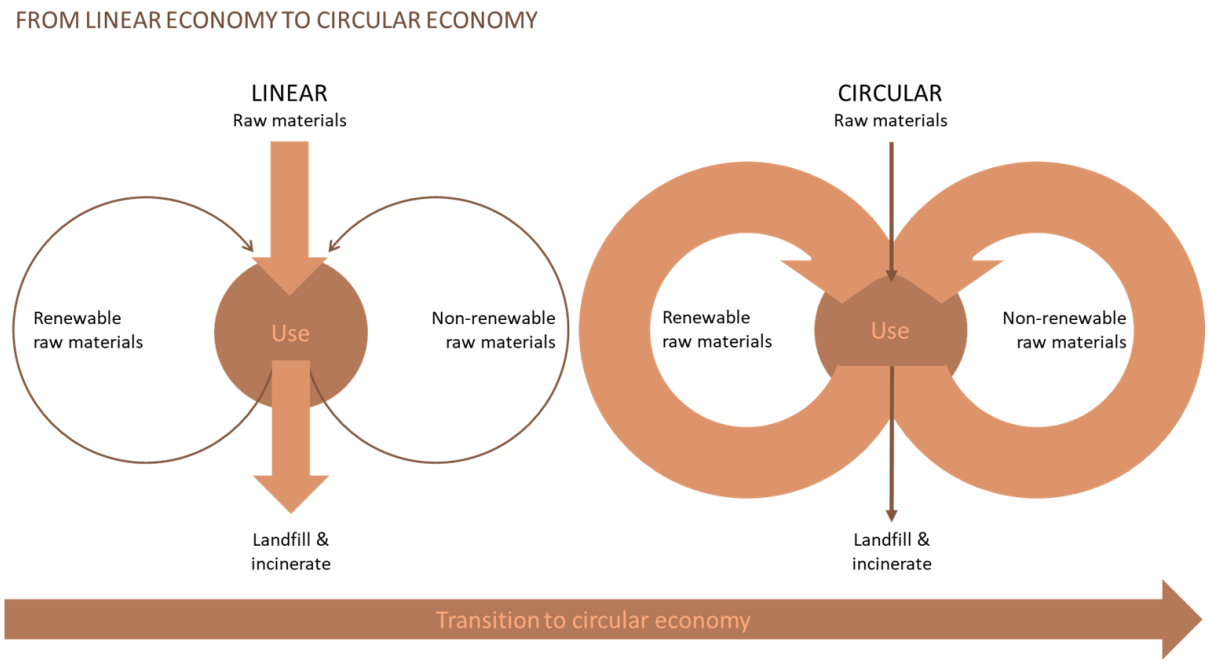


Figure 2: From linear economy to circular economy (PBL Netherlands Environmental Assessment Agency , 2017)

2.1.2. CIRCULAR ECONOMY IN THE AEC INDUSTRY

In the case of the AEC sector, the linear approach is the dominant method in the "design for construction", with the end of life managed by demolition (Charef et al., 2021). While the circular economy presents huge potential for global economic growth while accelerating society towards a sustainable future, according to Thelen et al. (2018). But there is no consensus on a definition of the circularity of a building, according to Charef et al. (2021). At this moment there is a lack of familiarity with the notion of what the circular economy means for the AEC sector compared with the manufacturing industry. Moreover, the nature of a building is very different from a given manufactured product, in terms of its use and fabrication process. Indeed, in the construction industry, each owner wishes to have a bespoke building and not a standard one. Moreover, the management of a building from its construction phase to its demolition involves a wide range of stakeholders with different skills and stakes. Lastly, the timescale of the different phases of a building's lifecycle varies drastically and is considerably long during its operation (Charef et al., 2021). To ensure that the circular economy in the AEC industry is approached in the same way throughout the research, the following definition, of the Ellen MacArthur Foundation (2014; 2013) which is widely accepted, will be used from this point on:

"A Circular Economy is an economic and industrial system where material loops are closed and slowed and value creation is aimed for at every chain in the system".

This definition fits well with the AEC industry where there is a lot of focus on closing and reducing material loops, with material scarcity in mind, and creating value in order to take advantage of circularity.

The circular economy, as opposed to the current linear economy, is seen as a sustainable economic system where economic growth is decoupled from resource use, through the reduction and recirculation of natural resources (Corona et al., 2019). 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 return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems, and business models (Foundation, 2014). The circular economy has the ultimate goal of retaining resources circulating at their highest value within planetary boundaries, in a manner that no additional natural resources are needed to produce materials, and the discarded materials are not viewed as waste (Guerra & Leite, 2021a). Besides the circularity of resources in closed-loop systems, the circular economy also focuses on better management of the resources by refusing, rethinking, and reducing unnecessary consumption. Examples of circular strategies include dematerialization of products, intensification of product use, and increase of manufacturing efficiency (Guerra & Leite, 2021a).

The concept of circular economy is getting global momentum in politics, business, and academia, through the mission of the Ellen MacArthur Foundation (2021). According to the Ellen MacArthur Foundation (2014), is the circular economy based on a few simple principles. The basic principles are specified by the Ellen MacArthur Foundation and are shown in Figure 3. This shows that products should be designed in a way that materials can be disassembled and re-used and only later be recycled or disposed (Meijers, 2020). But by the circular economy the knowledge and tools for bringing it into practice still largely need to be developed. This is especially true for the building sector, where innovation diffuses rather slowly and where the focus has been on issues like energy use and energy efficiency (Leising et al., 2018).

With a global economy that is only 9.1% circular, there is a massive circularity gap. Closing the gap will not only be a matter of reducing material input or cycling more, it will also be crucial to optimize and extend the lifetime of what has already been built. Then the world is moving from a linear to a circular economy. This change affects all characteristics of the built environment and can be applied in different ways and on different levels, according to Thelen et al. (2018). Different models and ladders related to the degree of circularity and the strategies to prevent waste are known, e.g. the 3-R principle (Platform CB'23, 2020), the Ladder van Lansink (Lansink, 1979), and the 10-R model (PBL Netherlands Environmental Assessment Agency , 2017). In general, the higher the strategy is ranked on the ladder, the lower the need for resources and the pressure on the environment, and is thereby more circular

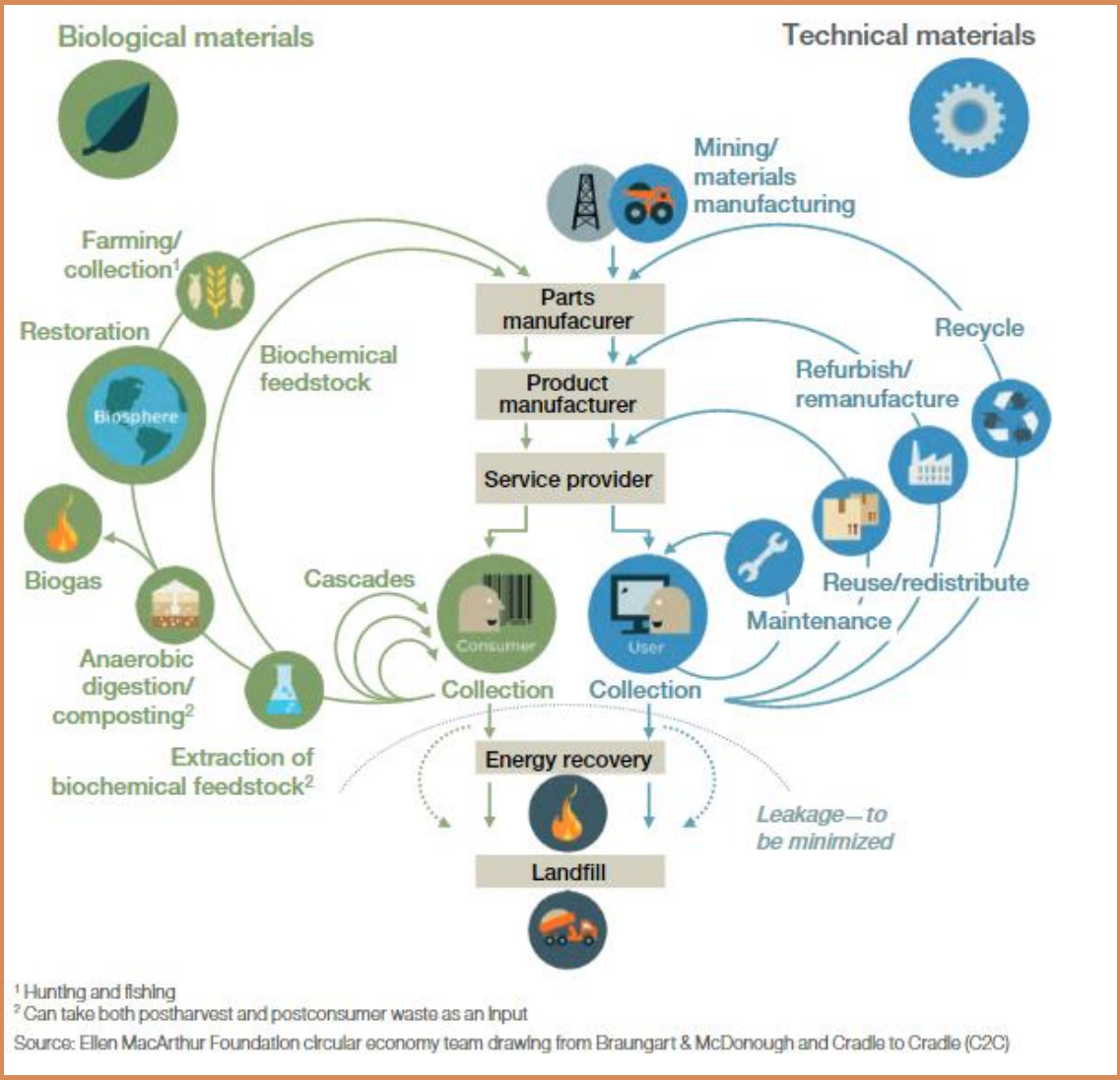


Figure 3: The circular economy - an industrial system (Foundation, 2014)

1. A circular economy aims to design out waste. Waste does not exist: products are designed and optimized for a cycle of disassembly and reuse. This tight component and product cycles define the circular economy and set it apart from disposal and even recycling, where large amounts of embedded energy and labor are lost.
2. Circularity introduces a strict differentiation between consumable and durable components of a product. Unlike today, consumables in the circular economy are largely made of biological ingredients or 'nutrients' that are at least non-toxic and possibly even beneficial, and can safely be returned to the biosphere, either directly or in a cascade of consecutive uses.
3. The energy required to fuel this cycle should be renewable by nature, again to decrease resource dependence and increase systems resilience (Foundation, 2014).

(Meijers, 2020). In this research, the ideas of the 10-R model by the Planbureau voor de Leefomgeving (PBL) are adopted, and are shown in Figure 4. This model is chosen because it represents the different circularity strategies with a priority order from high to low to prevent raw materials, material use, and waste production. The 10-R model stated that higher circular strategies come with innovations that affect the whole supply chain. Technological innovation is particularly important in the recycling of materials and waste flows. Innovation in product design and business models becomes more important with higher circularity strategies. These kinds of innovations can lead to changes in written and unwritten rules, habits, and attitudes for stakeholders throughout the product chain, according to Platform CB'23 (2019).

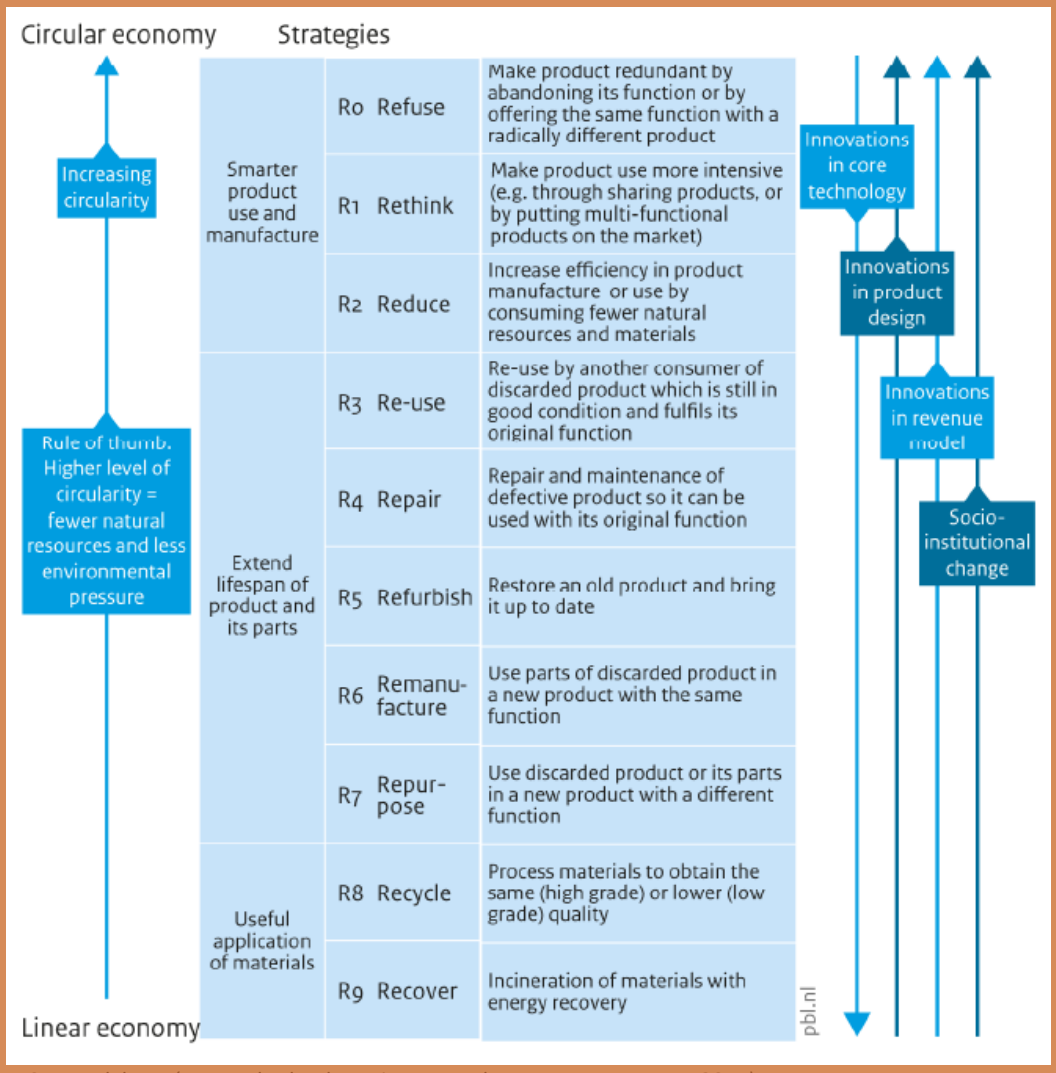


Figure 4: 10-R model PBL (PBL Netherlands Environmental Assessment Agency , 2017)

As mentioned before, the move to a circular economy will affect all characteristics of the built environment and applies to all layers of a building (Thelen et al., 2018). A building consists of different 'layers', which are named in the Layers of Brand, see Appendix A (Brand, 1994). The Layers of Brand distinguishes various building layers in a building with a specific function. The characteristic of these building layers is that the lifespan of products generally differs. At the Layers of Brand, the building is subdivided into six shearing layers: ‘Structure’, ‘Skin’, ‘Services’, ‘Space plan’, ‘Site’, and ‘stuff’ (van Vliet et al., 2019). These shearing layers serve as the basis for a circular design strategy to determine and maintain value. By distinguishing between lifespans within buildings, design decisions can be made regarding their end-of-life scenarios, materials can be cascaded and technical materials can be kept

valuable (Franssen, 2019). It is important here that the different layers can be separated from each other, both based on their function and based on their lifespan. This makes it possible to retain the value of specific layers when adjustments are necessary for other layers. By categorizing the building under the various Layers of Brand, an indication is created of which elements must be assessed, if present within the project (van Vliet et al., 2019). The different lifetimes result in multiple moments during the lifespan of a building when different components have to be replaced, some components more frequently than others (Brand, 1994). This creates the opportunity to look at the building in a more circular manner, see what the possibilities are concerning the circular ambition of buildings, and can lead to different approaches for each layer.

2.1.3. BARRIERS OF CIRCULAR ECONOMY IN THE AEC INDUSTRY

Why is circularity not yet often applied in the AEC industry? Despite the growing attention and endorsement received, the circular economy is being introduced slowly and infrequently so far. The limited circular economy implementation is frequently blamed on various barriers. Currently, there are many barriers for implementing circular designs and approaches that have the potential to meet the principles of the circular economy. The research of Charef et al. (2021) shows that most of the barriers are common to multiple approaches and that most of the barriers relate to organizational concerns. Based on the research of Guerra and Leite (2021), five groups of barriers for the implementation of circular strategies are identified: (1) budget and upfront costs; (2) schedule and project timeline; (3) lack of awareness and change resistance; (4) current construction business model; and (5) lack of regulations and implementation guidelines.

Based on the five barriers the most significant challenges are identified and related to budget and upfront costs, lack of awareness and circular economy education, lack of policies, and changes required in current construction business models. The upfront cost barrier is tied to a lack of in-house technical and technological know-how, which further challenges the transition from linear to circular business models (van Eijk, 2015). Education and understanding of circular economy benefits is another barrier (Guerra & Leite, 2021b; Kirchherr et al., 2018). Also, Versteeg Conlledo (2019) agrees that the lack of knowledge is a big barrier, as discussed in the introduction, because circular construction is often perceived as a high-risk project and there is too little knowledge about the impact of choosing a circular building on cost, time, and quality. Because of the lack of knowledge in workable practices, the re-thinking process into a circular built environment is not yet made by all construction parties (Versteeg Conlledo, 2019). Education and information can lead to a barrier. Education and information about the circular environment are needed to align and connect the value chain. Limited information sharing is a barrier to accelerating and scale-up the circular built environment (Thelen et al., 2018). Notably, a lack of circular economy knowledge is a barrier, but good awareness of circular economy alone does not necessarily translate into a company's willingness to adopt circular economy strategies, as shown in the research of Kirchherr et al. (2018). Along with circular economy awareness, market conditions such as consumer demand and economic attractiveness are necessary for a transition towards circularity, according to Guerra and Leite (2021). There is also another market condition that represents a barrier towards circularity, the lower price of virgin materials when compared to recycled materials (Guerra & Leite, 2021b). Culture and beliefs are underlying obstacles, which include company culture and personal beliefs. These two elements decide the speed of the transition. This can become a barrier when organizations or people are unconvinced or uninformed (Haigh et al., 2021). Finally, regulatory barriers are another highly discussed theme in the circular economy literature (Guerra & Leite, 2021b). Regulations and legislation are important drivers for the economy, according to Haigh et al. (2021). Because legislation usually follows public opinion, regulations may not account for a fast-growing, worldwide trend like a circular economy. This could for example cause delays in obtaining permits.

This gives an overview of the most important barriers that would help develop a model in this research to overcome the current obstacles in the shift to a circular economy in the AEC industry (Charef et al., 2021).

2.1.4. NEED FOR KNOWLEDGE AND AWARENESS OF CIRCULARITY IN THE AEC INDUSTRY

As described in the previous section, the complicating factors of the implementation of circularity in the AEC industry are different barriers that can be divided into five groups (Guerra & Leite, 2021b; Kirchherr et al., 2018). Barriers with a lot of impacts, according to Adams et al. (2017) are the lack of awareness, lack of knowledge, and change resistance.

Bringing awareness to the detriment caused by the construction industry's linear economic model is cited as a first step to enable the adoption of a circular economy model in the AEC industry. If the public sector and AEC stakeholders understand the circular economy and its value, the obstacle will be reduced and it will be easier to shift, according to a study by Guerra and Leite (2021). Additionally, the study cited the need for a cultural change and a shift from short-term thinking to long-term thinking when it comes to natural resources and their availability. Construction has a complex, traditional and decentralized supply chain. One enabler for the adoption of a circular economy model in the built environment is access to transparent data to make easier, faster, and more informed decisions (Guerra & Leite, 2021b). So, by reducing these obstacles, there will be less resistance to circularity in the AEC industry and the transition will be faster.

To get the structural changes into the system and provide AEC stakeholders with the right transparent data, it is important, according to Voorend (2021), to translate circularity into circular design strategies. By using circular design strategies, more knowledge can be developed and disseminated. Section 2.3. describes six circular design strategies which can be used effectively for knowledge development and dissemination.

2.2. MANAGEMENT IN CIRCULAR CONSTRUCTION PROJECTS

To add circularity to construction projects, it is important that awareness is created and that circularity is steered towards. Through correct management and awareness, a number of barriers to applying circularity in the AEC industry will be overcome. A construction project is managed throughout the entire process on a number of management aspects. By incorporating circularity into these aspects, better considerations can be made for certain choices and circularity can be controlled throughout the project. It is important to make all parties in the right phase aware of circularity and the action points which go along with circularity. There is a role for the project manager in steering and raising awareness of circularity in a construction project.

2.2.1. MANAGEMENT ASPECTS: COST, TIME & QUALITY

A project is a collection of activities to accomplish a specific objective, according to Chitkara (1998). Babu and Suresh (1996) said that successful project management ensures the completion of the project in time, within budget, and to the project specifications. It is facilitated by the identification and successful application of the methodology for tradeoff analyses. Several researchers (Ahuja et al., 1984; Bowen et al., 2012; *Resource Allocation in a PERT Network under Continuous Activity Time-Cost Function*, n.d.) have developed models and solution procedures to incorporate a non-linear relationship between cost and completion time. Later, quantitative research (Babu & Suresh, 1996) concluded that simultaneous consideration of time-cost-quality in project management is an improvement. This has also created the so-called Iron Triangle, which consists of cost, time, and quality, shown in Figure 5. The factors, cost, time, and quality are the three points of a triangle, and neglecting one factor will have a corresponding detrimental effect upon the other two (Bowen et al., 2012).

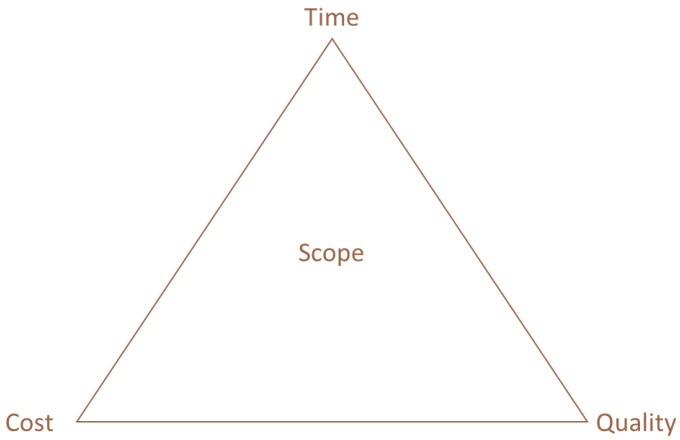


Figure 5: Iron Triangle

The clients of the construction industry are primarily concerned with the Iron Triangle: quality, time, and cost, and yet the majority of construction projects are procured based on only two of these management aspects, namely time and cost (Bowen et al., 2012). This is understandable since the majority of project management control systems highlight cost and time, and overlook the relative importance of quality. It is argued by Bowen et al. (Bowen et al., 2012), that the major failings in traditional approaches to project delivery have been in extensive delays in the planned schedules, cost overruns, serious problems in quality, and an increase in the number of claims and litigation associated with construction projects. It can be concluded that in order to plan and manage a project successfully, the three management aspects time, cost, and quality should be considered (Atkinson, 1999).

Many writers agree that cost, time, and quality should be used as success criteria, but not exclusively. Time and costs are at best, only guesses, calculated at a time when the least is known about the project. Quality is a phenomenon, it is an emergent property of people's different attitudes and beliefs, which often change over the development life-cycle of a project (Atkinson, 1999). The management aspects cost, time, and quality mean the following:

- Cost: Clients have been increasingly concerned with the overall profitability of projects and the accountability of projects in general. Cost overruns, in association with project delays, are frequently identified as one of the principal factors leading to the high cost of construction (Bowen et al., 2012).
- Time: Timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors, and consultants alike. Bowen et al. (Bowen et al., 2012) note that there has been universal criticism of the failure of the construction industry to deliver projects in a timely way. Bowen et al. (2012) said also that a disciplined management effort is needed to complete a construction project on time, and that this concerted management effort will help to control both cost and quality.
- Quality: To the client, quality may be defined as one of the components that contributes to “value for money” (Bowen et al., 2012). Omachonu and Joel (2004) define total quality management as: “…the integration of all functions and processes within an organization to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction.”

Using the Iron Triangle the effects on a project can be determined. The trade-offs can be analyzed and made based on the management aspects cost, time, and quality (Babu & Suresh, 1996). Any change can contribute to effects on cost, time, and quality. The three management aspects, therefore, play a major role in applying circularity in a construction project. Every circular strategy that is applied to a project has consequences for cost, time, and quality. To support the project team to make better decisions, it must become clear what the effects are on the three management aspects. By being clear about the effects of circularity on the management aspects, the project can also be better managed throughout the entire process.

2.2.2. STEERING TOWARDS CIRCULAR CONSTRUCTION PROJECTS IN THE DEFINITION PHASE

A construction project consists of five different phases, shown in Figure 6. Dividing a project into phases makes it possible to lead the project in the best possible direction. Through this division into phases, the total workload of a project is divided into smaller components, thus making it easier to manage. First, the construction project can be broken into three main sections, simply described as Pre-Construction, Construction, and Post-Construction (Anderson, Huhn, Rivera, & Susong, 2006). The Pre-Construction Phase consists of planning, budgeting, designing, and permitting. The Construction Phase is mainly the management of the construction process and budget control. After the Construction Phase comes the Post-Construction Phase. The Post-Construction phase consists of all the final processes completed to hand the building entirely over to the building owner. This includes completing all punch list items, a final walkthrough, training, and more. The Post-Construction Phase increasingly includes project maintenance (Anderson, Huhn, Rivera, & Susong, 2006). To make it easier to manage, a construction project can also be divided into five phases:

- Initiation phase: The initiation phase includes the initiation of a project with the development of an idea for a new building and its feasibility, which results in ambitions and assumptions (Meijers, 2020).
- Definition phase: In this phase, the requirements that are associated with a project result are specified as clearly as possible. This involves identifying the expectations that all of the involved parties have concerning the project result (Projectmanagement-training, 2021).
- Design phase: The list of requirements that are developed in the definition phase can be used to make design choices. In the design phase, one or more designs are developed, with which the project result can be achieved (Projectmanagement-training, 2021).
- Realization phase: During the realization phase, everything that will be needed to implement the project is arranged. Potential suppliers or subcontractors are brought in, a schedule is made, materials and tools are ordered, instructions are given to the personnel. It depends on the contract form whether the contractor is brought in, in this phase, or already in an earlier phase. All matters must be clear for the parties that will carry out. During the realization phase, the process will be managed.
- Maintenance & operation phase: After completion, the building can be put into use, this is also referred to as the use phase. However, the building needs some maintenance. That is why the building must also be managed. For proper management, a maintenance and operation plan will have to be drawn up. This indicates when maintenance and replacement of building components will have to take place. A good maintenance plan also includes multi-year planning and a multi-year budget, so that money is also reserved to keep the building in good condition.

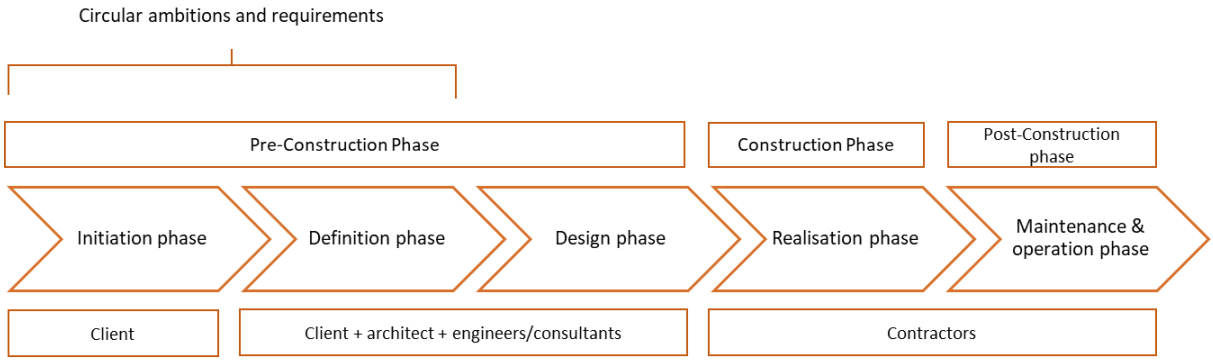


Figure 6: Phases construction project

Throughout all the phases of the project, it requires coordinated teamwork among all the players involved to attain the successful delivery of a completed construction project (Anderson, Huhn, Rivera, & Susong, 2006).

In the initiation and definition phase, the ambitions and requirements for the project are determined by the stakeholders, according to Többen (2019). The ambitions are mainly drawn up in the initiative phase. After which, in the definition phase, the ambitions are converted into requirements for the project by making choices. In the definition phase, the ambitions are finalized by, for example, setting up a Program of Requirements. The choices for the requirements made in the definition phase influence the management aspects of cost, time, and quality of the project.

It is important to initiate awareness for circularity from the first phase (Benachio; Freitas & Tavares, 2020). In the definition phase, the management aspects come into play, after which trade-offs for circularity are made and will be guided further in the project. The focus of this research will be on the definition phase. According to Versteeg Conlledo (2019), the circularity of the project is shaped in the definition phase by choosing some starting points in advance, to be able to speak a common language. The results of the research of Versteeg Conlledo (2019) show that it is important to establish the direction and ambition of projects, so having circular economy principles, from the start of the project. This is also argued by the review of Benachio et al. (2020) where also states that one of the most discussed subjects in articles through all areas of research is that the concepts of Circular Economy should be introduced in the early stages of a project. It is also important that if you have circular ambitions for the project, this needs to be used from the start until the end of the project, in all the layers (Benachio; Freitas & Tavares, 2020). Otherwise, ambitions dilute, or decisions are made on other arguments because it might be easier, cheaper or better known or more reliable, etc. Also, an important finding which is different by circularity in the definition phase is that circular economy commitment and ambition should be present within the project team, suppliers, and subcontractors (Versteeg Conlledo, 2019).

In the project definition phase, project management is tasked with identifying the means or processes by which decisions about the project purpose can be collectively made by these stakeholder groups and important by the client (Whelton, 2004). Where multiple stakeholder interests are not yet reconciled, the process can appear ill-structured and the project purpose remains ill-defined. Whelton (Whelton, 2004) defines an ill-structured problem as a problem whose structure lacks definition in some respect. Ill-structures occur more and more often when circularity is added to the project, as the circularity of the project often has no definition. Choices about the degree of circularity in the project must be made in this phase to be able to include it in the design phase (Whelton, 2004).

2.2.3. ROLE OF PROJECT MANAGEMENT BY A CIRCULAR ECONOMY IN THE AEC INDUSTRY

As discussed earlier in the literature review, is sustainability in construction projects a vast and complex subject that must be considered from the very earliest stages as the potential environmental impacts are very significant. To bring circularity into a project as early as possible there is a task for the project managers to mention circularity as early as possible in the conversation. The emerging literature on this topic provides strong indications that considering circularity impacts project management processes and practices. However, according to Schipper and Silvius (2014), at the moment, the standards for project management fail to address the sustainability/circularity agenda.

According to Kerzner (2017) is project management the application of knowledge, tools, and skills to achieve project requirements. The definition of construction project management is described by Walker (2015) as the following:

'The planning, coordination, and control of a project from conception to completion (including commissioning) on behalf of a client, requiring the identification of a client's objectives in terms of utility, function, quality, time and cost; the establishment of relationships between resources; integrating, monitoring and controlling the contributors to the project and their output; and evaluating and selecting alternatives in pursuit of the client's satisfaction with the project outcome'

The management aspects, applicated by project managers, are used to direct the use of resources effectively and efficiently to achieve a complex, unique, one-time task within cost, time, and quality constraints. This all should be done within the requirements of the client, which will be different for each client. Project management is also responsible for bringing the client and the stakeholder groups together to achieve a common purpose: the development of a circular constructed facility. The project definition team consists of multiple and distributed stakeholder groups. These include the project manager, clients, advisors, regulatory agencies, etc. (Whelton, 2004).

The project manager should take on the role of making all parties aware of circularity and incorporating circularity into the three management aspects of money, time, and quality. By providing the project manager with insight into the effects of circularity on the management aspects, the project manager must have more leverage when steering towards circularity. The most important steps can be made by the project manager in the definition phase where the three management aspects are weighed up.

2.3. CIRCULAR DESIGN STRATEGIES FOR CONSTRUCTION PROJECTS

It becomes clear that the circular economy is a promising approach to help reduce our global sustainability pressures and that there is an important role for the project managers in the definition phase. It is now valuable to find ways to broaden and disseminate knowledge about circularity in the AEC industry. As discussed in the paragraph above, circular design strategies can make a good contribution to this. But which circular design strategies? What do circular design strategies for construction projects entail and how can they contribute to broadening and disseminating knowledge in the field of circularity?

At the moment, there are many different circular strategies. For example, the European Commission associates the move to a more circular economy with circular strategies such as: boosting recycling and preventing loss of valuable materials, showing how new business models, eco-design, and industrial symbiosis can move Europe toward zero-waste, and reducing greenhouse emissions and environmental impacts (Bocken et al., 2016). Circular strategies can enable economically viable ways to continually reuse products and materials, using renewable resources where possible (Bocken et al., 2016). Circular strategies can be divided into circular business strategies and circular design strategies.

Circular business strategies are based on business models. Business models define the way a firm does business and they are viewed as an important driver for innovation. Business model choices define the architecture of the business and expansion paths, but once established, companies often encounter great difficulty in changing business models, according to Bocken et al. (2016). The move to a circular business model is an example of a radical change, which will require a new way of thinking and doing business. To help businesses, there are various circular business strategies developed to change the business models (Bocken et al., 2016a).

Without a systemic change in the way that we design products, services, systems, and infrastructure, the potential of a circular economy will never be achieved. Design for a circular economy has also to consider different design strategies for closed-loop systems as a pivotal point for its success (Moreno et al., 2016a). To achieve this, various circular design strategies are being developed.

There must be clarity about which circular strategies can be used, to be able to collect more knowledge, standardize it, and distribute it. This study will only discuss circular design strategies. In the AEC industry, circular design strategies can be used in the design of projects. Prior to the design, comes the process of arriving at the right circular design strategies or the right combination of circular design strategies. A lot of research is currently still being done on circular design strategies and it is in the emerging phase that they are used in projects. Platform CB'23 is also conducting a lot of research into circular design strategies. Platform CB'23 connects construction sector-wide parties in the Netherlands with circular ambitions. The platform contributes to the transition to a circular construction sector by focusing on building and sharing knowledge, identifying and putting obstacles on the agenda, and drawing up construction sector-wide agreements. Platform CB’23 (Platform CB’23, 2021) has produced a guideline on circular design strategies. The guideline is about circular design, the moment in which circular ambitions take shape. The guideline discusses six circular design strategies, which can be used separately and can be used in combination:

- Designing for prevention;
- Designing for the reduction of life cycle impact;
- Designing for future-proofing;
- Designing with reused objects;
- Designing with secondary raw materials;
- Designing with renewable raw materials; (Platform CB’23, 2021).

Not only the CB'23 platform has researched circular design strategies, but many other studies have also been conducted into circular design strategies. Five articles were reviewed that examined strategies to design construction projects circularly. For each article, an analysis has been made of which strategies are treated and researched. This review shows that not only Platform CB'23 has studied these six circular design strategies, but that other studies have also been conducted on the same strategies. Table 1 reveals how much each circular design strategy is appointed in the different articles.

It can be deduced from the results that each circular design strategy has emerged from at least two studies. From the review, it can be seen that the older the research, the less circular design strategies are covered in the research. Bakker et al. (2014) investigated product life extension through design in 2014, which resulted in two circular design strategies which described circularity in its broadest sense. Over the years, the circular design strategies have increasingly been classified separately, where they used to be mainly combined. In particular, the circular design strategies which are drawn up in 2014, were classified separately over the years, as more and more became known about the different strategies in circularity.

Table 1: Review articles of the parameters

Circular design strategies	Platform CB'23 (2021)	Moreno (2016)	Bakker et al. (2014)	Bocken et al. (2016)	Wastling (2018)
Designing for prevention	x	x	x		
Designing for the reduction of life cycle impact	x	x			x
Designing for future-proofing	x	x		x	x
Designing with reused objects	x		x	x	x
Designing with secondary raw materials	x			x	
Designing with renewable raw materials	x	x		x	

These six circular design strategies form the basis for developing and sharing knowledge. This group of six design strategies can be used to arrive at a tailor-made strategy. Every construction project is unique and requires a tailor-made strategy based on the parameters of the project. To clarify when which circular design strategy can best be applied, more information is needed, which is the focus of this research. It must first become clear what six circular design strategies entail and how they can be applied in circular construction projects.

2.3.1. CIRCULAR DESIGN STRATEGIES

At the moment, a circular design is not yet seen as standard in the design of construction projects. As mentioned, there are also many different strategies for working circularly, which makes standardization complicated. The six circular design strategies give concrete shape to circular ambitions in a construction project when making the circular choices, drawing up the requirements, and designing the construction project. The choices made here have a major influence on the result of the construction project. It is therefore necessary to know which design strategies exist, under which conditions you can apply them, and what the characteristics are (Platform CB'23, 2021). This chapter discusses the six circular design strategies. For each circular design strategy, drawn up by Platform CB'23 (2021) and substantiated by other studies, it is described which circular design choices should be made when, which resources should be used to implement a circular strategy, and which characteristics the circular design strategies have. Each circular design strategy is substantiated by an example project.

2.3.1.1. DESIGNING FOR PREVENTION

The strategy 'designing for prevention' focuses on preventing the use of products, elements, or materials by forgoing the structure, cleverly combining different functions, or providing a different solution. Prevention means that measures are taken to reduce the quantity of waste (Bakker et al., 2014). Prevention solutions often lie in combining objects or implementing a standard solution in a different way. Thinking along with other disciplines is also a condition for achieving success with this strategy (Platform CB'23, 2021). This strategy is especially applicable to the phase before the design phase: the initiation phase and definition phase (Platform CB'23, 2021).

Ajayi and Oyde (2018) claimed that dedicated measures to reduce waste through the design process could reduce total waste by up to a third. Prevention measures ensure that materials, products, or elements of lesser sizes should be used. Which ensures a large reduction in waste and a reduction in raw materials required for the project. The earlier a change is implemented in a project lifecycle, the more its positive impact, and the less the cost of such change. Preventive measures are similarly applicable to dedicated effort towards waste management. The earlier such effort, the more likely it would prevent waste from occurring at a later stage.

Circular thinking underpins the EU Waste Framework Directive, which presents a waste management hierarchy of prevention, reuse, recycling, other recovery, and disposal, with prevention and reuses the preferred waste management approaches (Bakker et al., 2014). According to Bakker et al. (2014) the definitions of prevention and reuse show that prevention and reuse partially overlap, as reuse also contributes to reducing the quantity of waste. Prevention and reuse can be achieved through a range of product life extension strategies, like repair, refurbishment, and remanufacturing. By including product recycling it is possible to explore the full spectrum of relevant product life scenarios in a circular economy (Bakker et al., 2014).

Moreno (2016) classifies the strategy of 'designing for preventive' as design for resource conservation. Design for resource conservation focuses on both the technical and biological cycles and uses a preventative approach in which products are designed with the minimum of resources in mind (Moreno et al., 2016a).

The strategy 'designing for prevention' does not stand alone. For example, when investigating alternatives, the impact in a life cycle perspective must be taken into account (strategy 'designing to reduce life cycle impact'). This strategy has a large measure of avoidance of (sub)objects. Avoiding (sub)objects mean reduction at a higher scale level (Platform CB'23, 2021). Leaving out things that are not needed now can affect the adaptability that will be needed in the future (strategy 'designing for future-proofing'). Long-term interests, after the first life cycle of the structure, can also be taken into account (Platform CB'23, 2021).

Example case: The strategy 'designing for prevention' has been applied in the project Rabobank Dommelstreek. Rabobank Dommelstreek has redeveloped the existing office in Geldrop. An office has been created with all facilities under one roof with a new environment that better matches the new way of working. Rabobank Dommelstreek has made a conscious decision not to go for new construction, but to redevelop the existing bank branch. At the location of the old advice center, the existing building has been stripped to its shell, renovated, and expanded. By redeveloping the existing building and making it part of the new building, the use of materials is greatly reduced. Moreover, in this way, the construction of a completely new building and the cost/time it would have taken is made unnecessary. The project focused on preventing the use of products, elements, or materials by cleverly combining different functions and offering a different solution. A different solution is offered by reusing the existing building instead of building it from scratch, and functions are combined in the building through the new way of working (Van den Pauwert architecten BNA, 2011). In this project, the focus was on the circular design strategy 'designing for prevention'. But other circular design strategies have also been applied, such as 'designing for future-proofing'. More circular design strategies can be applied per project.

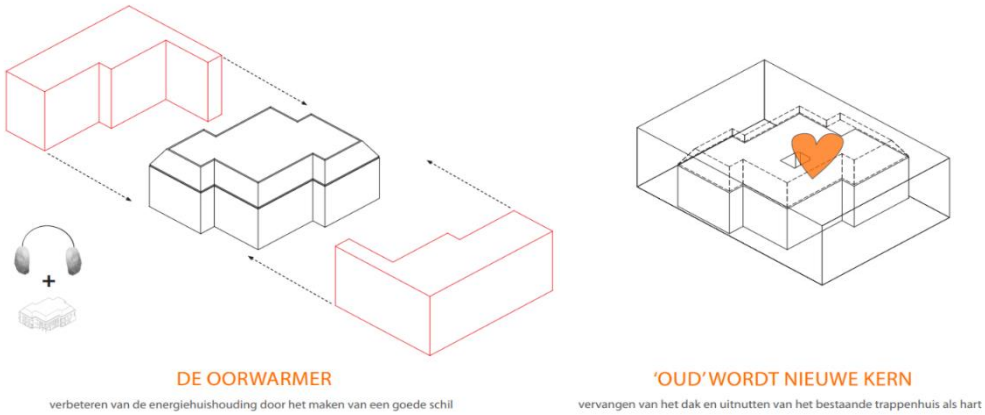


Figure 7: The old Rabobank is the core of the new Rabobank (Van den Pauwert architecten BNA, 2011)

2.3.1.2. DESIGNING FOR THE REDUCTION OF LIFE CYCLE IMPACT

By the strategy 'designing for the reduction of life cycle impact' is the impact of circular material use weighed up by providing insight into the consequences for the environmental impact and environmental performance in the use phase and at the end of the lifespan (Platform CB'23, 2021). In this perspective, all impacts determine which design variant is the most favorable. To this end, alternatives can be assessed from several sides and based on several criteria. The solution that integrally causes the lowest impact is then chosen (Platform CB'23, 2021).

According to Moreno et al. (2016), falls this strategy under design for long-life use of products: "This strategy focuses on the technical cycle and refers to extending the utilization of a product during its use through extending its life and offering services for reuse, repair, maintenance and upgrade, or by enhancing longer-lasting relationships between products and users through "emotionally durable design" to reduce the environmental impact".

Decisions made during a building's early design stages critically determine its environmental impact. However, designers are faced with many decisions during these stages and typically lack intuition on which decisions are most significant to a building's impact. Life-Cycle Assessment (LCA) is a method that can be used in the early design stages (Platform CB'23, 2021). LCA, when applied to buildings, is a method for predicting how a facility will perform over its lifetime, which includes raw material extraction, manufacturing, construction, operation, maintenance, repair, replacement, and demolition (Basbagill et al., 2013). LCA can be used in this stage to enable better early-stage decision-making by providing feedback on the environmental impacts of building information modeling (BIM) design choices. According to Basbagill et al. (2013), emphasizing the decision for this strategy early on can often deliver the most significant reductions in the embodied carbon footprint.

For this strategy, designers need to be informed about the relative environmental impact importance of the material and the dimensioning of building components. According to Basbagill et al. (2013), for designers, it needs to be mapped out which material and dimension decisions achieve the greatest embodied impact reductions. The assessment assumes at least a complete object life cycle, including an assumption for the end of the life cycle. Where possible, a future scenario is included in the assessment.

Design choices that focus on improving environmental performance in the realization phase, use phase, and end of life cannot be considered in isolation in a circular design. An integrated approach ensures that the impacts are assessed in relation to each other (Platform CB'23, 2021). Platform CB'23 (2021) gives an example that a more bindier in masonry mortar extends the potential life of the masonry, but requires a higher environmental impact on the masonry in the realization phase.

Example case: The strategy 'designing for the reduction of life cycle impact' has been part of the design strategy in the Triodos bank project. The project has an exceptionally sustainable approach to the construction process, has a design inspired by nature and the bio-based material choices are unique. The building aims to achieve a BREEAM Outstanding Sustainability certificate, the highest achievable sustainability score for buildings. Light, air, water, and energy are provided as naturally as possible and the building is completely energy neutral. The building consists of wooden construction and floors and is built to be demountable so that at the end of its life, the materials can be disassembled and reused. This project is a clear example of a project where several circular design strategies, like 'designing with renewable raw materials' and 'designing for future-proofing', are involved in order to be able to properly implement this strategy (JP van Eesteren, 2021).

Figure 8: Triodos bank, inspired by nature (JP van Eesteren, 2021)

2.3.1.3. DESIGNING FOR FUTURE-PROOFING

The circular design strategy, 'designing for future-proofing', focuses on making the design adaptable to future wishes and requirements. A building structure can be both spatially functional and technically adaptive. A building or object is spatially functionally adaptive if it can handle changes in functions and space requirements. A building or object is technically adaptive if connections are detachable and parts are accessible and physically independent of each other (Platform CB'23, 2021).

According to Bocken et al. (2016), is 'designing for future-proofing' about creating products with parts or interfaces that fit other products as well, which can also be applied at the building level. Moreno et al. (2016a) extend this strategy even further. Moreno et al. (2016a) say, that this strategy focuses on both the technical and biological cycle and refers to design aimed at enabling the longer circulation of materials and resources in multiple cycles.

The main reason for designing futureproof systems is, according to Rehman and Ryan (2018), to keep the system in service for a long time and reduce waste. Future-proofing is the act of slowing down the flow of products, ensuring they function for longer, as well as being desired and used for longer by their owner. The principle of design for product integrity concerns avoiding a product becoming obsolete in the first place, as well as designing it so that it can be restored to its highest level of value (Wastling et al., 2018). Future-proof design is one way to obtain a design that defers obsolescence and extends the system's service life and generally includes additional elements in the current solution in order to accommodate future capabilities as projections of the future solutions required to meet those future requirements (Rehman & Ryan, 2018).

The future-proofing concept deals with the issues associated with creating a design that lasts for a sufficiently long time. Future-proofing aims to ensure that a system will not be superseded by the need for future capability in a long lifecycle, and will facilitate anticipated future modifications. The future-proofing concept considers the evolution of future requirements i.e. some aspect(s) of the future use of the system such that, when the anticipated need does arise, the system will be prepared to the full extent or some desired degree (Rehman & Ryan, 2018).

According to Platform CB'23 (2021), future-proofing can be applied at different scale levels: building/artwork, construction part/element, product, and material. For buildings/artworks, it must be spatially-functionally adaptive, so that it is as flexible as possible and can function for as long as the given function or can take on another function without major adjustments. Building parts/elements,

on the other hand, must be technically adaptive. This involves aspects such as reusability, technical lifespan, and releasability. For products, the technical lifespan is important, and that it is reusable. At the material level, it is especially important that it is recyclable (Platform CB'23, 2021).

The term nurturing is important in this strategy because objects that the user or other interested party attaches to remain in use for longer. As a designer, one should strive for a building with the highest possible appreciation from users (Platform CB'23, 2021).

Projects: The strategy 'designing for future-proofing' is one of the strategies that has been applied in the DNB renovation project. After the renovation, the building is future-proof and can last for decades. The project argues for a way of building and development that is neutral about the function that a building is given. Possible adjustments by future generations are constantly taken into account and a lot of attention is therefore paid to modular construction. The building is fully adaptable and demountable. The facades are replaced by prefabricated elements, which can be removed again. The same applies to the entire interior, such as the interior walls and floor finish. Wet, glued connections are avoided as much as possible and use dry connections that can be easily loosened again (Strukton, 2021).

Figure 9: Renovation DNB with a modular construction (Strukton, 2021)

2.3.1.4. DESIGNING WITH REUSED OBJECTS

Reuse is described as using a product or component again for the same purpose for which it was conceived (Bakker et al., 2014). The strategy 'designing with reused objects' concerns the reuse of construction products or construction components/elements, whether or not after processing. Reusing components in a new function is also conceivable, such as using old facades as interior walls. A complete building or work of art can also be reused in its entirety or used for another purpose (Platform CB'23, 2021).

The essential question in this circular design strategy is: how can the functional value of an object be maximized while retaining use?

This strategy transforms objects and products to eliminate the problem of waste and its negative environmental impacts (Kozminska, 2019). Extending the utilization period of products can be a highly effective strategy for reducing the use of resources. As argued by Bocken et al. (2016) "The greenest product is the one that already exists, because it doesn't draw on new natural resources to produce". Extending the life of an existing object means that fewer new raw materials are needed compared to replacement. It contributes to the protection of existing values and resources and the prevention of

waste. Reuse has a major influence on the life cycle impact of the same (sub)object and the object in which it is applied (Platform CB'23, 2021).

The strategy 'designing with reused objects' falls under slowing of resource loops because the utilization period is extended and/or intensified, it is resulting in a slowdown of the flow of resources (Bocken et al., 2016b; Wastling et al., 2018). The strategy provides a service to collect old or used components and recover the value in the materials by reusing them to make new components (The circular design guide, 2020).

Designing for future reuse demands extended research on the layers of buildings, properties of materials, dismountable joints, maintenance techniques, and reuse scenarios (Kozminska, 2019). This strategy demands an interdisciplinary and flexible design process that reuses construction waste and enables the future reuse of building materials facilitating the collaboration of experts from diverse disciplines.

Because each object has its specific technical lifespan, it is necessary to determine the reuse options for each situation. In order to be able to reuse, the components must be detachable. The reuse of objects is influenced by the detachability within the object and between other structures with a different technical life. There are also specific risks associated with reuse. Platform CB'23 (2021) gives as an example the risk: fatigue of materials and damage due to disassembly and transport. Reusing components also faces other challenges, which concern environmental (eg, recycling potential), social (eg, social perception of reused materials), infrastructural (eg, lack of processing plants), and legal issues (eg, non-flexible construction law) (Kozminska, 2019).

This strategy, according to Bocken et al. (2016), includes "Designing for attachment and trust". Designing for attachment and trust refers to the creation of products that will be loved, liked, or trusted longer. This is also referred to as "design for emotional durability" a situation where "users and products flourish within long-lasting empathic partnerships" (Bocken et al., 2016b).

When reusing objects or sub-objects, it is essential to map out the impact throughout the entire life cycle. And then weigh this against the advantage of reuse: protecting resources and existing value (Platform CB'23, 2021).

Projects: The strategy 'designing with reused objects' is one of the strategies which is focused on by the project renovation Stadhuistoren and Stadhuis Eindhoven from !mpuls. During the design process, the natural step was used as a vision. The natural step and the red list are used when choosing new materials. However, the highest class of sustainability according to the Lansink ladder is the reuse of existing materials, which was the focus of this project. Ceiling plates that have been incorporated into the facade as insulation material, existing metal ceiling panels that have been incorporated into the parapet as sound-absorbing panels, doors that have been used as walls, etc. Other materials have been offered via a materials platform for reuse elsewhere. Everything that is left (5%) is then disposed of via reputable recycling companies. The reuse of materials and recycling of materials has provided for revenues. At the moment, however, it has cost even more time and money to find out everything in advance, because there was still limited knowledge. A mix of circular design strategies was also applied in this project. For example, there is also a focus on flexibility by using smart sun protection and a logical design grid. Floors are therefore easy to rearrange. Walls are easy to dismantle and move without major investments required. As a result, a future-proof building has also been created (Brink, 2021).

Figure 10: Renovation Stadhuistoren and Stadhuis Eindhoven

2.3.1.5. DESIGNING WITH SECONDARY RAW MATERIALS

The use of secondary raw materials ensures that depletion of natural materials is avoided and transport distances are shortened by using locally available second raw material-based materials. The strategy 'designing with secondary raw materials' involves designs with raw materials that have been used before or with residual flows from another product system (Platform CB'23, 2021). These resources are used in such a way that they replace primary resources. Secondary raw materials tend to be a valuable replacement for primary materials especially since construction works require vast quantities of raw materials (Meža et al., 2021). In this way, it contributes to the goals of a circular construction economy: after all, protecting resources and preventing waste (Platform CB'23, 2021).

In contrast to the 'designing with reused objects' strategy, this design strategy emphasizes the reuse of raw materials. Choosing secondary raw materials can influence the life cycle impact in several ways. For example, due to lower production energy or more transport energy compared to the primary material (Platform CB'23, 2021). Using second raw materials originating from recycling a broad range of inorganic waste materials (e.g., mining waste, different industrial wastes, construction, and demolition waste) has been recognized as a promising, generally more cost-efficient, and environmentally friendly alternative to the exploitation of natural resources, according to Meža et al. (2021). Despite the benefits of using second raw materials, several challenges need to be addressed before using second raw materials even more. One of them is the long-term durability and little-known response of construction works built using such alternative materials.

According to platform CB'23 (2021), the executing party must receive a functional specification instead of a prescriptive specification where possible. This allows the availability of alternatives to be combined with suitability, as the performance approaches, without prescriptive specifications creating an impediment. When making an inventory of available secondary raw materials, an estimate must be made of the future value of the material to be recycled. Roughly three qualities can be distinguished here (Platform CB'23, 2021):

- high-quality secondary raw materials (upcycling): harvested raw materials with improved quality, functionality, and/or higher value than the residual flows.
- equivalent secondary raw materials (recycling): raw materials with comparable quality, functionality, and/or value as the residual flows or the original raw material.

- low-quality secondary raw materials (downcycling): newly applied raw materials with lower quality, reduced functionality, or lower value than the source material from residual flows or the original raw material (Platform CB'23, 2021).

The design team has the option of choosing secondary material. The design team also has a major influence on the reusability of this material in the future, concludes platform CB'23 (2021). It is the responsibility of the design team to choose the application that guarantees the highest future value. A high detachability and a clean application of the material are required.

Project: The strategy 'designing with secondary raw materials' is one of the strategies which is focused on by the project, Heembouw office. Recycled and biobased building materials have been used as much as possible in the new Heembouw office. Reduce, reuse and recycle is the guiding principle for the design of the interior. Circular concrete has been used in the foundation, by means of Freement. The Smart Liberator of De Rutte Groep returns used concrete to its original raw materials: sand, cement, gravel. The circular concrete foundation has been laid and the circular concrete foundation can later be the new raw material for new constructive concrete. Recycled wood has been used for the wooden paneling of the stairs and permanent furniture. The other furniture is made from recycled material (Heembouw, 2021).

Figure 11: Circular concrete in foundation by new office Heembouw (Heembouw, 2021)

2.3.1.6. DESIGNING WITH RENEWABLE RAW MATERIALS

The construction industry is material and process-oriented, which indicates that a large number of materials (renewable and non-renewable) are consumed in a project. According to the circular design guide (2020), smart material choices are important to achieve a circular economy in the construction industry. Consideration should be given to the end-of-life treatment of a product when choosing materials and inputs, i.e. durable, biodegradable, recycled, or recyclable materials. In the strategy 'designing whit renewable raw materials', attention is mainly paid to biodegradable. The strategy is designed with non-renewable resources such as fossil, water, minerals, and fuels can be conserved, environmental impacts can be reduced through efficient material and energy use including less water discharge, use of toxic materials can be avoided, local ecosystems can be recovered, and the lifespan of landfill can be extended (Geng et al., 2012).

The strategy 'designing with renewable raw materials' is about designing with as much as possible or only building materials from renewable sources. Renewable raw materials are grown, naturally supplemented, or naturally cleaned (Platform CB'23, 2021). With this strategy, products of objects are designed with safe and healthy materials that create food for natural systems across their life cycle.

According to platform CB'23 (2021), the use of renewable raw materials prevents the use of non-renewable raw materials and their possible depletion. It thus directly contributes to the protection of resources and the regeneration of biotic and renewable abiotic raw materials. According to Moreno et al. (2016), this strategy must mainly focus on the biological cycles and refers to thinking of "waste

equals food" in which resources are captured and returned to their natural cycle without harming the environment. Materials from renewable sources are by definition circular if the biological cycle is not broken. This is the cycle in which biological nutrients are returned to the biosphere. Biodegradability is the capability of being degraded by biological activity, compositing is a related process, in which organic matter is biologically decomposed, performed by microorganisms, mostly bacteria, and fungi (Bocken et al., 2016). And in such a way that natural capital is restored and the regeneration of biotic raw materials becomes possible (Platform CB'23, 2021). A risk is that renewable materials are placed outside the biological cycle through non-releasable combinations with non-renewable raw materials. The strategy "design for dis- and reassembly" is important for this design strategy. Design for dis- and reassembly is also vital for separating materials that will enter different cycles (biological or technological cycle) (Bocken et al., 2016).

A renewable resource can be depleted, but sustainable management and good stewardship prevent this. A renewable raw material can be of both abiotic and biotic origin. Abiotic raw materials are minerals, metals, and fossil raw materials that are obtained from nature. Biotic raw materials are extracted from living sources and are of vegetable or animal origin. Renewable material is produced from renewable raw materials (Platform CB'23, 2021). Platform CB'23 (2021) also strives to use renewable raw materials from the immediate environment, which are in balance with the local ecology. Transport of raw materials requires energy and can increase the pressure on certain regions disproportionately.

With this design strategy, the exposure to the elements should be taken into account in the design. All materials degrade through exposure to the elements. Taking maintenance and replacement into account in the design is therefore essential. Due to the functioning of the biological cycle, renewable materials can degrade prematurely in the event of ill-considered detailing, insufficient protection, or an unfavorable orientation in a structure. The design team is responsible for a proposal for the maintenance and replacement strategy of these objects (Platform CB'23, 2021).

Projects: The strategy 'designing with renewable raw materials' is one of the strategies that the project Floating Office Rijnhaven focused on. The project complies with a strict code of conduct for BREEAM certification, which means that sustainability, energy savings, and the environment are taken into account on all fronts during the design and construction. The building is largely built of wood and can be completely dismantled. In CLT (Cross Laminated Timber) a complete pinewood hull is built up of 3 layers. This hull consists of laminated pine uprights, beams, cross-glued thick upper floors, and roof. The wooden appearance gives a comfortable feeling, which is positive for the quality of the project. This includes the balconies on both facades on the 1st and 2nd floors. The facades will be largely filled with structural glazing and partly with Platowood cladding on HSB elements. Using wood as the main construction material significantly reduces the building's CO2 footprint (Brink, 2021).

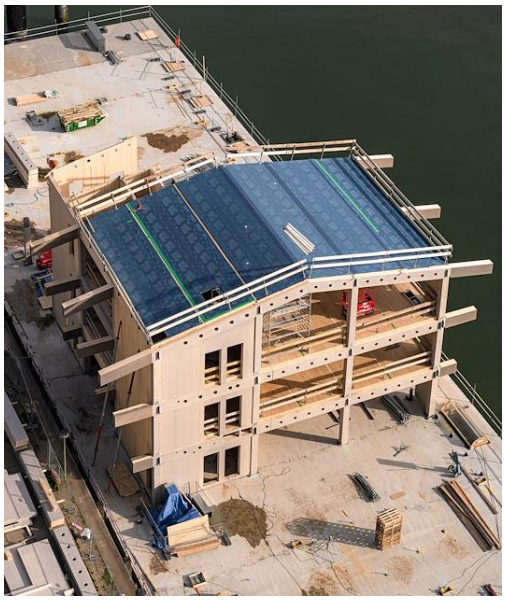


Figure 12: Floating office Rotterdam, largly built of wood (Brink, 2021)

2.3.2. CHARACTERISTICS OF CIRCULAR DESIGN STRATEGIES

In order to see clear differences and similarities between the six circular design strategies, the characteristics per circular design strategy are mapped out. Based on the characteristics of the circular design strategies, choices can be made between the different circular design strategies to create a tailor-maid strategy. These characteristics of each circular design strategy can be drawn upon the basis of the literature review on the six circular design strategies. Table 2 shows all characteristics per circular design strategy.

Table 2: Characteristics of the circular design strategies

Circular design strategies	Characteristics	Circular design strategies	Characteristics
Designing for prevention	Refuse Less material use Minimalist construction Reduce (Combining functions) Re-use (objects)	Designing with reused objects	Re-use Detachable (Technical) Lifespan
Designing for the reduction of life cycle impact	Environmental impact (use phase / end of life) Material/object life cycle End of life cycle Lifespan Detachable (modulair and remontabel design) Rethink	Designing with secondary raw materials	Secondary raw materials Recycle (upcycling, downcycling) Repurpose Remanufacture Detachable Re-use
Designing for future-proofing	Flexibility (Spatial-functional adaptive) Adaptability Re-use (Technnical) Lifespan	Designing with renewable raw materials	Renewable raw materials Detachable Compostable Material/object life cycle

The characteristics indicate what the circular design strategies consist of and the way of circular designing a construction project. Each circular design strategy has its way of designing, which sometimes requires characteristics of other circular design strategies. Some characteristics also appear in multiple strategies, these are indicated by an underline.

Applying the characteristics and thus the circular design strategies can vary in which layer of a building it is applied. For this, the characteristics can be placed next to the Layers of Brands. In appendix A is an overview of the characters linked to the Layers of Brands. Based on the assumption that these layers have different life cycles, design decisions can also be made regarding their end-of-life scenarios (van Vliet et al., 2019).

2.3.3. CIRCULAR DESIGN STRATEGIES LINKED TO LEVELS OF CIRCULARITY

The six circular design strategies are discussed above. Based on this information about the circular design strategies, better decisions for circular designs can be made, it can be used for standardization and spreading information, and it can be used for the basis of the model to get more knowledge about circularity. However, there is still some missing information and not everything can just be applied or it is not optimal to apply. As described before, a tailor-made strategy refers to a project-specific composition of relevant design strategies that the project team puts together. However, it is the building assignment (project parameters) that determines which design strategies are applicable, according to Platform CB'23 (2021). This can be further investigated in what sizes and in what way each circular design strategy applicable is. Not every situation lends itself to all six circular design strategies described. The role of the project team will also be different in one of the six circular design strategies. Client (eg. state, municipality, developer), architect, advisor, and contractor are four

categories of roles involved in a circular design process and part of the project team. They are part of an ecosystem, in which the role can vary per circular design strategy (Platform CB'23, 2021).

Based on the information collected above, the circular design strategies can be linked to the 10-R model. The level of circularity is presented in the 10-R model, which is presented earlier in the literature review. The 10-R model represents the different circularity strategies with a priority order from high too low to prevent raw materials and material use and waste production. The circularity strategies are divided into three groups: smarter product use and manufacture, extending the lifespan of the product and its parts, useful application of materials. Each group represents the degree of circularity. PBL gives the rule of thumb: more circularity = fewer raw materials and less environmental pressure. The bottom group, useful application of materials, is not necessarily focused on less material use, and the circular strategies that are lower on the ladder fall under this. The middle group, extending the lifespan of the product and its parts, already ensures that fewer materials are needed later on. This includes the circular strategies that are already higher on the ladder. The circular strategies that are highest on the ladder are the most circular and fall under the group of smarter product use and manufacture (Meijers, 2020).

All six circular design strategies can be placed in the 10-R model, shown in Figure 13. This figure shows that all circularity strategies are captured by the six circular design strategies. Each circular design strategy consists of different levels of circularity and group. Only the circular design strategy 'designing with renewable raw materials' does not cover a circularity strategy in the R-model but is one step better in the area of circularity.

What is also mentioned before, the higher the circular strategy is ranked on the ladder, the lower the need for resources and the pressure on the environment, and thereby more circular. Circular design strategies can also be approached in this way. Circular design strategies that are higher on the ladder, such as 'designing for prevention' and 'designing for reduction of lifecycle impact', will ensure a lower need for resources and a lower pressure on the environment. The 10-R model also stated that higher circular strategies come with innovations that affect the whole supply chain. These kinds of innovations can lead to changes in written and unwritten rules, habits, and attitudes for stakeholders throughout the product chain (Platform CB'23, 2019). On the basis of Figure 13, an overview has been created of the ranking of the circular design strategies on material use and emissions, and the amount of innovation required for the circular design strategy.

LEVELS OF CIRCULARITY

Groups	Strategies	Explanation
Smarter product use and manufacture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1 Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)
	R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
Extend lifespan of product and its parts	R3 Re-use	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function
	R4 Repair	Repair and maintenance of defective product so it can be used with its original function
	R5 Refurbish	Restore an old product and brink it up to date
	R6 Remanufacture	Use parts of discarded product in a new product with the same function
	R7 Repurpose	Use discarded product or its parts in a new product with the same function
Useful application of materials	R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9 Recover	Incineration of materials with energy recovery

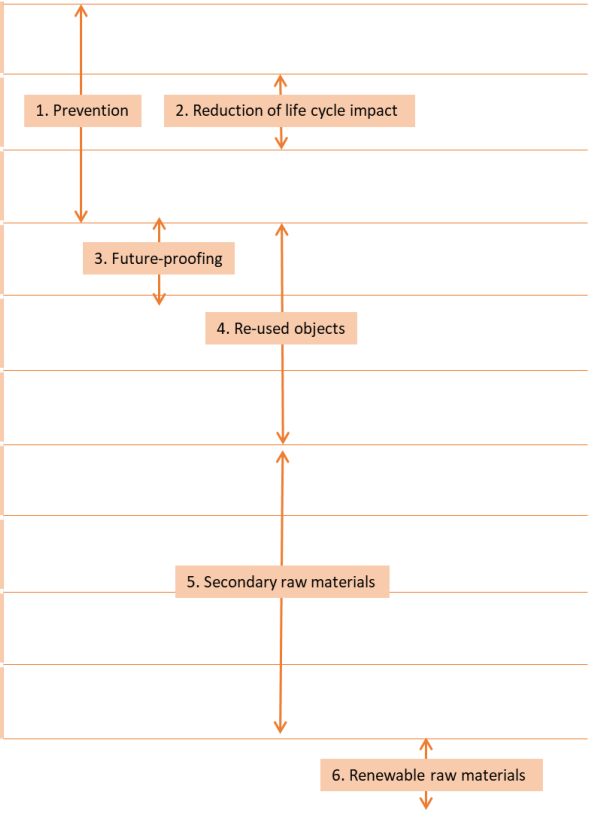


Figure 13: Levels of circularity based on the 10-R model

2.4. PROJECT PARAMETERS

Each construction project will have its unique characteristics, but the processes of construction itself are repeated in their essentials from project to project (WEF, 2016). Because each construction project is unique, standardization for circularity is difficult. A construction project can be categorized by project parameters. The value of the project parameters will be different for each project, which means that each project will have to build circular in a different way. Considering these project parameters is therefore important for any construction project.

Many project parameters determine the characteristics of a construction project. Table 3 presents the main project parameters found in the literature. For each article, there is looked at which project parameters are treated and researched. Based on these articles, a list of project parameters, which according to the literature should be used in practice, has been drawn up. In the remainder of this study, it will be examined whether these parameters are used in practice.

It can be distracted from the results that each project parameter is appointed in at least one study. The project parameters ‘investment size’, ‘number of stakeholders’, ‘productivity’, and ‘lifespan’ are at least common in the studies. The project parameter “complexity” occurs in all five studies. According to the different literature, this list of project parameters can be used to categorize projects and create a tailor-made strategy. The project parameters provide more information about the projects, which makes it possible to determine which circular design strategy can be applied best. The connection between the project parameters and which circular design strategies can best be applied is investigated in this research.

Table 3: Review articles of the project parameters

Parameters	Chitkara (1998)	Youker (2017)	Linares Garcia (2018)	Archibald (2013)	Tukel and Rom (1997)
Project size	x	x			
Project type			x	x	
Investment size					x
Duration		x	x		x
Complexity	x	x	x	x	x
Number of stakeholders				x	
Environment		x	x	x	
Productivity	x				
Series of projects or one of a kind		x	x	x	
Level of detail		x	x		
Urgency		x		x	
Lifespan			x		

2.4.1. PROJECT PARAMETERS OF CONSTRUCTION PROJECTS

This section attempts to define the unique parameters of different types of projects, which are mentioned in Table 3. Project parameters can be used to categorize construction projects but also outline how the project management approach must vary for each different type of project (Youker, 2013). A project manager must know something about different types of projects and how the project management approach must differ for the different types of projects. Many different project parameters have been found in the literature. The project parameters determine the outcome of a project but, according to Chitkara (1998)**,** the six main parameters that can sufficiently define a construction project are size, complexity, quality, productivity, completion time, and cost.

The project management profession needs a categorization system for different types of projects to communicate effectively (Youker, 2013). According to Youker (2013), the categorization of projects is based on the product or deliverable of a project. Youker (2013) has also developed a list of the project parameters that define the difference between projects: size, duration (length of time), geographical location, investment cost (large, medium, or small), complexity, and urgency.

Linares Garcia et al. (2018), considered also multiple critical decision-making parameters to categorize projects and to reflect project decisions. Linares Garcia et al. (2018), have examined the following parameters: Type of project, Project delivery methodology, location setting, crossing conditions, project length, project width, project max span, winning bid, and cost per square foot. Many of the parameters correspond to those examined by Youker (2013) and Chitkara (1998). Some of the parameters have not been named before and are not included further. Some parameters' names are changed later in the research to convey a clearer understanding.

Archibald (2013) has researched a global system for categorizing projects. Archibald (2013) has identified the many parameters of projects that could conceivably be used as criteria to categorize projects: stage of life-cycle, grouped or single, geography, timing, uncertainty, stakeholder, and complexity.

Tukel and Rom (1998) have conducted a nationwide survey, to identify and categorize parameters of projects as well as performance measures and constraints. The results demonstrate that while many common project characteristics exist, there are noticeable differences in projects across industries. Some unexpected results are discovered, for example, for many project managers, maximizing project quality is more important than other scheduling objectives examined in the literature (Tukel & Rom, 1998). From the research of Tukel and Rom (1998), a few similar project parameters were found with the other studies, like investment size, duration, and complexity.

According to the literature, the project parameters presented in Table 3 are the most important parameters for categorizing projects and drawing up a tailor-made strategy. It has also emerged from the literature that the project management approach must vary for each different type of project. It must be clear to project managers what kind of project it is, after which they can act and communicate better. Due to the limited knowledge about circularity, project managers must use the project parameters for circular projects. What the parameters mean is further described below.

2.4.2. DEFINITIONS OF THE PROJECT PARAMETERS

The different researches combined provide the list of project parameters. A definition is given for each project parameter, based on the literature.

- Project size: Denotes the number of tasks to be executed in a project and each task is measured in terms of quantities of work involved. Project size can be measured in several dimensions but the amount of surface (m2) or other scarce resources (skilled people, facilities, other) are the most tangible and obvious (Archibald, 2013). This study looks at the amount of surface (m2).
- Project type: Projects can be divided into three project types: new construction project, renovation project, or temporary project.
- Duration: Depends upon the speed with which the project is to be executed. The duration defines the period from the initiation phase up to and including the realization phase.
- Investment size: Investment size ensure the financial stability of the construction project at various stages of its life cycle. At the pre-investment stage, the financial model and budget of the project are considered as a mechanism for ensuring the sustainability of the project (Mishlanova, 2019). The scope of the investment for circularity is important for this research. Is there room to focus more on circularity or does everything have to be researched within a tight budget? What is still possible and what is not?
- Complexity: Is a measure of variety like tasks to be executed. Complexity increases as the number of dissimilar task increase and it decreases if the tasks are repetitive (or similar). Managers of high complexity projects rate the average importance, their success criteria, and the importance for the customer, supplier, and stakeholder satisfaction significantly higher than those of low complexity projects (Müller & Turner, 2007).
- Number of stakeholders: Stakeholders is the term used to describe those who have an interest in, or concern for, the activities of a project. Stakeholders vary depending on a wide number of factors therefore within a construction project there are many different possible stakeholders (Moore, 2021).
- Environment: Every construction project influences the environment, but an environment also influences the construction project and especially the construction process. Is the building located in the middle of the busy city or on a stretched-out plot of land?
- Productivity: In its broader sense, measures the ratio of a planned effort to produce a unit quantity of work divided by the actual effort employed to achieve this unit of work (1998).
- Series of projects or one of a kind: Serial building is seen as efficient and entails several advantages. With serial construction, the concept has been worked out down to the last detail and can be implemented again and again. With one of a kind project this efficiency is lower, the project still has to be fully thought out and elaborated, just to set up a project.
- Level of detail: Level of detail refers to architecture. Is there a high level of detail in the design or is the design kept simple? The detail level looks at the complexity at the element level. Are the connections complex or kept simple, etc.

- Urgency: How urgent something is, is the degree to which something is stringently desired or needed. Construction projects can differ in urgency. For this research, it is important to know whether circularity is urgent in the project or not. The urgency of circularity in a project is determined by the client.
- Lifespan: The lifespan of buildings is composed of a series of interlocking processes, starting from initial architectural and structural design, through to actual construction, and then to maintenance and control as well as to eventual demolition or renovation of buildings. Inside this lifespan, essential requirements are generated from considerations of social, environmental, and economic issues for high-efficient energy-saving building systems in compliance with building codes and regulations (Chen et al., 2006).

Any of these, or any combination of the project parameters, could be used to categorize a project, according to Archibald (2013). The parameters are interdependent and interactive, which means that each parameter is a function of the other.

2.5. CONCLUSION

Due to the need for a transition towards a circular economy, there is a great demand for more knowledge and awareness of applying circular principles in the AEC industry. Bringing awareness to the detriment caused by the construction industry's linear economic model is cited as a first step to enable the adoption of a circular economy model in the AEC industry. The complicating factors of the implementation of circularity in the AEC industry are different barriers (Guerra & Leite, 2021b; Kirchherr et al., 2018). Barriers with a lot of impacts are the lack of awareness, lack of knowledge, and change resistance. By reducing these obstacles, there will be less resistance to circularity in the AEC industry and the transition will be faster.

To add circularity to construction projects, it is important that awareness is created and that circularity is steered towards. Through correct management and awareness, several barriers to applying circularity in the AEC industry will be overcome. A construction project is managed throughout the entire process on some management aspects: cost, time, and quality. Here is a role for the project manager in steering and raising awareness of circularity in a construction project. It is important to make all parties aware of circularity in the right phase. The most important steps can be made by the project manager in the definition phase where the three management aspects are weighed up. By giving more insight into the effect of circularity on the three management aspects, better considerations can be made for certain choices and circularity can be controlled throughout the project. By providing the project manager with insight, the project manager must have more leverage when steering towards circularity. This subject is currently a large research gap that this research is focusing on.

To access transparent data to make more informed decisions and to get the structural change into the system, it is important to translate circularity into circular design strategies. The European Commission also associates the move to a more circular economy with circular strategies. Circular strategies can enable economically viable ways to continually reuse products and materials, using renewable resources where possible. Based on the information about the circular design strategies, better decisions for circular designs can be made, it can be used for standardization and for spreading information. In this research, the information about the circular design strategies is used for the basis of the model to get more knowledge about circularity.

Every construction project is unique which requires a tailor-made strategy based on the parameters of the project. The group of six circular design strategies can also be used to arrive at a tailor-made strategy. It becomes clear what the six circular design strategies entail and how they can be applied in

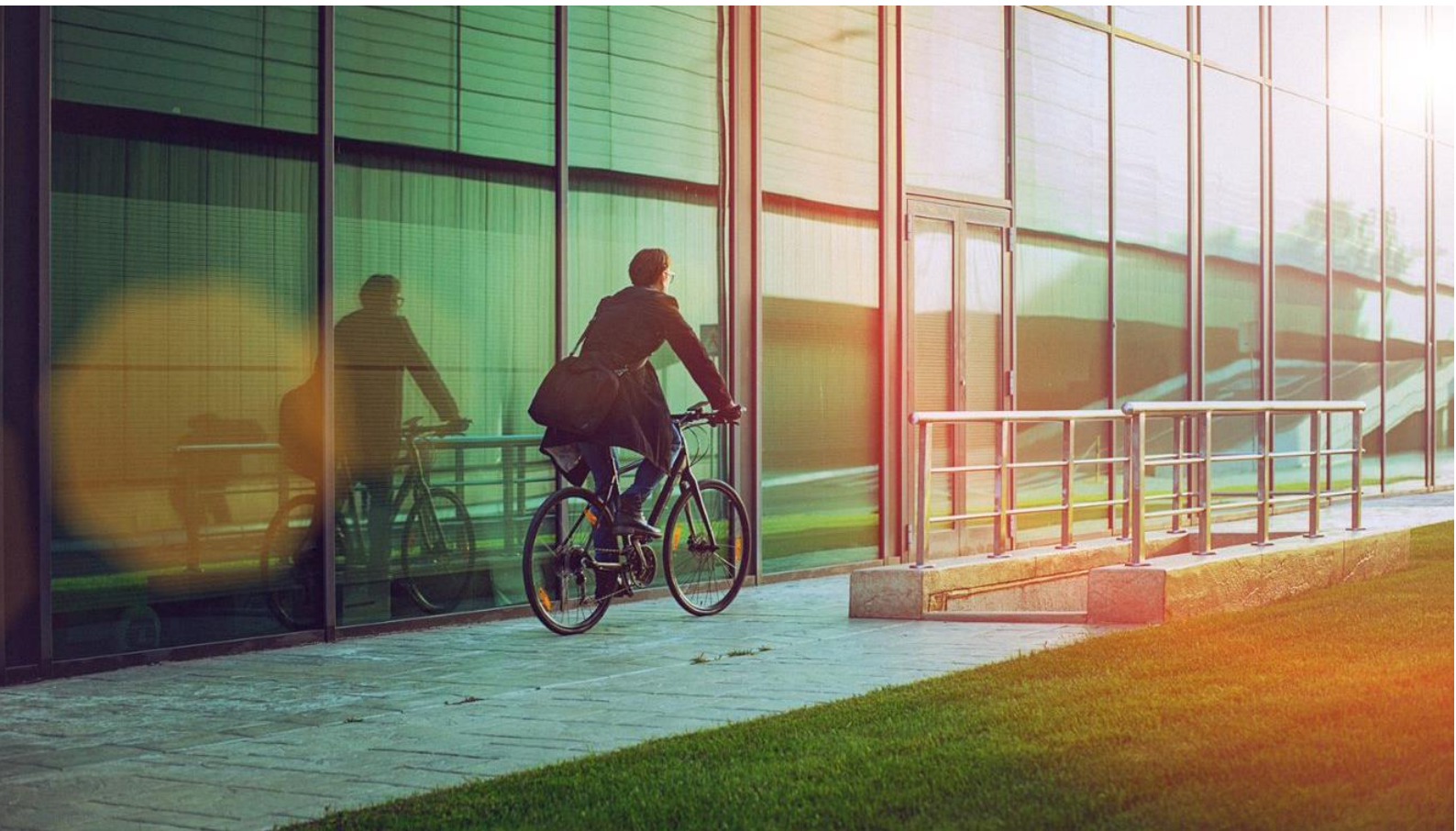
circular construction projects. Not every situation lends itself to all six strategies described. To clarify when which circular design strategy can best be applied, more information is needed. Collecting this needed information is the focus of this research.

As mentioned before every construction project is unique which requires a tailor-made strategy based on the parameters of the project. The value of the parameters will be different for each project, which means that each project will have to build circular in a different way. Based on the literature, 12 project parameters have been prepared. Any of these, or any combination of the project parameters, could be used to categorize a project. The parameters are interdependent and interactive, which means that each parameter is a function of the other. Considering these project parameters is therefore important for any construction project. Which can give more information about adding circularity in construction projects.

Insight into the effects of the circular design strategies 'designing for prevention', 'designing for the reduction of life cycle impact', 'designing for future-proofing', 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials' on circular construction projects is important to create more awareness and more knowledge about circularity in the AEC industry. To be able to define the construction projects, the twelve project parameters 'project size', 'project type', 'investment size', 'duration', 'complexity', 'number of stakeholders', 'environment', 'productivity', 'series of projects or one of a kind', 'level of detail', 'urgency', and 'lifespan', is needed. This research will provide insight into all this information, which can give the project manager more guidance in steering and creating awareness about circularity in construction projects.

CHAPTER 3.

METHODOLOGY



CHAPTER 3. METHODOLOGY

Chapter 3 presents the methods and techniques used to achieve the research objective and to answer the research question and sub-questions. The research objective this research wanted to achieve was:

"To help clients by taking the next step in the move from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies to advise clients in this process."

The following main question was prepared to answer in this research:

"How can a project manager advise clients in making circular choices by using circular design strategies in the definition phase for the construction project?"

With the following sub-questions:

> *"Which circular design strategies are there for the built environment and which characteristics do the circular design strategies have?*
>
> *Which parameters are there to categorize the construction projects and what influence do the project parameters have on the aspects of cost, time, and quality?*
>
> *What are the consequences of the project parameters for the choice for one or a combination of circular design strategies and for the three aspects of cost, time, and quality?*
>
> *How can the project manager interpret and use the outputs of this research to advise clients in making circular choices in the definition phase for the construction project?"*

3.1. RESEARCH METHODOLOGY

To be able to answer the research questions, the research has been split up into three different phases. The research questions for each research phase, the methods used to answer each question, and the delivered products per phase have been incorporated into the research design. The visualization of the research design can be found in Figure 14.

The first phase consisted of the exploration of literature to answer sub-question 1 and sub-question 2. The first phase delivered the theoretical background on circular design strategies, the characteristics of the circular design strategies, what circular economy and the circular design strategies entail for the built environment, and which project parameters there are in the built environment. The literature review has been supported with example cases of circular projects that have applied circular design strategies. This phase was aimed at gaining insight into the role of project management by implementing circular economy, into which phases the focus lies on the circular economy, and on how circular economy work in the AEC industry and its barriers. This phase has also set the basis for understanding the nature of circular design strategies and project parameters. Phase 1 is elaborated in a literature review with a conclusion that identifies the concepts that had to be further investigated in the following phases. The literature review has offered a good starting point for this design science research.

The design science research has taken place in phase 2. The second phase aimed at getting a deeper understanding of which project parameters are used in practice to categorize construction projects (2), what influence the parameters have on the aspects of cost, time, and quality (2), what the

consequences are of the project parameters on the choice of circular designs strategies and for the three aspects cost, time, and quality (3), and how the project manager can interpret and use the outputs of this research to advise clients (4). To achieve these goals, explorative interviews, expert interviews, and surveys have been conducted. First, research question 2 is further answered through explorative interviews with experts. The parameters to categorize construction projects drawn up in the literature review are checked based on explorative interviews with experts. The project parameters that have been emerged from this research are used to answer research questions 3 and 4. Once the parameters are clear, the set-up for the interview research starts. This part of the research is based on the Delphi Method. Experts from the built environment with knowledge about circularity and circular design strategies have been the target group of this part of the research. Expert interviews were first conducted with the target group, followed by surveys based on the results of the interviews. Based on the expert interviews, it has become clear what the effects of all the parameters are on the three aspects of cost, time, and quality and on the choice for the circular design strategies. The surveys, conducted by the same target group, have been provided consensus on the collected data from the expert interviews.

The last phase included a synthesis of the previous phases. The last phase included the merging of the findings from the literature and the design research. This has resulted in a model that the project managers can use when advising the clients. Once the model is made, a validation of the model in a construction project is done. The validation resulted in information on how project managers interpret and use the model to help clients make their tailor-made strategies. The last phase resulted in the development of the model and in answering the last research question and the main research question.

In the following paragraphs, the methods and techniques that are used to arrive at the products and results are described.

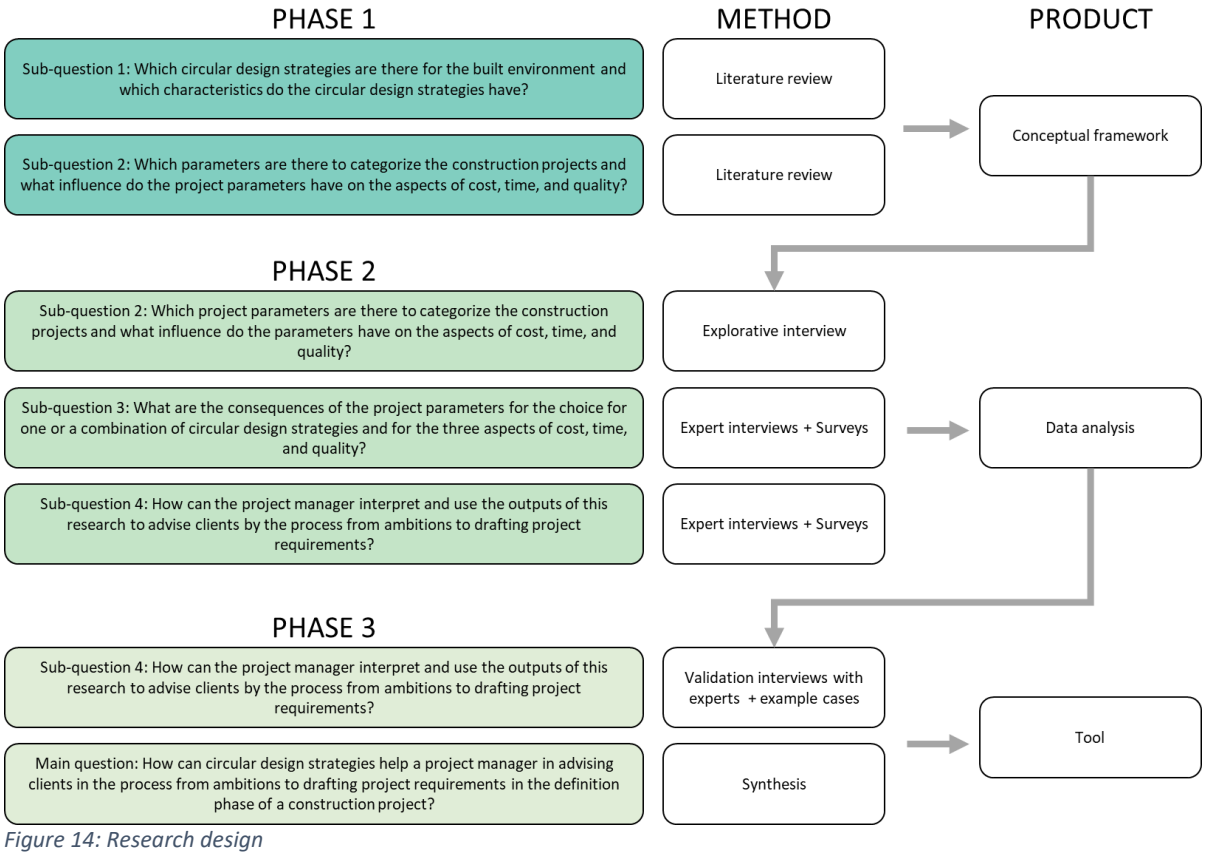


Figure 14: Research design

3.2. LITERATURE REVIEW

As mentioned, the literature review has been carried out in the first phase and has formed the basis for the following phases.

The literature review aimed to answer the following sub-questions:

1. *Which circular design strategies are there for the built environment and which characteristics do the circular design strategies have?*
2. *Which parameters are there to categorize the construction projects and what influence do the project parameters have on the aspects of cost, time, and quality?*

The literature review aims to collect fundamental knowledge about the circular economy in the AEC industry, circular design strategies, and project parameters. The consequences of the circular economy on the AEC industry and the obstacles that the circular economy entails in the AEC industry have been discussed. Afterward, the literature review has been focussed on the circular design strategies, after which the characteristics of the circular design strategies were drawn up. To map out in which phase of the project and who is involved in the obstacles that circular design strategies entail, the life cycle of building and the important management aspects have been discussed. Last of the literature review, to be able to distinguish between construction projects later in the research, project parameters have been discussed.

The topics that have been looked at in the literature review included:

- Circular economy in the AEC industry;
- Circular design strategies and their characteristics;
- Lifecycle of building and role of project manager and management aspects by circular construction projects;
- Project parameters to categorize construction projects.

Secondary sources have been used to arrive at the correct information with the literature review and to be able to answer the research questions. Secondary sources provide second-hand information and commentary from other researchers. Examples of secondary sources are journals articles, reviews, and academic books. To support the literature review, also example cases have been used, mainly to underpin the circular design strategies.

The literature review has been used to develop a conceptual framework, which is used as a foundation for the continuation of this research. The conceptual framework summarizes all the conclusions and findings of the literature review so that all missing information is revealed. In this study, research was carried out into the missing information.

3.3. DESIGN SCIENCE RESEARCH

The design cycle of the design science research has been used to carry out this research. The design cycle is one of the methodological research cycles recognized in academic research. Design science research is developed as a way to carry out formative research to test and refine educational designs based on theoretical principles derived from prior research. But design research is not aimed simply at refining practice. It should also address theoretical questions and issues if it is to be effective (Collins et al., 2004). The internal design cycle is the heart of any design science research project. This cycle of research activities iterates more rapidly between the construction of an artifact, its evaluation, and subsequent feedback to refine the design further. During the performance of the design cycle, it is important to maintain a balance between the efforts spent in constructing and evaluating the evolving design artifact. Both activities must be convincingly based on relevance (Hevner, 2014). The design artifact for this research is the following:

"To overcome problems with introducing circular economy in construction projects, a decision support tool should be used, to develop well-founded circular decisions, to help clients in by taking the next step in the move from circular ambitions to circular project requirements."

Design science research is an iterative process and consists of four phases. The four phases have been completed during this research. Figure 15 shows the iterative process of design science research. The required data has been collected in different ways in the different phases. The data is collected using explorative interviews, the Delphi Method, and validation interviews.

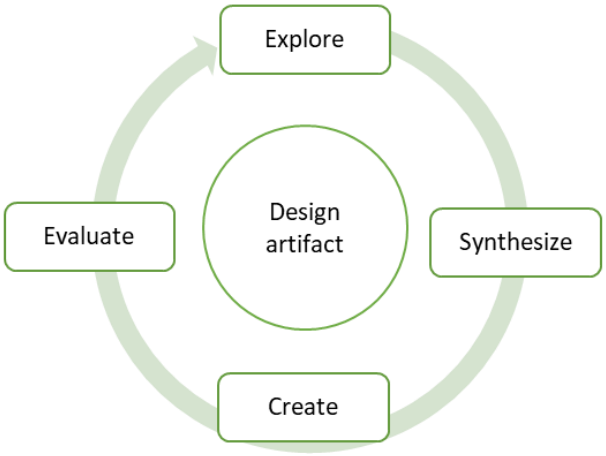


Figure 15: Design science research (Wieringa, 2014)

3.3.1. EXPLORATIVE INTERVIEWS

The project parameters found in the literature are theoretical project parameters. The research aims to include further in this research, project parameters that are used in construction projects. To validate the project parameters found in the literature with what is used in construction projects by experts, explorative interviews were held with experts.

There are three fundamental types of interviews: structured, semi-structured, and unstructured. Structured interviews are, essentially, verbally administered questionnaires, in which a list of predetermined questions are asked, with little or no variation and with no scope for follow-up questions to responses that warrant further elaboration. An unstructured interview is an interview in which questions are not prearranged. Semi-structured interviews consist of several key questions, but also allow the interviewer or interviewee to diverge to pursue an idea or response in more detail (Gill et al., 2008). Part of this research was to gain insights into the parameters that can categorize construction projects. To gain insight into the various parameters that can categorize construction projects, it was decided to conduct semi-structured interviews at different levels.

The explorative interview that is performed consists of three parts. The first part has mainly focused on the interviewee's experience with construction projects and the interviewee's role in the construction process. Subsequently, the second part has consisted of topics that correspond to setting parameters for categorizing construction projects. The last questions have been asked about the experience of the interviewees with circular construction projects. The semi-structured interview has helped with finding the project parameters that are used in the practice and gives more background information about the expertise of the experts. By using semi-structured interviews, the experts had the opportunity to make additions and explain in more detail.

To also look at the project parameters from a circular point of view, the questions from the interview protocol were also asked to experts with an interest in sustainability and circularity. This was questioned through a brainstorming session. During the session, all respondents could individually answer the questions and tick when they accepted or rejected the parameters. During the brainstorming session, the experts could also make additions or explain things in more detail.

Project parameters are set to be able to categorize construction projects and affect the three management aspects cost, time, and quality. The explorative interviews and the brainstorming session

have been held with the various experts because each expertise looks at the projects differently. More information about the parameters and whether the parameters are complete has been obtained through these explorative interviews and brainstorming session. The parameters that have been emerged from this have been used in research questions 3 and 4.

Guiding themes and questions interviews

The following questions have been the focus of the explorative interviews and the brainstorming session:

1. When you think about project parameters, what do you think about them?
2. Is there a way that you distinguish projects from each other?
3. I have drawn up these parameters so far, are there any parameters missing here?
4. I have drawn up these parameters so far, are there any parameters that do not belong here?

Attention has also been paid to the management aspects. To find out how important these are and whether they are seen as parameters or as management aspects, the following types of questions are asked:

1. Do you think that the terms cost, time, and quality also belong to the parameters, or do they have a different function?

The detailed interview protocol can be found in Appendix B. Due to the semi-structured way of interviewing and by using a brainstorming session, this protocol only served as a guideline and has the interviewer follow the interviewee based on the course of the conversation (Gill et al., 2008). Because the project parameters are looked at from two angles (project managers vs. experts with interests for circularity), the response of the interviews varied between interviewees based on the interviewee's expertise. But the list of project parameters validated by the expert is at the start the same for every interview (structured part of the interview). For each project parameter, the interviewees indicated which project parameters are used and whether project parameters are missing. In this way, it has been validated whether the project parameters are used in practice, whether project parameters should be added, and to get a better understanding of this topic from different expertise.

Data collection

The explorative interviews are included face to face interviews. For the explorative interviews, an interview protocol has been set up in advance. The brainstorming session was also held face to face and addressed the same questions as formulated in the interview protocol. The interviews and the brainstorming session have been recorded, the most important statements and explanations have been transcribed, and the completed table with accepted and rejected parameters has been processed in an excel overview. The most important statements from the interviews can be requested from the researcher.

The data was collected from project managers in the construction field. These are the experts who apply the project parameters to categorize projects and who play an important role in implementing the results of this research. The second group of experts who were presented with the same questions through the brainstorming session is experts with an interest in sustainability and circularity. As a result, the project parameters have been looked at from two different angles.

Data analysis

Binary data has been used to analyze the data collected in the explorative interviews and the brainstorm session. By using binary data there is evaluated whether something is accepted or something is rejected. Binary data can have only two values, accepted is 1 and rejected is 0. Binary data are useful for calculating proportions or percentages, such as the proportion of defective products in a sample or the percentages of accepted data (Frost, 2021). By the data analysis of the explorative interviews, the binary data has been used to determine the percentage of accepted data per project parameter. If the percentage of the project parameter is higher than the median, the project parameter is accepted. If the percentage of the project parameter is less than the median, the project parameter is rejected (Frost, 2021). Based on the data analysis, it is determined which project parameters are further included in the research and which project parameters are not included.

3.3.2. DELPHI METHOD

Concerning the research problem, this research has specified the Delphi Method as crucial to get a clear overview of the effects on construction projects by choosing circular designs strategies. In this research, the expert's opinions are described by linguistic terms, to make the consensus of the experts consistent, utilize the Delphi Method to adjust the rating of every expert to achieve the consensus condition (Ching-Hsue Cheng, 1999).

The Delphi Method (DM) is defined by Okoli and Pawlowski (2004) as follows:

"Delphi can be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem."

To accomplish this "structured communication" there is provided: some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses. There are many different ways to conduct a DM and there is not one method that is the best or appropriate way to perform (Okoli & Pawlowski, 2004). For this research, the DM was used in a way in which the four aspects of structured communication were applied.

The DM uses a carefully designed questionnaire, which is developed and tailored in several rounds. In this research, an interview and survey are used to arrive at the results. A target group should be determined for the interviews. Based on the target group, experts are asked to participate in the study. The experts engaged are interviewed anonymously and are then confronted with each other's knowledge and points of view. The interviewees do not know each other and do not know who else has taken place in the panel of experts. At the DM there is a feedback mechanism. Information obtained is recorded and reported to participants at regular intervals as part of a new attempt at information processing. Feedback is not only about the actual expectations for the future that are expressed, but above all also about the arguments and considerations underlying those expectations (Saffie et al., 2016). In this way, there is working towards a well-founded joint position, according to Saffie et al. (2016). By confronting the participants with each other's ideas and insights in each new round, it is possible to work towards a consensus. The number of participants is not important. However, there must be a guarantee that diverse interests and problem definitions are addressed, so that a problem or topic is viewed and discussed from different points of view (Toolshero, 2021). This is done by having different target groups, like clients, project managers, sustainability consultant, architects, and contractors, that all have different views on the subject.

The process to perform the DM is shown in a process flow diagram, Figure 16. The process is divided into three phases. In the first phase, the collected information, found in the literature review and the

explorative interviews, has been used to draw up the interview protocol. After drawing up the interview protocol, the questionnaire has been executed by a pilot group to find out whether the interview is complete. In phase two, the focus was on optimizing the questionnaire and finding the right respondents. In phase two, the interview has also been conducted with the respondents. In phase three, the results have been summarized and analyzed. The summarized results have been linked back to the respondents and the second round, which is a survey to find consensus about the data, has been conducted again. The results of the second round have also been analyzed. The iteration of conducting interviews/surveys, summarizing, and analyzing has been continued until there was consensus about the results.

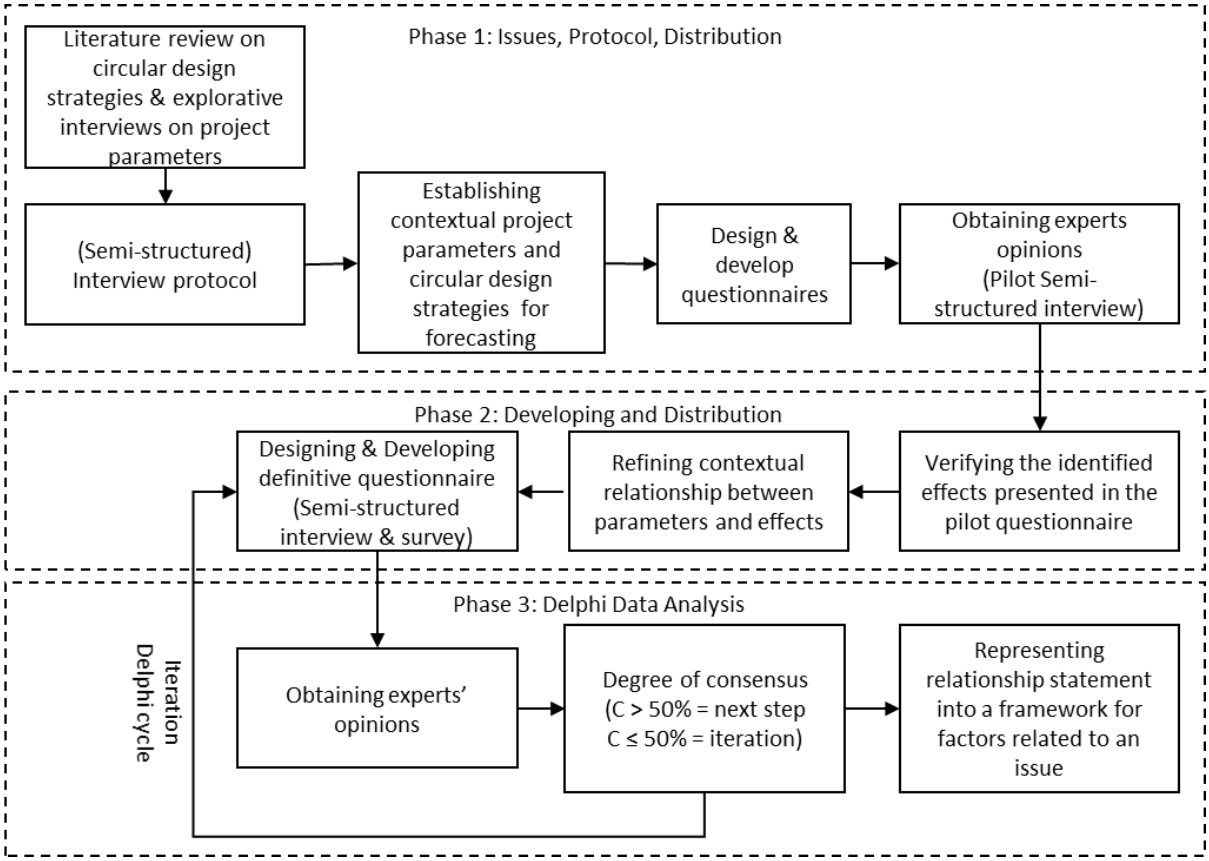


Figure 16: Delphi Method Process (Ayub et al., 2020)

3.3.2.1. EXPERT INTERVIEWS

To gain insight into the influence which the parameters have on the aspects of cost, time, and quality and what the consequences are of the project parameters on the choice of circular designs strategies and for the three aspects cost, time, and quality, quantitative and qualitative data had to be collected. For this part of the study, mixed methods have been used to collect the data. To collect this data, expert interviews were conducted by experts with experience in the areas of circular construction projects and circular design strategies.

The interview has become the main data collection procedure and especially for the collection of qualitative data, according to Englander (2012). Interviewing is a popular way of gathering qualitative research data because it is perceived as "talking", and talking is natural. Also, quantitative research data can be gathered by interviews but is used less often. Although it may be less formal than some quantitative methodology, it is important to design a systematic interview technique as well as carefully analyze and validate interview data (Griffee, 2005). The expert interview is conducted as a combination of a quantitative interview and a qualitative interview. The quantitative part of the

interview is to find out the overall trends, followed by the qualitative part to better understand the reasons behind the trends.

The difficulty in mixed-method designs has often been described as the problem of combining textual and numerical data, and this “mixing of paradigms” remains the major challenge (Gubrium, Holstein, Marvasti, & McKinney, 2012). By quantitative interviews, the analysis is based on numbers. For quantitative research, the form of the numerical data is crucial for determining the type of analysis. Quantitative questionnaires are structured, with all subjects asked the same questions, in the same order, and with subjects responding from a “forced choice” by selecting one option from an assigned set of choices. Numerical values represent each choice. The data set is always in the form of a matrix, with subjects’ responses listed line by line in rows listing each item value and the variables forming columns. Data are analyzed statistically at one point in time following the completion of data collection (Gubrium, Holstein, Marvasti, & McKinney, 2012). Quantitative interviews are further similar to qualitative interviews in that they involve some researcher/respondent interaction. But the process of conducting and analyzing findings from qualitative interviews differs from that of quantitative interviews. Through qualitative research, the analysis is based on language, images, and observations. Qualitative interviews are mainly considered semi-structured interviews (Gubrium, Holstein, Marvasti, & McKinney, 2012). These interviews consist of a question stem, to which the participants respond freely. Probing questions, planned or arising from the participant’s response, may be asked. Questions are asked of all participants in the same order. These interviews may be conducted face-to-face, in written format, or by internet survey (Gubrium, Holstein, Marvasti, & McKinney, 2012). As mentioned, for this study, the mixed-methods have been used. The structured quantitative interview method was used to determine whether the project parameters have a positive or negative effect on the management aspects of cost, time, and quality and it was used to find out for each project parameter which circular design strategies of the six could best be applied. At the same time, the respondents were asked for the reasons for this choice for both components. To collect the reasons, the semi-structured qualitative interview method is used.

The target group of the interview is experts from the built environment with knowledge about circularity and circular design strategies. They must have this knowledge to achieve the right results. The quality of respondents in a sample is essential for the results received for research and not only the quantity (QuestionPro, 2021). In the research, there has been used a sample of the target group. A total of 15 experts were interviewed. The experts can be divided into five areas of expertise: clients, architects, sustainability consultant, project managers, and contractors. The target group is not very large, but the margin of error is low. The sample of the target group has been collected using my contacts, contacts from the internship company, and contacts from the university. The qualitative questions have been given simultaneously to the same sample as those who respond to the quantity questions. There are advantages in using the same sample: the n is the same, and the responses can also be quantified.

The mixed-method for the expert interviews was used with the aim to map the influence of project parameters on the management aspects of cost, time, and quality and to find out what the consequences are of the project parameters on the choice of circular designs strategies and for the three aspects cost, time, and quality. This is part of the results and is validated by a quantitative survey, see next paragraph.

Guiding themes and questions interviews

The interview can be divided into two parts. The first part has been consists of questions about the effects of project parameters of circular projects on the management aspects of cost, time, and quality. The following question has been the focus of the expert interviews:

1. Can you answer the following question per project parameter: What effects does the parameter "…" have in a circular project on the parameters of cost, time, and quality and on the project?

The second part has been asked about the choices for circular design strategies based on characteristics. The following question has been the focus of the expert interviews:

2. Can you answer the following question per project parameter: What effect does the parameter "…" have on the choice for a circular design strategy?

Each interviewee indicated in the first part whether the effect is negative or positive of the project parameters on the management aspects and what the reason for the answer is. In the second part, each interviewee indicated which circular design strategies can best be applied and why.

A detailed interview protocol can be found in Appendix C. Due to the mixed method used for the expert interviews, the interview protocol was used to guide the researcher in asking questions and answer options to respondents. The interview schedule contains a list of questions and answer options that the researcher has read to respondents. The aim was to pose every question-and-answer option in the very same way to every respondent. This is done to minimize interviewer effect, or possible changes in the way an interviewee responds based on how or when questions and answer options are presented by the interviewer (Blackstone, 2012).

Data collection

First, in phase 2, the interview protocol for the expert interview and sets of questionnaires structured questions for Round 1 of the DM have been prepared. Round 1 of the interviews of the DM, has been piloted to test and adjust the questions to eliminate potential procedural problems. After conducting the pilot interviews, it was verified whether the desired results are achieved with the formulated questions. Based on this information, the protocols and questionnaires have been refined. In phase 2 the interview protocols have been refined and the first round questionnaires have been conducted at the experts from the target groups. Phase 3 has been started with summarizing and analyzing the results of the questionnaires. In phase 3, different steps have been performed to perform the Delphi Data analysis for forecasting the results found in the interviews. This method is based on group thinking of qualified experts that assure the validity of the collected information (Glumac et al., 2011). These expert interviews are conducted face-to-face or via Teams. Data are analyzed all at once at the end of data collection using content analysis. (Gubrium, Holstein, Marvasti, & McKinney, 2012). The interviews were transcribed and the results can be requested by the researcher.

Data analysis

Data collected from interviews need to be statistically analyzed to draw meaningful research conclusions. The quantitative and qualitative data have been analyzed in two different ways to arrive at the correct results. The results are summarized according to the Delphi Methods and fed back to the respondents, after which the survey is conducted to check whether the collected data is consensus.

Quantitative data analysis simply means analyzing data that is numbers-based or data that can be easily "converted" into numbers without losing meaning. As with the analysis of survey data, analysis

of quantitative interview data usually involves coding response options numerically, entering numeric responses into a data analysis computer program, and then running various statistical commands to identify patterns across responses (Blackstone, 2012). The methods can vary from basic calculations (averages and medians) to more sophisticated analyses (correlations and regressions). For this study, basic calculations were used to determine whether the effect of the project parameters on cost, time, and quality is positive, neutral, or negative. All data have been processed in Excel where the average is calculated. The effect that is most often mentioned is seen as truth and included in the follow-up of the study. The same process was done for the circular design strategies per project parameter. The circular design strategies mentioned by more than half of the respondents are seen as truth and are further included in the study.

The qualitative part of the interviews has been analyzed by following the concept of thematic analysis. Thematic analysis is a method that has become a widely-used tool for analyzing qualitative data. Thematic analysis is very flexible and can be used within most theoretical frameworks (Terry, Hayfield, Clarke, & Braun, 2017). According to Terry et al. (2017) thematic analysis includes the following steps: the data transcribed to an appropriate level of detail, the generation of initial codes, subsequent translation into themes, checking of the themes, and lastly an analysis of the coded data set. Inductive coding and theme development were used to generate codes and themes. Inductive coding and theme development involves working 'bottom up' from the data, and developing codes (and ultimately themes) using what is in the data as the starting point. An inductive approach is some fallacy, as the researcher is never a black slate, and inevitably brings their social position and theoretical lens to the analysis, but an inductive orientation signals a data-led analysis (Terry, Hayfield, Clarke, & Braun, 2017). By analyzing the data, there is focused latently. In latent coding, the codes capture implicit meaning, such as ideas, meanings, concepts, assumptions that are not explicitly stated (Terry, Hayfield, Clarke, & Braun, 2017). Latent codes go beyond participant-expressed meanings, to the underlying patterns/stories in the data. The underlying statement has been sought and whether it can be linked to an effect or a circular design strategy. This way of analysis shows when respondents mean the same thing but say it differently. The themes mainly resulted from the project parameters, so that the codes are linked to the correct project parameters. The coding and themes have been reviewed afterward for checking whether a coherent pattern is seen and whether the codes reflect the data set in its entirety. The thematic analysis has been done by using the software ATLAS.ti. ATLAS.ti's powerful analysis and automation tool help effectively penetrate data. Gain a quick overview, evaluate statements and opinions, discover meanings and patterns, answer complex questions, and draw stringent conclusions. With ATLAS.ti data material can be analyzed at any depth and intensity (ATLAS.ti, 2020). The tool is specifically intended for qualitative research such as the analysis of interviews and discussions. The themes and codes, that came out of the thematic analysis have been used as a starting point, together with the results from the quantitative analysis, for the survey of the next step in the DM.

3.3.2.2. SURVEYS

To gain consensus on the data collected through the expert interviews, the next round in the DM is a survey. By confronting the participants with each other's ideas and insights in a new round with questions, it is possible to work towards a consensus. The survey made it clear whether the respondents support the results and whether they agree with their argumentation.

Today the word "survey" is used most often to describe a method of gathering information from a sample of individuals, according to Scheuren (2020). Information is collected using standardized procedures so that every individual is asked the same questions in more or less the same way. The survey's intent is not to describe the particular individuals who, by chance, are part of the sample but

to obtain a composite profile of the population. Surveys can be classified in many ways. For this study, respondents were asked whether they agree or disagree with the results drawn from the expert interviews. If they disagree, an additional explanation has been requested.

The survey consisted of two parts. The first part consisted of the question of whether the respondent agrees with the condition if the parameter has a positive effect and the condition if the parameter has a negative effect. The second part of the survey consisted of the question of whether the respondent agrees with the circular design strategies that best fit a particular project parameter. If the respondent disagreed, they were also asked to justify why the respondent disagreed. Importantly, the survey revealed whether the respondents agreed with the conclusions drawn from the data obtained from the first round of interviews. The more the respondents agree, the more consensus about the data collected in the expert interviews.

The survey is based on the information found in the expert interviews. The survey is based on the summary of the expert interviews and is designed and administrated to the same experts. First, the experts have read the summary resulting from expert interviews. After this, the survey has been conducted. The goal of the survey is to provide consensus on the results of the expert interviews (Ayub et al., 2020). The iteration of conducting interviews/surveys, summarizing, and analyzing has been continued until there was consensus about the results.

The industry standard for all reputable survey organizations is that individual respondents should never be identified in reporting survey findings (Ayub et al., 2020). All of the survey's results should be and have been presented in completely anonymous summaries, such as statistical tables and charts. To gain consensus, it is important to have the survey completed by the same experts as interviewed in the previous step. The experts have expressed their initial thoughts and expertise during the interviews and could now change their minds about certain answers through the summary of all interviews. This is part of the feedback mechanism in the DM. By reading the summary with the results of all respondents from the expert interviews, the respondents can change their minds or stick to their answers. The survey was therefore requested from the same 15 respondents as in the expert interviews. As soon as more and more respondents agree with the statements, the consensus is reached. Once consensus was reached, the data has been used to create the model and the results of this research.

Guiding themes and questions interviews

The survey has also been divided into two parts. The first part has been consists of questions about the effects of project parameters of circular projects on the parameters of cost, time, and quality. The following question has been the focus of the survey:

1. Can you indicate whether you agree with the condition if the parameter has a positive effect and whether you agree with the condition if the parameter has a negative effect? If you disagree, you can indicate why you disagree.
    a. The effect on "…" is positive with the following condition …
    b. The effect on "…" is negative with the following condition …

The second part of the survey has been asked about the choices for circular design strategies based on characteristics. The following question has been the focus of the expert interviews:

2. Do you agree with the selected circular design strategies for the different project parameters for a circular project?
    a. "…" strategies can be used by the parameter "…" with the following reason …

Based on the first part of the survey, it has become clear whether the respondents agree with the condition when the project parameters have a positive or negative effect when circularity is added to a construction project. With the second part of the survey, it has become clear whether the respondents agree with the selected circular design strategies for the project parameters.

The information has been collected using standardized procedures, so every individual is asked the same questions in more or less the same way. A survey was prepared in advance and sent to all respondents in the same way. The purpose of working with a standardized procedure is that there is no difference in way of answering the questions.

Data collection

After conducting the expert interviews, the next step as described earlier was to process all results in a summary and to send it to all respondents, see Appendix E. After reading the summary, the respondents were able to complete the survey. By sending the summary first, the group reached a higher degree of consensus, because the members understood each other's reasoning. Based on Okoli and Pawlowski's (2004) research, the respondents should reach a consensus faster if they receive some sort of feedback about the respondents' reasoning. The survey can be conducted in many ways, including over the telephone, by mail, or in person. The survey was created in Google Forms and sent by email to the same group of respondents. Mail surveys can be relatively low in cost. As with any other survey, problems exist in their use when insufficient attention is given to getting high levels of cooperation. Mail surveys can be most effective when directed at particular groups, which is the case in this survey. The link to the survey is shown in Appendix F. The answers and the results from the survey can be requested by the researcher.

Data analysis

The data collected through the surveys were analyzed to check whether there is consensus about the results. When analyzing the survey, it was important to pay enough attention to the quality of the collected data and to know which elements are statistically significant. For the analysis of the survey data, the Mode was used to find out the most frequently given response. In this case, there were two possible answers: agree or disagree. By looking at the Mode, it became clear how many respondents had agreed and how many people disagreed. The more people agree, the more consensus there is about the result in question. If the answer has disagreed, the reason why the respondents in question disagreed is considered. As soon as the same argument is given more than once, the statement of the reason is adjusted. This means that there was no consensus yet and that the iteration starts again. Once the predominance has been answered in agreement, the results are consensus and have been used further in the research. Respondents are always anonymous to each other, but never anonymous to the researcher. This has given more opportunities to follow up for clarifications and further qualitative data (Okoli & Pawlowski, 2004). The results of the surveys were analyzed in Excel. In Excel, the Mode can be calculated using a simple method. The data and the results are presented in a table form.

3.3.3. VALIDATION

During the research, a validation session has been held for concerning the model which is built around the collected data. The model was validated using two different methods. First, the model was validated by a focus group that is part of a construction project in the definition phase. The participants of the focus group applied the model to the construction project and completed a survey to gain insight into whether the model works well and whether it is clear to the target group that will use the model.

In the second session, circular example cases that have already been performed were tested in the model to gain insight into whether the results of the model are related to the practice.

3.3.3.1. VALIDATION DSM PROJECT

To guarantee the accuracy and applicability of the model, a validation session has been taken place with an independent focus group that consists of experts who are part of the DSM project. The model is built with a specific purpose, which has been mentioned at the beginning of this chapter, and the validity should be determined with respect to that. According to Sargent (2010), simulation models are increasingly being used to solve problems and to aid in decision-making. The developers and users of these models, the decision-makers using information obtained from the results of these models, and the individuals affected by decisions based on such models are all rightly concerned with whether a model and its results are "correct." According to Sargent (2010) is this concern addressed through model verification and validation. Model validation is often defined as "ensuring that the computer program of the computerized model and its implementation are correct".

Face Validity has been used for the first validation session. With Face Validity, individuals with knowledge of the system asked whether the model and/or its behavior are reasonable. Sargent (2010) gives the following example: is the logic in the conceptual model correct and are the model's input-output relationships reasonable?

A focus group was used for the validation of the model to explore the feasibility of the model and for subsequent research implementation based on the perspective of the participants with interests, skills, knowledge, and experiences in construction projects in the definition phase (Subiyakto et al., 2015). The participants were involved as an advisor with the construction project DSM in the definition phase. They were selected because of their knowledge about the project and their experience in the process from ambitions to requirements.

For Face Validity, the DSM project is used. The DSM project concerns a new head office for DSM Delft. DSM Delft focuses on research into food and beverage. The new head office serves as a showcase for DSM Delft but also aims to promote synergy between the various parts. The building houses offices, labs, and pilot areas. The project aims to achieve BREEAM Outstanding. The project, therefore, focuses on sustainability but also on the use of materials. The project is now in the final definition phase.

This validation session has been held to test the model on the DSM project. After this, a survey has been filled in by the participants of this validation session to find out whether the model works correctly or which adjustments can still be made. The adjustments have still been processed in the model.

Guiding themes and questions validation session

After a short explanation of the model, the participants applied the model to the DSM project, to which the participants answered the validation questions. The validation questions are made up of the following four themes:

- Appearance/views of the Model
- Use of the model
- Results of the model
- Expectations of the model

Based on the questions that fall under the four themes, it has been validated whether the model works properly. It has been validated whether the model is easy to use, clearly displays the input and results and whether it is clear what the results mean. In the last theme, it is validated whether the model

meets the expectations of the user. This validation shows whether the model is expected to be applied in the right phase and by the right people. Based on the answers, it has emerged whether the model meets the purpose of the model. Questions have also been asked as to whether points could be adjusted or added to the various themes.

Data collection and analysis

To perform the Face Vadility, a focus group session has been organized with two participants, in which the model has been tested based on the DSM project, a survey has been completed with validation questions and points for improvement have been discussed. The data for the validation has been collected by means of a survey, which is shown in Appendix D. The survey has been requested via Google Forms and completed by the participants during the session. The results of the survey show what are the positive points of the model and where there are still areas for improvement. The points for improvement have been analyzed. In the analysis, it has been checked whether the points for improvement can be applied or whether more data needs to be collected to apply the point for improvement. If there is a need for more data to apply the point for improvement, it has been accepted and has been included in the recommendations for further research. If the point for improvement can be applied, it is adjusted in the model and it is explained how the model has been adjusted. The validation ends with an improved model based on Face Validity.

3.3.3.2. VALIDATION EXAMPLE CASES

The validation of example cases has been performed to guarantee that the results recommended by the model also work out well in practice. Through case comparison, it has become clear whether the circular design strategies used in practice to realize the example cases are also recommended by the model (Winkler, 2013). The validation of the model with example cases from the practice ensured that the model works properly in practice and that there are no errors in the model.

Event Validity has been used for this validation session. The “events” of occurrences of the simulation model have been compared to those of the real system to determine if they are similar. Sargent (2010) gives the following example: compare the number of fires in a fire department simulation to the actual number of fires.

Six example cases have been used for validation. These are the example cases that support the literature study in explaining the six circular design strategies. The example cases concern construction projects in the built environment, which are built circularly. For each circular design strategy, an appropriate completed construction project has been named in the literature study, as an example. Each of these example cases has applied at least one circular design strategy and often a combination of several circular design strategies. The project parameters for each example case have been entered into the model and the results have been validated.

The validation session with the case comparison has revealed positives and flaws in the model. Furthermore, the validation has worked as confirmation that the results recommended by the model also work out well in practice.

Guiding themes validation session

During the validation session, the focus has been on the following four themes.

- Result of the model
- Agreements
- Difference
- Expectations of the model

Based on the four themes, it has been determined whether the model provides the results and advice that are in line with practice. The focus in this validation session was on the results that came from the model. This has been compared with the example cases, where similarities and differences were searched for. It has been determined whether the differences and similarities were expected or whether an adjustment had to be made in the model.

Data collection and analysis

To perform the Event Validity, the example cases used to support the literature study were used to perform the case comparison. The information used for the literature study has also been used for this validation session. Based on this information, the project parameters have been entered and the results obtained. The results have been compared with what has been carried out in practice for the relevant construction project. Based on this validation session, similarities and differences have been achieved. The similarities and differences have been analyzed and determined whether this was expected or not. Once it was expected it was accepted. As soon as it was not expected, an adjustment was made in the model. Chapter 4.5.1.2. are displayed the results of the Event Validity.

3.4. SYNTHESIS

After conducting the literature review, explorative interviews, expert interviews, surveys, and related analysis the findings and conclusions have been lined up.

All results collected by means of the DM have been combined in a model. The results from the interviews and surveys about the effects per project parameter on the management aspects of cost, time, and quality and about which circular design strategies can best be applied per project parameter, have been combined in a well-arranged table in Excel. This shows for each circular design strategy what the effects are per project parameter on the management aspects of cost, time, and quality. From the table, it can be determined whether the circular design strategy has a positive effect, negative effect, or neutral effect on the different degree of the project parameters. The table with all information combined is used as input for the model.

The main objective of this research was to help clients by taking the next step in the move from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies to advise clients in this process. The results are processed in an excel model that the project managers can use when advising the clients. The model resulting from the results provides more information about the effects of circular design strategies on the management aspects of a construction project, which can help clients create a tailor-made strategy. The preliminary findings and the model has been validated by a construction project with a group of project managers, to reflect on the clearness and usability of the model.

CHAPTER 4.

RESULTS

CHAPTER 4. RESULTS

This chapter presents the result of the explorative interviews and the Delphi research. It included more insight into the influence the project parameters have on the management aspects of cost, time, and quality and what the consequences are of the project parameters on the choice of circular designs strategies. Based on the synthesis of the results, project managers can advise clients in making circular choices for the construction project in the definition phase, by providing a model with the necessary information about circular design strategies. Since this research is conducted following the Delphi Method, the results and analysis are combined in this chapter to work towards a model that can be used by project managers. First, the list of project parameters must be finalized, which is described in section 4.1. Second, the results from the Delphi Research are explained in paragraph 4.2. Then in paragraph 4.3. the results are combined which is used as input for a more user-friendly model. Paragraphs 4.2 and 4.3 answer the third sub-question of this research: what are the consequences of the parameters for the choice for one or a combination of circular design strategies and for the three aspects of money, time, and quality? In paragraph 4.4. answers to the last sub-question of this research are given: how can the project manager interpret and use the outputs of this research to advise clients in making circular choices in the definition phase for the construction project? This section describes the structure and use of the model. Finally, paragraph 4.5. discussed the outcomes of the validation session resulting in the final validated model.

4.1. DEFINITIVE PROJECT PARAMETERS

Several project parameters such as 'project size', 'duration', and 'phase' have emerged from the literature study. Any of the project parameters, or any combination of the project parameters, can be used to categorize a project. Through exploratory interviews, it emerged which project parameters are also used in practice. By interviewing two different target groups, a definitive list of project parameters was formed. To arrive at the definitive list there have been project parameters added and project parameters have been removed from the list formed in the literature study.

Exploratory interviews were held with five project managers, within the company Brink Management/Advies, shown in Table 4. The explorative interviews reflected on the project parameters found in the literature. The parameters that emerged from the various articles were presented to the project managers. During the explorative interviews, the project managers gave their views on the relevant and non-relevant project parameters. Based on the vision of the project managers, project parameters are accepted or rejected. Project parameters that are accepted are parameters that the project managers apply during their work to distinguish projects. Parameters that are rejected are parameters that do not apply in this way. During the interview, they were also asked whether any project parameters were missing. Data analysis determined which parameters are added to the definitive list with project parameters.

Table 4: Description respondents project managers

Role	Participant	Description
Project manager	Participant A	Project management in all phases. Sometimes all phases, sometimes a specific phase. From new construction to renovation of existing constructions. Mainly fulfills the role as project manager towards the client. Involved in the definition phase for half of the projects.
Project manager	Participant B	Long experience in the construction sector with the role of project manager. Has already supervised all types of construction projects in different phases.
Project manager	Participant C	Extensive experience as project manager and management. In recent years mainly management. Connecting to projects from the program of requirements and then the team is responsible for setting up the plan of requirements and triggering the clients on sustainability and circularity.
Project manager	Participant D	As a project manager a lot of experience in all areas. Been active in all phases and also from new construction to renovation.
Project manager	Participant E	Carries the role as a project manager with a lot of focus and attention on circularity. Previously gained a lot of experience as an architect and as a contractor.

A brainstorm session was held with a group of four people, within the company Brink Management/Advies, who work a lot with and are interested in circularity, shown in Table 5. The same questions about the parameters were presented during the session. Using notes, every participant could give their input and they could tick which parameter from the literature study is applied and which is not. The biggest difference with the group of project managers is that the project parameters in this session are looked at with a circular mindset. The data is analyzed in the same way as the data from the exploratory interviews. Based on data analysis, it is determined which parameters are added to the list of parameters accepted by the group with project managers.

Table 5: Description respondents circularity group

Role	Participant	Description
Project manager	Participant A	Project manager with a lot of interest in the field of circularity. Experienced with circular projects.
Project manager	Participant B	Project manager with a lot of interest in the field of sustainability and circularity.
Project manager	Participant C	Project manager with a lot of interest in the field of circularity and driving force within the company sustainability and circularity group.
Project manager	Participant D	Project manager with a lot of interest in the field of circularity. Experienced with circular projects.

4.1.1. ANALYSIS EXPLORATIVE INTERVIEWS

The explorative interviews were analyzed to arrive at the project parameters that were included in the research. The results of the explorative interviews were converted into binary data which is used to analyze these data. Using binary data is a good method for analyzing the explorative interviews because the binary data can be used to find out from all interviews which project parameters are used by most project managers in practice and which project parameters are used less often or not at all by

project managers in practice. So, the binary data is used to determine the percentage of accepted data per project parameter. If the percentage of the parameter is higher than the median, the parameter is accepted. If the percentage of the parameter is less than the median, the parameter is rejected. The results are substantiated by the reasons given by the participants during the explorative interviews.

The median is the value found in the middle of an ordered set of data. By a binary data set (0,1) the median would be the value found in the middle between 0 and 1. The median is in this case 0,5.

The mean is the average value of a data set. In de data set, the average would be the sum of all the values of the data set, divided by the total number of values, which gives the average per data set.

Each parameter has its own data set, collected by the explorative interviews with the project managers. The total set of data is shown in Appendix G. Table 6 shows an overview of the data sets of each parameter with the average. This shows that only productivity is rejected. With the average of 0.4 is the parameter below the median and has it been concluded that the parameter is rejected. The participants have provided an explanation for the rejection, such as participant D and participant E. Participant D cannot imagine anything with productivity and therefore says not to use it. According to participant E, certain methods are more productive than other methods but do not use productivity as a project parameter.

Table 6: The results of the explorative interviews per participant + the average data analysis of the project parameters

Parameters	Participant A	Participant B	Participant C	Participant D	Participant E	**The average**
Project size	1	1	1	1	1	**1**
Project type	1	1	1	1	1	**1**
Duration	0	1	1	1	1	**0,8**
Investment size	1	1	1	0	1	**0,8**
Complexity	0	1	1	1	1	**0,8**
Number of stakeholders	1	1	1	1	1	**1**
Environment	1	1	1	1	1	**1**
Productivity	1	1	0	0	0	**0,4**
Series of projects or one of a kind	1	1	1	1	1	**1**
Level of detail	1	1	1	1	1	**1**
Urgency	1	1	1	1	1	**1**
Lifespan	1	1	1	0	1	**0,8**

The explorative interviews also resulted in a list with project parameters that, according to various project managers, should be added to the list of project parameters. Table 7 shows an overview of the data set of each project parameter which should be added to the list of project parameters with the mean. In this analysis means a 1 that the parameter was mentioned in the interview and a 0 that the parameter was not mentioned in the interview. If the average is higher than the median of 0.5, the parameter is added to the list. Table 7 shows that the parameter's ‘function’ and ‘client’ are added to the list of project parameters. There are several functions that a building can have and each function provides a different approach. Three out of five participants use, because of these reasons, the project parameter ‘function’ in practice, why it should be added to the list of project parameters. According to participant A, the parameter ‘client’ must be added because “at the start of a project, we always look at what is specific about the project, including what is specific to the client”. The results from the binary data analysis of the accepted and rejected project parameters and of the added project parameters resulted in a modified list of project parameters, which is shown in Table 8.

Table 7: The average data analysis of the added parameters

Add	Participant A	Participant B	Participant C	Participant D	Participant E	The average
Function	1	1	1	0	0	**0,6**
Client (type client)	1	1	1	0	1	**0,8**
Fase	1	0	0	0	0	**0,2**
Needs	0	0	0	1	0	**0,2**
Mindset projectmanager	0	0	0	0	1	**0,2**
Knowledge projectteam	0	0	0	0	1	**0,2**
Market conditions	1	0	0	0	0	**0,2**

Table 8: Total list with project parameters according to explorative interviews

	List of project parameters	The average
1	Project size	1
2	Project type	1
3	Duration	0,8
4	Investment size	0,8
5	Complexity	0,8
6	Number of stakeholders	1
7	Environment	1
8	Series of projects or one of a kind	1
9	Level of detail	1
10	Urgency	1
11	Lifespan	0,8
12	Function	0,6
13	Client (type client)	0,8

4.1.1.1. RANKING PARAMETERS

To see if there is a difference in importance between the parameters found in the literature, the project managers were asked to rank the project parameters. The higher the ranking, the more important and influential the project parameter is when categorizing projects. It can be seen from the responses of the interviewees that most of the interviewees had difficulty ranking the parameters as important and less important. For example, participant E immediately indicates that no number can be attached to the project parameters because all project parameters are equally important. The other participants had also difficulty with the prioritizing of the project parameters because the participants saw no difference in importance between the different parameters and found the parameters almost equally important. For example, participant B if he had to make a ranking could divide the project parameters into four levels of importance. Participant C, on the other hand, had a clear top three and thought the other parameters were equally important. The overview of the data from all five participants with the ranking of the parameters for each participant is shown in Table 9. The analysis shows that the project parameters have been assessed too variable, making it difficult to conclude. The main reason that the data is so variable is that the participants see the parameters as equally important and in practice would make no difference between the parameters. Based on the varying responses of the five participants to the prioritization of the project parameters, nothing has been said in this study about the prioritization of the project parameters. Because of this conclusion, no distinction is made in this study between the importance of the project parameters.

Table 9: Results ranking project parameters according to explorative interviews

Parameters	Participant A	Participant B	Participant C	Participant D	Participant E
Project size	2	3	2	7	1
Project type	1	4	1	6	1
Duration	5	3		8	1
Investment size	3	3	3	9	1
Complexity		2		1	1
Number of stakeholders	7	2		2	1
Environment	8	4		4	1
Productivity	9	3			1
Series of projects or one of a kind		4		10	1
Level of detail		2		5	1
Urgency		1		3	1
Lifespan		1			1

4.1.1.2. ANALYZING MANAGEMENT ASPECTS

In the explorative interview, the question was asked: "Do you think that the concepts of cost, time, and quality also belong to the parameters, or do they have a different function?". This question is asked to find out how important these concepts are and whether they are seen as parameters or as management aspects. The answers to this question were similar for all interviewees. In summary, these three management aspects determine all previously mentioned project parameters. For example, participant D says: "It is determined from these management aspects whether the other parameters can be achieved. For each parameter, it is determined whether you make it in terms of cost, time and quality". Table 10 shows that all interviewees accept the three management aspects and that the mean is 1.

Table 10: The average data analysis Cost, Time & Quality of the explorative interviews

Parameters	Participant A	Participant B	Participant C	Participant D	Participant E	**The average**
Costs	1	1	1	1	1	1
Time	1	1	1	1	1	1
Quality	1	1	1	1	1	1

Table 11 shows the ranking of the three management aspects. It can be seen from this that everyone considers all three management aspects equally important and cannot be prioritized.

Table 11: Results of explorative interviews ranking Cost, Time & Quality

Parameters	Participant A	Participant B	Participant C	Participant D	Participant E
Costs	1	1	1	1	1
Time	1	1	1	1	1
Quality	1	1	1	1	1

4.1.2. ANALYSIS BRAINSTORMING SESSION CIRCULARITY GROUP

Based on the data analysis of the data collected during the brainstorm session, it is determined which project parameters are further included in the research, according to four people with an interest in circularity. The participants of the brainstorming session criticize the same list of project parameters, collected by the literature review, as the group received by the explorative interviews.

Again, binary data is used to analyze the data collected in the brainstorming session. When using binary data, it is evaluated whether something is accepted or something is rejected. By the data analysis of the brainstorming session, the binary data is used again to determine the percentage of accepted data

per parameter. If the percentage of the parameter is higher than the median, the parameter is accepted. If the percentage of the parameter is less than the median, the parameter is rejected.

In this case, the median is also 0,5. The mean is again the average value of a data set. In de data set, the average would be the sum of all the values of the data set, divided by the total number of values, which gives the average per data set.

Each project parameter has its own data set, collected by the brainstorming session. The results of the brainstorm session are attached in appendix H. Table 12 shows an overview of the data sets of each parameter with the average. The table shows that there are four project parameters rejected by the circularity group: 'project size', 'duration', 'complexity', and 'number of stakeholders'. According to the participants, these project parameters make no difference to the application of circularity in a project. Circular projects do not need to be distinguished on these parameters. The rejected parameters are different from the rejected parameter by the interviewed group and many more parameters are rejected. It can be said that circularity in a project gives a different view of the project parameters.

Table 12: The results of the brainstorming session per participant + the average data analysis of the project parameters

Parameters	Participant A	Participant B	Participant C	Participant D	**The average**
Project size	0	0	0	0	**0**
Project type	1	1	1	1	**1**
Duration	0	0	0	0	**0**
Investment size	1	1	1	1	**1**
Complexity	0	0	0	0	**0**
Number of stakeholders	0	0	1	0	**0,25**
Environment	1	1	1	1	**1**
Productivity	1	1	1	1	**1**
Series of projects or one of a kind	1	1	1	1	**1**
Level of detail	1	0	1	0	**0,5**
Urgency	1	0	1	0	**0,5**
Lifespan	1	1	1	1	**1**

The brainstorming session also resulted in a list of project parameters that, according to the people with an interest in circularity, should be added to the list of parameters. Table 13 shows an overview of the data set of each parameter with the mean. 1 means that the parameter was mentioned during the brainstorm session and 0 means that the parameter was not mentioned during the brainstorm session. The average must also be higher than the median (0.5). If the average is higher than 0.5, the parameter is added to the list of project parameters. Table 13 shows that the parameters 'function', 'ambitions', 'users', and 'phase' are added to the list of project parameters. The project parameters have been added by the participants because this influences the degree of circularity in the project and how circularity can be incorporated into the project. For example, according to participant C, the project parameter 'ambition' should be added according to the following reason: "if the ambition for circularity is high, more attention will be paid to circularity in the project". Circular projects can be distinguished based on these project parameters. Much more and other project parameters are added than what was done by the explorative interviews with the project managers. Only the parameter 'function' is added by both groups. It can be concluded that circularity creates different project parameters for a project. The results from the binary data analysis of the accepted and rejected project parameters and of the added project parameters resulted in a modified list of project parameters, which is shown in Table 14.

Table 13: The average data analysis of the added parameters from the circularity group

Add	Participant A	Participant B	Participant C	Participant D	The average
Function	0	0	1	1	**0,5**
Type building	1	0	0	0	**0,25**
Ambitions	1	0	0	1	**0,5**
Users	1	1	0	0	**0,5**
Phase	0	1	0	1	**0,5**
Imago client	0	1	0	0	**0,25**
Ownership / rent	0	0	0	1	**0,25**
Expected organizational development	0	0	0	1	**0,25**

Table 14: Total project parameters prepared by the circularity group

List of project parameters	The average
Project type	**1**
Investment size	**1**
Environment	**1**
Productivity	**1**
Series of projects or one of a kind	**1**
Level of detail	**0,5**
Urgency	**0,5**
Lifespan	**1**
Function	**0,5**
Ambitions	**0,5**
Users	**0,5**
Phase	**0,5**

4.1.2.1. ANALYZING MANAGEMENT ASPECTS

In the brainstorming session, the same question as in the explorative interviews was asked: "Do you think that the concepts of cost, time, and quality also belong to the parameters, or do they have a different function?". The answers to this question were about the same for both groups. In summary, these three parameters determine the previously mentioned project parameters. Participant A said: "These are three of the five Grotik aspects which overarching the project parameters. Cost shows whether reuse material costs more or less, time shows whether a project takes longer or shorter, quality says more about the quality of the recycled materials". Table 15 shows that all participants accept the three parameters and that the mean 1 is.

Table 15: The average data analysis, Cost, Time & Quality

Parameters	Participant A	Participant B	Participant C	Participant D	The average
Costs	1	1	1	1	1
Time	1	1	1	1	1
Quality	1	1	1	1	1

4.1.3. RESULTS EXPLORATIVE INTERVIEWS

Based on the explorative interviews with project managers and the brainstorming session, the project parameters from the literature were verified and supplemented. The verification shows that not all project parameters from the literature are used by project managers in practice. The project parameter productivity is therefore removed from the list. It also appeared that relevant project

parameters are still missing in the literature. For example, the project managers think that the project parameters 'function' and 'client' should be added.

If the list of project parameters of the project managers is placed next to the list of project parameters of the circularity group, there is a difference in the project parameters, shown in Table 16. The circularity group finds the project parameters 'project size', 'duration', 'complexity', and 'number of stakeholders' no longer of added value in the categorization of circular projects. The circularity group finds also that the project parameters 'function', 'ambitions', 'users', and 'phase' should be added to the list of project parameters. By putting the two lists of project parameters side by side can be concluded, that circular projects look at the categorization of projects in a different way, and according to the reasoning of the circularity group, are they looking at the project parameters from a different perspective.

To get the optimal list of project parameters, the project parameters that need to be added according to the circularity group are added to the total list of the project managers. The project parameters rejected by the circularity group are accepted by the project managers. The project managers use these parameters in the current situation, as a result of which these parameters were not removed from the definitive list. The list of project parameters is prepared from the parameters that are applied in the current situation with the addition of the project parameters of the circularity group. Productivity is a notable project parameter that is not included in the final list of project parameters. This is because the productivity parameter has been rejected by the project managers. This project parameter is currently not applied in practice, so it is not included in the final list of project parameters. The definitive list of parameters is shown in Table 16. The definitive list of project parameters was further used in the research. Appendix I shows the definitive list of project parameters with options and explanations.

Table 16: Final list of project parameters

	List of project parameters from the literature review	List of project parameters from the project managers	List of project parameters from the circularity group	Definitive list of project parameters
1	Project size	Project size	Project type	Project size
2	Project type	Project type		Project type
3	Duration	Duration		Duration
4	Investment size	Investment size	Investment size	Investment size
5	Complexity	Complexity		Complexity
6	Number of stakeholders	Number of stakeholders		Number of stakeholders
7	Environment	Environment	Environment	Environment
8	Productivity		Productivity	
9	Series of projects or one of a kind	Series of projects or one of a kind	Series of projects or one of a kind	Series of projects or one of a kind
10	Level of detail	Level of detail	Level of detail	Level of detail
11	Urgency	Urgency	Urgency	Urgency
12	Lifespan	Lifespan	Lifespan	Lifespan
13		Function	Function	Function
14		Client (type client)		Client (type client)
15			Ambitions	Ambitions
16			Users	Users
17			Phase	Phase

4.2. RESULTS DELPHI RESEARCH

Concerning the research problem, this research has specified the Delphi Method (DM) as crucial to get a clear overview of the effects on construction projects by choosing circular designs strategies:

> *"At the moment there are no standard processes for what impact the determined circular design strategies have on the management aspects of cost, time, and quality of a construction project."*

The DM has resulted in data collected through expert interviews and data collected through surveys. The surveys provide consensus on the data collected through expert interviews. By analyzing and processing the data collected by the Delphi Method, the third sub-question of this research is answered: what are the consequences of the parameters for the choice for one or a combination of circular design strategies and for the three aspects of cost, time, and quality? In this section, the most significant portions of the research findings, indicate key trends or relationships, and highlight expected and unexpected findings are pointed out and the data processed in such a way that it can be used by project managers and the model.

4.2.1. DATA COLLECTION

This research has specified the DM as crucial to get a clear overview from which circular design strategies can be chosen and of the effects on construction projects by choosing circular design strategies. To implement the DM, expert interviews and surveys have been conducted with the same group of respondents. The DM was performed from November 2021 until January 2022. The respondents included Dutch experts with various roles in the construction sector, consisting of clients, project managers, architects, contractors, and sustainability consultants. It has been decided to choose experts from different disciplines of the construction sector to be able to map out all insights from different angles. A total of fifteen experts were interviewed and asked to complete the survey. Based on the interview protocol (Appendix C.) the respondents have been interviewed with the mixed method. In the second round of the DM, the surveys were sent to the same respondents. Of these respondents, ten of the respondents responded to the survey, as a result of which the role as the client is represented by only one person. This has been taken into account when analyzing the results. The other roles are still represented by at least two people.

Table 17: Description of the respondents

Role	Respondent	Description
Sustainability consultant	Respondent A	Long experience in construction and now for a year full focus on sustainability. Working as a sustainability coach on several construction/renovation projects.
Client	Respondent B	Client for the construction of a temporary business/catering building. The building will be put down for 10 years and then it must be possible to disassemble and move it.
Architect	Respondent C	Experienced architect. In recent years, there has also been an increasing demand for sustainability/circularity in projects, as a result of which a lot of knowledge has been gained in recent years on both renovation and new construction projects.
Contractor	Respondent D	Deputy director of development, responsible for the front end, such as tender, calculations, and engineering. More and more demand and also more and more projects are realized circularly.
Project manager	Respondent E	Extensive experience in various roles in the construction industry. Always been involved with sustainability/circularity. Now the role as a project manager in urban development with a focus on circularity.
Project manager	Respondent F	Lots of experience as a project manager. For several years now working on sustainable/circular renovation projects.
Architect	Respondent G	Experienced architect with an interest in sustainability and circularity. Working for an architectural firm with many sustainable and circular projects and circular partners.
Sustainability consultant	Respondent H	Experienced consultant in installation technology and building physics. As a consultant involved in sustainable and circular projects.
Contractor	Respondent I	An experienced contractor with 10 years of experience as a Breeam Expert. Working on sustainable and circular projects for a long time.
Sustainability consultant	Respondent J	Working as a consultant to make circularity measurable, calculate the environmental impact, etc. Also supports experts from the construction industry in making choices in the field of circular tendering.
Client	Respondent K	Experienced advisor in the field of sustainability and circularity at a client. Worked on GPR score, valuation of tenders, enthusing parties, etc.
Client	Respondent L	Experienced advisor in the field of sustainability and circularity at a client. Working on making real estate more sustainable and especially focusing on utility.
Project manager	Respondent M	Experienced project manager with a focus on sustainability and circularity. Working on drawing up implementation plans, route maps, integration of circularity in projects, etc.
Architect	Respondent N	Project developer and architect with a lot of activity in the field of sustainability and circularity. Done and working on several projects, including temporary construction and demountable construction.
Contractor	Respondent O	Worked as a plan planner for a contractor. Develops the plan from start to finish. Already working on sustainability in projects and increasing demand for circularity.

4.2.2. INFLUENCE OF CIRCULARITY ON THE MANAGEMENT ASPECTS

The interviews and surveys indicate that most of the respondents experience many changes in the management aspects of cost, time, and quality in a construction project when applying circularity. The respondents also noticed that this differs per project and that it is difficult to map out in advance. Based on the previously established list of project parameters, the respondents were asked about their experiences with the effects of applying circularity on the management aspects. This shows that for certain project parameters, circularity has a positive effect, has a negative effect, or remains neutral. The analysis of the results is shown in Appendix J.

The interviews gave insight into what influence the project parameters have on the management aspects. The interviews provided the condition of when a project parameter has a positive, neutral, or negative effect. A consensus was created about the results of the interviews through the round of surveys. Key trends, expected and unexpected findings emerged from the interviews and surveys. The findings are structured for each management aspect.

4.2.2.1. MANAGEMENT ASPECT COST

The respondents are not convincing about the effect of the different project types. Whether it has a positive or negative effect is close to each other. The conditions that indicate why the parameter gives a positive effect or a negative effect are important for this. Consensus on this was obtained through the survey. New construction projects are currently negative because the great need for circular/secondary/renewable materials is not yet available. According to a sustainability consultant, it will currently take a little more time and a little more money. This is mainly due to the limited supply. It is also not yet clear in advance what will be available when the building will be constructed and what will still be available now and in the future.

With renovation projects, the effects remain neutral, but there is also a high chance that it will have a negative impact. It emerged from the interviews that in renovation projects, what comes out must be scanned and the existing situation must be taken into account in the design. The extra time is reflected in extra costs. Temporary construction against this is clearly positive according to the respondents. It is positive if disassembly is taken into account in advance so that at the end of the project not everything has to be written off through demolition.

"Temporary construction projects offer great opportunities for applying circularity. If we deal smartly with recycled materials or with demountable temporary construction. By making a temporary building that you can then disassemble, you have the financial advantage that circularity also offers." (architect)

The analysis shows that the 'environment' has hardly any effect on costs. The majority of respondents indicate that it remains neutral in both an urban and a rural environment. In an urban environment, there is often less space, which can make it more complicated with the transport and storage of materials. But this does not have to be different for a circular project than for a traditional project. It also remains neutral with the different types of clients and users. According to a sustainability consultant, you depend on the will of a client and not on the type of client. According to an architect, if a user uses it himself, he has a higher ambition. If the ambition is there, it would have a positive effect, if not, it would have a negative effect. It does not necessarily matter whether it is for tenants or whether the client enters it himself.

Adding circularity to a serial project is seen as a positive effect on costs by all respondents.

"If you can apply circularity serially, it works very well. It has a positive effect on your costs because you can spread your costs over a longer period. You can also use materials more often, so you can also mass-produce, which is always beneficial." (Contractor)

The parameter one-of-a-kind project was labeled negative by just over half. This is because it is built once, making it more difficult to reuse it later. The longer design process to make it circular also has a negative effect on costs.

According to the respondents, a shorter 'lifespan' of a project has a positive effect on costs. This can be linked back to the project type of temporary construction. The condition, therefore, comes down to the same: a shorter 'lifespan' gives a positive effect when the building or the materials are reused to a high standard after their 'lifespan' so that it yields something at the end of the project.

The analysis also shows that the 'function' is difficult to determine and is labeled as neutral by many respondents. However, a distinction can still be made between residential 'function', utility, and other functions. Residential functions are currently still negative because the circular construction methods cannot yet compete with the well-developed linear construction method. An architect agrees, who says that: concerning residential functions, it is noted that the real application of circular construction methods is still a bit too far because the construction technology of residential projects is so well-conceived in a linear way, you really can't compete with that yet.

Utility, on the other hand, is regarded as positive, because at the moment in utility is most of the work done on the field of circularity and in utility is most of the knowledge about circular construction. The respondents still find it difficult to say anything about the other functions and therefore say that it will remain neutral. It depends on other aspects whether it is positive or negative.

"In utility, a lot is already being done with modular systems, buildings with the function of education is less so, and not yet in research environments. There is still a lot of difference, but that has more to do with the resistance and the experience." (Sustainability consultant)

Opinions differ between the respondents about the project parameter 'ambitions'. One group says that a high ambition for circularity can generate more costs than a low ambition because adding circularity is currently seen as an extra cost. The other group counters that more ambition has a positive effect across the entire LCA. An architect would add that a high ambition costs more in the short term, but can also yield more quality, which ensures that fewer costs are incurred across the LCA. Ultimately, it concerns the entire project, so it will have a positive effect.

The different 'phases' shows also a clear difference in the effects on cost. The earlier in the project, the more respondents rated the application of circularity positively in terms of costs. According to the architect, it is especially important to take the right starting points at the very beginning, the decisions that have the most influence in the field of circularity. In this the initiation phase and the design phase are the most important, they have the most influence on cost, time, and quality.

If circularity measures are only included in the design phase, more respondents label it as negative and that it is already being applied too late. The realization phase is also seen as negative because a lot of things and methods can no longer be applied. According to the client, if you are already in a design phase and you come up with circularity, then it is extra. Then you saddle it with an extra ambition and then it is always more expensive.

When analyzing the effects on the management aspects, it was also analyzed whether the role of the respondent influenced the results. The analysis showed that the role of the respondents hardly played influenced the effects of the project parameter on the management aspect of cost. If it had influenced the results, respondents with the same role would more often give the same answer. Respondents with the same role only give the same answer two or three times. The three sustainability consultant do not even give all three the same answer to a certain project parameter. The project managers, clients, and architects all give the same answer to the 'complexity' parameter. Also, the project managers and the contractors give the same answer to the project parameter 'phase'. All three clients indicate that a series or project has a positive effect and a one-of-a-kind project has a negative effect on the management aspect of cost. The three clients also value the project parameter level or detail in the same way. Furthermore, at least one of the three with the same role always gives a different answer, which means that it cannot be said that the role of the respondent influenced the results.

4.2.2.2. MANAGEMENT ASPECT TIME

The results for the management aspect time are more convincing than those for the cost. Larger groups of respondents indicate the same in terms of the effects. For example, a clear majority indicates that a larger project has a positive effect on time because a larger construction project also has more scope which ensures that the extra time has less influence.

A large majority also agreed that a smaller project has a negative effect on time, as the extra time has more influence on a smaller project. According to the project manager, it will not take much longer in terms of time to implement. It will take more preparation time because you have to do more in the preparation to ensure that it is circular.

The analysis of the effects over time shows that the 'environment' has hardly any influence. As with the management aspect cost, the effect for both rural and urban environments remains neutral. There is certainly a difference between the areas, but that will not change if circular construction is carried out compared to traditional construction.

"Time is always a more difficult factor, you have to take into account more things. But in the field of circularity it shouldn't make any difference and you should just be able to apply it." (Contractor)

All respondents agree that serial building also has a positive effect on time. This is because more experience is created throughout the series and the right people are involved. Also, the time put into it at the front can be spread over the entire series.

The project parameter 'level of detail' clearly shows how much all respondents agree with each other. A higher 'level of detail' is often more complicated which leads to more time to create it but also makes it more difficult to reuse it later. A lower 'level of detail' has a positive effect on time because it is easier to achieve. However, a low 'level of detail' lacks ambition in the elaboration, according to an architect. According to the client, if you want to do it right, don't fix too much beforehand, the more complicated it gets to find everything. If you have to find something with exactly certain dimensions or detail, that will cost you a lot of time and eventually money.

The project parameter 'urgency' is one of the exceptions because with this project parameter the respondents are very divided. Six respondents indicate that a high 'urgency' has a positive effect on time, while seven respondents indicate that it has a negative effect. It was also included in the study that a high 'urgency' has a negative effect. This is because the knowledge is not yet ready, so it is not feasible to apply in a short time. The respondents also do not fully agree on the project parameter 'ambition'. The high ambition is particularly striking. Six respondents say a positive effect and seven respondents say a negative effect. This is because having high ambition is very important according to

an architect. High ambitions contribute to better quality. According to a project manager, if they have high ambitions, they are willing to put in some extra time. This ultimately has a negative effect on time, because more time is needed to apply circularity by high ambitions.

The project parameter 'client' has a neutral effect for both the private client and the public client, as does the cost management aspect. According to a project manager, it doesn't have to matter to each other. If you apply circularity in the private sector, it is the same as in the public sector. Ultimately, it's about what you apply, so it does not have to cost more or less time and money in one sector. Also, the 'lifespan' remains neutral in terms of time. You have to map out in advance which materials you have and how long they can last, according to a client. But according to a client, this can be fine-tuned in advance and does not have to affect the time.

When analyzing the results on the management aspect time, it was also examined whether the role of the respondent influenced the results. As with the management aspect of cost, it would have had an impact as soon as the respondents with the same roles gave the same answers. This is also not the case with the results on the management aspect of time. Only the clients give answers in the same way on four project parameters. But on four project parameters out of sixteen, it is not enough to say that the role influences the results. In contrast, contractors do not value any project parameter in the same way. The project parameter 'complexity' is answered in the same way by respondents from three different groups. The effect on the project parameter is also valued in the same way by sustainability consultants and architects. As with the cost management aspect, project managers value the project parameter 'phase' in the same way. Furthermore, there are also many project parameters on the management aspect of time to which respondents with the same role do not answer in the same way.

4.2.2.3. MANAGEMENT ASPECT QUALITY

Concerning the management aspect quality, the respondents agree that the project parameters often have a neutral effect on the quality of the project if circularity is added. This is because there are minimum requirements in the Netherlands that a construction project must meet. These requirements also apply to circular construction. The quality must therefore be the same or better than with a traditional construction project. For example, it can be seen that with the project parameters 'project size' and 'project type', cost and time could have a positive or negative effect on the management aspects, that now everything has a neutral effect on the management aspect quality. For example, the project parameter 'project type' indicates that the quality for each type can be easily managed and that it will therefore remain neutral if circularity is added.

With the project parameter 'duration', a longer duration can have a positive effect on the quality and a shorter duration can have a negative effect on quality. According to a sustainability consultant, speed often has a negative effect on the implementation of parts that you do not know much about. Then you tend to choose what you know because you want to go for an agreed quality at an agreed time, so you choose the known path, and not all circularity options are considered. As soon as the duration is longer, there is more time available to consider all options, which has a positive effect on the quality of the project.

"You should expect to have time to look at circularity in the project by a longer duration. That the implementation also has the time to develop this properly and take circularity on board. Also depends on the people, how much knowledge about circularity is there, how willing are they to cooperate, etc." (Sustainability consultant)

The project parameter 'investment size' has the same effect on the quality of the project. The larger the budget, the more positive the effect is on the quality of the project. Conversely, the more limited the budget, the more negative the effect has on the quality of the project. According to an architect,

this is since faster and less well-thought-out choices are made with a tighter budget. There is as much time as there is a budget, according to a sustainability consultant. In the current situation, more budget is needed to be circular and therefore to deliver better quality. You can apply circular principles within the budget, but not everything with a limited budget.

In the management aspect of quality, the project parameter 'number of stakeholders' also stands out. With fewer stakeholders, the effect can be both neutral and positive, according to the respondents. The more stakeholders it has, the more negative the effect becomes. According to a project manager, the smaller the group, the easier it is to get everyone involved with the circular ideas. But it also very much depends on what kind of stakeholder you have. If it is a conservative group, you must first convince the entire group why you want to apply circularity. As soon as you have to convince a large group, it becomes more difficult to add circularity with high quality in a construction project. The following condition has been confirmed by the survey: by more stakeholders, it is more difficult to communicate, there are more opinions and more people have to be convinced to cooperate. Although, according to a client, you can also see more stakeholders as a larger network. But with the condition that everyone must have the same vision on sustainability and circularity. At the moment it can be seen that there is still too little experience and it often takes even more effort to include more stakeholders. The fewer stakeholders, the more positive effect this should have on quality.

One-of-a-kind project also has a neutral effect on quality, whereas it had a negative effect on the other management aspects. A contractor indicates that the effect depends on other parameters and that it should remain at least neutral. Compared to a series of projects, according to a client, a unique project does require more attention but can turn out very well circularly and qualitatively.

A parameter that also stood out in the other management aspects is the type of 'client'. Both the private sector and the public sector as a client remain neutral on all management aspects, including quality. It can be concluded from this that the type of 'client' does not have that much effect if circularity is added to a project. According to a client, you should add circularity to a project because you want to do something with it and that does not depend on whether it is a private or public client.

Almost all respondents agree on the project parameter 'ambition'. A high ambition has a positive effect and a low ambition has a negative effect on the quality of the project. In the case of low ambitions, according to an architect, the well-known solutions that have been used more often take precedence. The easy way is then chosen, which is reflected in the quality. If there are high ambitions for circularity, more attention is paid to doing it right.

"If there are high ambitions and realistic ambitions within the team, you can see that the team add much more circularity into the construction project." (Sustainability consultant)

The project parameter 'user' gave a neutral effect on a construction project with the previously mentioned management aspects. But a project that will be used by tenants has a negative effect on the quality of the project. According to the respondents, a project that will be used by the client itself has a positive effect on quality. The type of 'user' has a clear influence on the management aspect of quality if circular construction is to be carried out. According to a sustainability consultant, more quality is generated if the client starts using it themselves. If the project is taken into use by the tenant, according to a project manager, much more attention must be paid to wear and tear. It must then be able to withstand a lot more, which, if circular construction is to be carried out, circular materials must also be able to withstand.

The project parameter 'phase' are assessed on quality the same as on the management aspects of cost and time. The sooner circularity is applied, the more positive effect it has. According to a sustainability consultant, if you include it well in your initiative phase, you ensure that the mindset is also there to look at the problem in that way and it becomes a little easier to take it along. If you want to cycle it in later, you have to create it.

It was also investigated whether the different roles that the respondents have in a construction project say something about the results. The roles have a very minimal impact on the results that the respondents have given for the effects on the management aspect of quality. The sustainability consultants did not fully agree on any project parameter with the effects that circularity has on the quality of the project. The project managers are in complete agreement on two project parameters. For example, all three project managers believe that a 'series of projects' has a positive effect on the quality and that a 'one-of-a-kind project' has a negative effect on the quality. The three project managers also agree that the sooner circularity is introduced into the project, it has a positive effect and as soon as the project is in the realization phase, it will have a negative effect. The three contractors also agree with the construction of the phases. The three architects assess the project parameter 'complexity' in the same way. According to the architects, higher complexity has a negative effect on the quality and lower complexity has a positive effect on quality. From this analysis, it can be concluded that the role of the respondent has no major impact on the management aspect quality.

4.2.3. CONSEQUENCES OF CIRCULARITY ON THE CHOICE FOR CIRCULAR DESIGN STRATEGIES

The interviews and surveys revealed the consequences of the project parameters on the choice for one or a combination of the circular design strategies. The respondents agreed that the choice of circular design strategies can vary per project, which means that the project parameters are important. Based on the established list of project parameters in paragraph 4.1., the respondents were asked about their experiences with which circular design strategy or a combination of the circular design strategies, they will apply to the construction project. The results have shown that the circular design strategies that can best be applied vary for each project parameter. The analysis of the results of the interviews is shown in Appendix L.

The interviews gave insight into which circular design strategies can best be applied to a construction project with the given project parameter. The interviews provided the reason why the respondents felt that the chosen circular design strategies are best applied to the construction project with the given project parameter. A consensus was created about the results of the interviews through the round of surveys. Key trends, expected and unexpected findings emerged from the interviews and surveys.

4.2.3.1. CIRCULAR DESIGN STRATEGIES ADVISED PER PROJECT PARAMETER

It is remarkable that, according to most respondents, the six circular design strategies can be divided into two groups, since the literature review shows that all six circular design strategies are important and can be applied effectively in the right situation. The first group consists of the strategies: 'designing for prevention', 'designing for the reduction of life cycle impact', and 'designing for future-proofing'. This group consists of strategies that are currently (unconsciously) often applied in projects and about which more knowledge is already available. This is agreed by a contractor, the first three are strategies that are already being used in construction projects. Everyone already wants to build in a minimalistic way because that saves costs. More and more functions are already being combined, for example, they used to have a separate kitchen and living room, but there is less and less demand for this now. The strategy 'designing for the reduction of life cycle impact' is actually what you should already be doing for the BENG, TCO, MPG, etc. (these are requirements that the project must meet with, for example, permit applications, etc.). The 'designing for futureproofing' strategy is also standardly looked at to

see whether the function of the building can be changed. According to the project manager, these three circular design strategies are already going well, they are being applied more quickly and they are already more common among the parties. The second group consists of the other circular design strategies: 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials'. These are the strategies that are newer in the built environment and even less knowledgeable about. According to a contractor, you have to search for these three strategies, in order to eventually get it, to make it real. To apply these three circular design strategies, there must be the possibility in the project to delve deeper into the strategies. As soon as that is not the case, they are quickly dropped and the team falls back on the three circular design strategies with which they already have more experience.

Project size

From the reasons for which the chosen circular design strategies have been chosen, it emerges that if a project is larger, there are more options and there can be discovered more. But the larger the project, the more the availability of the materials will play a role. Re-used objects can get more difficult because getting a large number of the same re-used objects in today's market is difficult. This reason makes also the use of renewable raw materials even more difficult. Because the use of renewable raw materials is still new in the construction sector, it is often not yet produced in large quantities. With a smaller project, one does not have to exclude the other, because a smaller project is easier to oversee and fewer materials need to be available. This makes that re-used materials and renewable materials can be applied more easily. It is remarkable that with a larger project there is a greater chance of discovering all options, but two strategies are still difficult to apply in the current circumstances, while with a smaller project you are more limited, but all strategies are feasible to apply.

Project type

With new construction, circularity becomes the starting point, which means that everything can be tried out. According to the respondents, a focus should be on future-proofing, to be able to adjust the project's function even later. However, it appears that the reuse of materials and the use of secondary materials is currently even more difficult. Whether reused objects and secondary raw materials can be used depends on what is available, according to a client. According to a client, it is also the case that the end customer is often not at all interested, for example, in a second-hand door in a new construction project, and that is very different with a renovation project. In a renovation project, the focus is therefore on the reuse of materials. A sustainability consultant, says that the focus should be on the question of what else can you use from the reused building itself and how much do you still have to replace from it. According to a client, prevention is also important here. Prevention becomes more interesting, in terms of what you can keep, and has a link with reused objects. Temporary construction is assessed differently by the respondents. It can be concluded, that just as with new construction, it is important to focus on future-proofing, because it concerns a short period. In this context, future-proofing means that you can adapt it or that you can reuse it in the future. According to the respondents, temporary constructions are also increasingly looking at renewable raw materials, that may not last that long but are simply broken down in a natural process.

Duration

What remarkable is about the most frequently mentioned circular design strategies for the project parameter 'duration' is that with a longer project there is a chance for 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials', but with a shorter project these three circular design strategies are more difficult to apply. It can be concluded from this analysis that more time is needed for these three circular design strategies to be able to apply

them properly. According to an architect, in a long term you have the time to look for materials or to wait for materials to become available, which are important for these three strategies. This is confirmed by a sustainability consultant: reuse, secondary raw materials, and renewable raw materials take a lot of time to research. These become much more difficult to apply with a short duration.

Investment size

With 'investment size', it is remarkable that there is talk about more expensive circular design strategies and cheaper circular design strategies. The clients indicate that there are many products on the renewable raw materials market, but say that these still have a fairly high-cost price, because they cannot yet be produced in large quantities. Then a larger budget makes it easier to apply this strategy. According to the clients, making the project future-proof and adaptable also requires more money. This makes the circular design strategies 'designing for future-proofing' and 'designing with renewable raw materials' more likely in a project with a width budget. With a tight budget, these two circular design strategies are also more likely not to be included in the project. With a tight budget, it is important to think carefully in advance and to use as few materials as possible, which generally saves a lot of money. What is stated by many respondents is that the less money is available, the use of the circular design strategies progresses from the last circular design strategy to the first circular design strategy.

Complexity

The analysis shows that the more complex the project becomes, the more difficult it becomes to apply circular design strategies 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials'. A project manager gives the reason for this that there is a chance because the project is already complex, several things make it even more complicated, which also makes guaranteeing something more difficult. As one client points out:

"The more complex, the more specific, the more difficult it becomes for real reuse of materials. It is easier to apply designing for prevention and designing for the reduction of life cycle impact. The other circular design strategies get more complicated because it is too specific to fit into a complex project." (client)

The less complex the project is, the easier it is to adjust something so that an object or material does fit or can be applied. With a low complexity, more attention remains to think about the circular design strategies.

Number of stakeholders

The 'number of stakeholders' is another aspect that has a lot of influence on the assessment of which circular design strategies are applied. The additional aspect that is involved is the knowledge that stakeholders already have about circularity. If there is sufficient knowledge, it does not matter whether many or few stakeholders are involved and all circular design strategies can be considered. If there is insufficient knowledge among the stakeholders, it becomes more complex with more stakeholders. The contractor mentioned that complexity and talking to a lot of people can make it very complex. That is why many stakeholders with insufficient knowledge will stick to the simpler strategies: 'designing for prevention', 'designing for the reduction of life cycle impact', and 'designing for future-proofing'.

Environment

The analysis shows that there is little difference between an urban area and a rural area when choosing between the circular design strategies. In both types of areas, all circular design strategies can be applied well. A rural area is seen as a pitfall that if there is more space, they are less pushed to think about the use of space.

Series of projects or one of a kind

With a 'series of projects' or a 'one-of-a-kind project', the difference is mainly in the application of the circular design strategy 'designing with reused objects'. According to a client, in serial projects you want to use as little material as possible, have the lowest possible impact, use renewable resources as much as possible, and build as much as possible in a circular manner. However, it is also noted by many respondents that there are not that many reused objects available at the moment so you have to adjust it every time in the series. This makes a one-of-a-kind project more profitable because fewer of the same objects are needed and that is why respondents indicate that there is an opportunity with reuse of objects.

Level of detail

According to a sustainability consultant, the power lies in simplicity. The simpler it remains, the better detachable and flexible it is and the more strategies there can be applied. However, a high 'level of detail' is associated with more complexity in the project. A high 'level of detail' makes it very specific and then things fall off, such as the reuse of objects and secondary raw materials, because they are often not dimensionally stable. By using a high 'level of detail', a lot is already determined in advance, making it difficult to adjust anything, for example in the dimensions. The circular design strategies 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials' require that flexibility, making it more difficult to apply these three circular design strategies to a project with a high 'level of detail'.

Urgency

The analysis showed that with low 'urgency' only the circular design strategies 'designing for prevention', 'designing for the reduction of life cycle impact', and 'designing for future-proofing' are mainly applied. The reason has been drawn up from the analysis of the interviews, which states, among other things, that these strategies are mainly chosen because the knowledge about these circular design strategies is already available. No effort is then made to gain knowledge about the other circular design strategies. This is often seen as a hassle and difficult. According to a sustainability consultant, if the 'urgency' increases within the project, you will also apply circular design strategies with a higher impact level. To do this, everything has to be considered.

Lifespan

With a long 'lifespan', the technical lifespan is much more important. It is important that the building can remain standing for as long as possible, with as little replacement as possible. With a longer 'lifespan', according to a client, among others, designing with reused objects becomes less. Objects have already had a life and are going for the second, third, or sometimes fourth round. Some things don't get any better and at some point, they just run out. The question then is whether they are still sufficient for a building with a longer 'lifespan'. There is still little knowledge about this, so many do not yet dare to apply it. In projects with a short 'lifespan', the circular design strategy 'designing with reused objects' can be applied well. According to a project manager, you do not have to choose between these strategies, you always have to apply them sometimes to a better and sometimes to a

lesser extent. If you know that it is only for 15 years, you have to look at what happens to the building afterward. If that is not taken into account, the materials have much more impact on the environment.

Function

It emerged from the interviews that a distinction can be made in general between the functions residential, utility, and other. Others mainly refer to more complex projects such as hospitals, education, and recreation. Others are still difficult for the respondents to say because certain functions have certain conditions/requirements. According to the respondents, 'functions' entail a different condition. It's about laws & regulations, with every function there are different rules and laws also on material, etc., but also what is allowed and what is not allowed. This is mainly due to reused objects and secondary raw materials. They may not be in a nursing home and may in a living, or vice versa. It is important to look at which strategy is possible or not for each function. However, something can already be said about residential and non-residential construction. The big difference lies in making the project flexible. Homes are used in the longer term, so prevention and reduction are more important there, that they last a long time, are easy to maintain, and are less likely to break. Homes are also often less complex to build, which means there is more opportunity for the circular design strategies 'designing with reused objects', 'designing with secondary raw materials', and 'designing with renewable raw materials'. Utility, on the other hand, must be flexible and ready to transform into another function since the manner of use demands flexibility. The other strategies are also increasingly being considered in non-residential projects, but that still depends very much on the client in what sizes they are applied.

Client

The respondents agree that the type of 'client' should not make a difference between which circular design strategies can or cannot be applied. The only difference that can be made between a private client and a public client is that the private sector is more inclined to go to the traditional construction method because the private sector has more knowledge about it and have fewer risks. While the public sector is more inclined to build circularly, because of their pioneering role. But if the private sector has the ambition, they can also go full steam ahead with circular construction. Ultimately, all circular design strategies in both sectors can and should be considered, according to the respondents.

Ambition

For the project parameter 'ambition', the respondents agree that all circular design strategies can and should be considered when the 'ambition' is high. It is expected that with a higher ambition you are more willing to invest to be able to consider all strategies. Almost all respondents also indicate that with a lower ambition, the circular design strategies 'designing for prevention', 'designing for the reduction of life cycle impact', and 'designing for future-proofing' are mainly applied. Mainly these three are applied because they are always being looked at, at the moment, as explained earlier. There is only one exception with a lower ambition. A sustainability consultant indicates that mainly the circular design strategies 'designing with secondary raw materials' and 'designing with renewable raw materials' can be applied. The sustainability consultant expects this because they are new products and they are fairly easily interchangeable with traditional products. The other strategies influence the design process because the adjustments go on a deeper level than the material used. With the other four circular design strategies, larger adjustments need to be made in the model, such as removing parts, to be able to apply the strategy. Other respondents, such as an architect, indicate that there is still little knowledge about the circular design strategies 'designing with secondary raw materials' and 'designing with renewable raw materials', which means that it will take more effort to apply them. With a low ambition, often no energy is put into this.

USER

The analysis shows that all circular design strategies can be applied to different types of 'users'. It is also important for both users that the building is flexible. For an owner, it is important that it can easily change the function so that it continues to meet changing needs. Once there are tenants in it, it is also important to keep up with the changing needs, so flexibility remains important. As soon as tenants become users, according to a project manager, robustness becomes more important. Tenants often attach less value to the property, which makes maintenance important. Flexibility is also important for this, but also prevention. The fewer materials used, the less needs to be replaced. Everything else can be applied very well and it depends more on other factors when it is not the case.

PHASE

The analysis of the interviews and confirmed by surveys showed that the further along in the process, the less circular design strategies can be applied. In the early stages of the process, all strategies can very well be applied. According to an architect, in the initiative/definition phase, the opportunities must be seen very well and it must be determined which strategy you want to follow. According to the architect, the circular design strategies 'designing for prevention', 'designing for the reduction of life cycle impact', and 'designing for future-proofing' should already be formulated as goals in the initiative/definition phase. In the initiative/definition phase you make clear which strategies you are going to apply and you can still consider everything. In the design phase, these three strategies already become more difficult to apply, more effort must then be made to include them in the plan and to adjust the plan. During the realization phase, many respondents indicated that it is no longer possible to apply a circular design strategy. However, there is still an opportunity for circular design strategies at the material level. According to a sustainability consultant, among others, you only have the option of exchanging traditional raw materials at the end. That makes the option of looking at the circular design strategies 'designing with secondary raw materials' and 'designing with renewable raw materials' an better choice.

4.2.3.2. ROLES OF RESPONDENTS

It was also investigated whether the different roles that the respondents have in a construction project say something about the results. The roles have a very minimal impact on the results that the respondents have given for preference for circular design strategies. The analysis only shows similarities within the roles if the respondents indicate that all circular design strategies can be applied. As soon as one respondent provides a selection of circular design strategies, the other respondents with the same role do not exactly go along with it. The others often say even more or less circular design strategies. From this analysis, it can be concluded that the role of the respondent has no major impact on the preference for circular design strategies.

4.2.4. AGENDA FOR CHANGES

Through the survey that was sent to all respondents, a consensus is sought in the total data set. First, the respondents read the summary of all data collected from all respondents, see appendix E, then the respondents answered the questions of the survey. The survey shows whether the respondents agree or disagree with the condition of why circularity has a positive or negative value for a certain project parameter. It also emerges whether the respondents agree or disagree with the circular design strategies drawn up for each project parameter. If there is a majority that disagrees, then no consensus has been reached and the second round of the DM would have started. The results of the survey can be requested by the researcher.

The analysis showed that consensus was obtained on all data. There are, however, several points where the condition or reason is better described or optimized. This is the case when respondents indicate that they disagree. The respondents disagree, which could be for two different reasons. It may be that the respondents have a note on the condition of how it has been drawn up or it may be that the respondents disagree because an incorrect conclusion was drawn from the interview and the condition is not correct. For the first reason, the notes are included in the condition, but nothing changes in terms of the content of the condition. The second reason actually changes something in the content of the condition. These conditions are discussed below.

4.2.4.1. CONSENSUS ABOUT EFFECTS ON THE MANAGEMENT ASPECTS

By the project parameter 'project size' is the condition for a smaller project if it has a negative effect on quality, adjusted:

No energy is put into innovations.

Of the nine respondents, three respondents indicated that innovation is not the right wording. An architect wonders what innovation is and indicates that circular construction can also be very simple and basic. This is also argued by a sustainability consultant who indicates that circularity does not have to be innovative, reuse of good materials is simply applicable. Because several respondents indicated that innovation is not necessary, the condition has been adjusted as followed based on the results from the interviews:

When no energy is invested in circular solutions.

By the project parameter 'investment size' is the condition for a tighter budget if it has a positive effect on time, adjusted:

When creatively looking for solutions.

Half of the respondents, who vary in their role in construction, indicate that in general, it takes time to find creative circular solutions. The respondents also indicate that with a tighter budget, there is often less time. According to a sustainability consultant, traditional solutions are then more likely to be used, which is positive for time but negative for circularity. The condition has therefore been adjusted to the following:

When looking for simple circular solutions.

There is no need to invest extra time, but it will still be possible to build circularly.

By the project parameter detail level is the condition for high detail level if it has a positive effect on cost, adjusted:

When cheaper products are used and higher quality is delivered, the end-of-life value increases.

Three out of eight respondents indicated that cheaper products often do not provide higher quality. A high 'level of detail' will probably not be possible with cheap products, according to a project manager. An architect argues for high-quality elements. The condition has been changed with the feedback to the following:

When high-quality products can be used so that higher quality can be delivered and the end-life value is higher.

High-quality products are applied in advance, which can lead to more costs in advance, but due to the value that results in end-life, it can be positive.

By the project parameter ‘lifespan’ is the condition for a long ‘lifespan’ if it has a negative effect on cost, adjusted:

When the costs for the materials increase, in order to maintain the quality longer.

The respondents who disagree indicate that you can divide the costs over a longer ‘lifespan’. According to a sustainability consultant, it affects the investment budget, but not the total budget. This is because better-quality materials can also be beneficial over the entire ‘lifespan’. The condition has therefore been amended as follows:

Becomes negative on the investment budget when the costs for the higher quality materials increase to maintain the quality for a longer time.

By adjusting the condition, it is now more in line with what the respondents have indicated. This indicates the specific budget for which it will cost more, which can be taken into account in advance during the design.

4.2.4.2. CONSENSUS ABOUT THE CHOICES FOR THE CIRCULAR DESIGN STRATEGIES

The respondents were in full agreement about the choice of circular design strategies. Only two points were noted. These are textual changes and not substantive changes. The project parameter ‘complexity’ is to properly apply the circular design strategies ‘designing for prevention’, ‘designing for the reduction of life cycle impact’, and ‘designing for future-proofing’. The reason for choosing these circular design strategies has been changed:

Circularity currently increases the ‘complexity’ and that, in combination with a complex building, makes it very difficult. The more complex, the more specific, the more difficult it becomes for the real reuse of materials. Then there is also less work with secondary and renewable raw materials because these circular design strategies are more difficult to adapt to a complex project. Detachability, flexibility, and adaptability are the question of whether this is still possible with high complexity. The fact that reused objects, secondary raw materials, and renewable raw materials are used less often also has to do with guarantees. It is more about prevention, reduction, and future-proofing.

At the reason is added “in most cases”. This was done because a sustainability consultant indicated that circularity does not necessarily lead to more complex designs. At the moment this is still the case in most cases, but it also depends on other factors. This has led to the following reason:

Circularity <u>in most cases</u> currently increases the ‘complexity’ and that, in combination with a complex building, makes it very difficult. The more complex, the more specific, the more difficult it becomes for the reuse of materials. Then they also work less with secondary and renewable raw materials, because it is more difficult to adapt to a complex project. Detachability, flexibility, and adaptability are the question of whether this is still possible with high complexity. The fact that reused objects, secondary raw materials, and renewable raw materials are used less often also has to do with guarantees. It is more about prevention, reduction, and future-proofing.

In a rural area, the analysis showed that all circular design strategies can be applied. A note has been made on the reason that all circular design strategies can be applied and has been processed:

In rural areas, a pitfall is that if you have more space, you are less pushed to think about the use of space. You then build faster with more volume and less compact. If it has to do with where your raw materials come from, then renewable raw materials in a rural area are easier.

The sustainability consultant disagrees with the last sentence, renewable raw materials often have to be processed and manufactured before being used as a building material, so it depends on where the factory is located. This has been modified as follows:

In rural areas, a pitfall is that if you have more space, you are less pushed to think about the use of space. You then build faster with more volume and less compact. If it has to do with where your raw materials come from, renewable raw materials in a rural area are easier, depending on where they are processed and manufactured.

The survey showed that all respondents who took part in the survey agree with the other best choices for circular design strategies and the reason for these circular design strategies. The analysis showed that there is no difference in how the respondents reacted between the different roles that respondents have in construction. As soon as several disagreed with the condition or with the stated reason, they were always respondents from different groups. No distinction can be made between the groups.

4.3. SYNTHESIS OF THE RESULTS

After the literature study, explorative interviews, and the Delphi research, the synthesis of the findings has been performed. The synthesis of the findings included combining all results into an overview. By combining all data, it is shown per project parameter what the consequences are for the choice of circular design strategies and what the effects are on the management aspects.

4.3.1. START POINT SYNTHESIS

An imaginary experiment has been conducted to combine the findings from the literature study, explorative interviews, and the DM which create a better understanding of which circular design strategies can be better applied in which projects and what consequences this has on the management aspects. The synthesis started by combining the project parameters found in the explorative interviews and the data collected through the DM. This resulted in the structure of the two tables, shown in Table 18 and Table 19, which can be seen complete with the results in Appendix K and M.

The first table shows the results on the management aspects, collected using the structured quantitative and semi-structured qualitative interview method. The mixed-method was used to determine whether the project parameters have a positive or negative effect on the management aspects of cost, time, and quality. Also, the condition is elaborated about when it gets a positive or negative effect. The first table shows per project parameter what the condition is if it has a positive or negative effect. The effect of circularity on the relevant management aspect that emerged from the expert interviews is also indicated using a gray color.

The second table shows per project parameter which circular design strategies are recommended to be applied and what the reason for the recommendation is. The data was collected using the structured quantitative/semi-structured qualitative interview method. The mixed-method was used again to also find out for each project parameter which circular design strategies of the six could best be applied and the reason why these circular design strategies can best be applied.

Based on the conditions drawn up in the first table, it can be found why something would have a positive effect or negative effect on the management aspects. This can also be used to determine what can be adjusted in the project, for example, to make it turn out positive. Based on the reasons why the recommended circular design strategies can best be applied, it is possible to find out whit which changes the other strategies can also be applied.

Table 18: Overview results on the management aspects

Project parameter		Cost		Time		Quality	
Project size	Big >10000m2	+	…	+	…	+	…
		/		/		/	
		-	…	-	…	-	…
	Small <10000m2	+	…	+	…	+	…
		/		/		/	
		-	…	-	…	-	…
Project type	New construction	+	…	+	…	+	…
		/		/		/	
		-	…	-	…	-	…
	Renovation	+	…	+	…	+	…
		/		/		/	
		-	…	-	…	-	…
	Temporary construction	+	…	+	…	+	…
		/		/		/	
		-	…	-	…	-	…

*the entire table is shown in Appendix K

Table 19: Overview advice circular design strategies

Parameter		Circular Design Strategies	Reason
Project size	Big >10000m2	…	…
	Small <2000m2	…	…
Project type	New construction	…	…
	Renovation	…	…
	Temporary construction	…	…
Duration	Long > 2.5 year	…	…
	Short < 2.5 year	…	…
Investment size	Wide budget	…	…
	Tight budget	…	…
Complexity	High complexity	…	…
	Low complexity	…	…
Number of stakeholders	> 10 stakeholders	…	…
	≤ 10 stakeholders	…	…
Environment	Urban area	…	…
	Rural area	…	…

*the entire table is shown in Appendix M

To achieve the goal of offering project managers a model with the necessary information about circular design strategies to advise clients in the definition phase, the data must be presented in one overview. The information from the above tables must be combined to provide insight into which circular design strategies are most appropriate for the project, based on the project parameters, and what the impact is on the management aspects. Hereby, it is important that the different project parameters are presented per circular design strategies and management aspects. This should lead to Table 20. In the next section, the underlying data is linked to this structure of the table.

Table 20: overview synthesis data

	Designing for prevention		Designing for teh reduction of life cycle impact		Designing for future-proofing		Designing with reused objects		Designing with secondary raw materials		Designing with renewable raw materials	
Cost	Project size	Bigger	Project size	Bigger	Project size	Bigger	Project size	Bigger	Project size	Bigger	Project size	Bigger
		Smaller		Smaller		Smaller		Smaller		Smaller		Smaller
	Project type	New construction	Project type	New construction	Project type	New construction	Project type	New construction	Project type	New construction	Project type	New construction
		Renovation		Renovation		Renovation		Renovation		Renovation		Renovation
		Temporary construction		Temporary construction		Temporary construction		Temporary construction		Temporary construction		Temporary construction
	Duration	Longer	Duration	Longer	Duration	Longer	Duration	Longer	Duration	Longer	Duration	Longer
		Shorter		Shorter		Shorter		Shorter		Shorter		Shorter
	Investment size	More	Investment size	More	Investment size	More	Investment size	More	Investment size	More	Investment size	More
		Less		Less		Less		Less		Less		Less
	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity
		Low complexity		Low complexity		Low complexity		Low complexity		Low complexity		Low complexity
	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More
		Less		Less		Less		Less		Less		Less

*the entire table is shown in Appendix N

4.3.2. COMBINING RESULTS

Table 18 and Table 19 have been drawn up from the analysis of the interviews and the surveys (shown in Appendix K and M). The first table shows per project parameter whether circularity has a positive, neutral, or negative effect on the management aspects cost, time, and quality. It also shows the conditions when it will have a positive or a negative effect. The conditions must be met to get the particular effect. The second table shows which circular design strategies can best be applied per project parameter. The reason for this is also described. Based on the reason, it can be checked whether the proposed circular design strategies also fit the project in question.

In the synthesis the two tables come together and are shown in one big table, the process is shown in Figure 17. The most important thing that has come together, in the table with the total data, is the circular design strategies and the effects on the management aspects. The six circular design strategies can be read horizontally. The three management aspects and the project parameters are displayed vertically. Colors indicate per project parameter whether it has a positive (green), neutral (orange), or negative (red) effect on the management aspect for the particular circular design strategy. The condition and reasons are omitted in the merged table. The merged table gives too much information in one, which makes it difficult to manage. Most of the information can be read in the earlier tables and is less important in the merged table.

To arrive at the total table with the merged data, two steps were followed. First, there is looked at each circular design strategy when it is recommended to apply to a certain project parameter. For example, with the project parameter ‘project size’, it is not recommended to apply the circular design strategy ‘designing with reused objects’ and ‘designing with renewable raw materials’ by a large project. These are then displayed in red (negative). In this way, every project parameter and every circular design strategy has been assessed. In the next step, the effects on the management aspects have been added. As soon as it gave a positive effect on the management aspect for the project parameter circularity and the certain circular design strategy was recommended to be applied, it was assessed as positive and it got the green color. Once the conditions remained the same but the effect became neutral, it was rated neutral and turned orange. Once the conditions remained the same but the effect was negative, it was rated negative and turned red. It is also possible that the circular design strategy was not recommended to be applied and had already been given a red color, then the effect on the management aspect no longer matters, because then it remains negative. In this way, a table has been drawn up for each management aspect, shown in appendix N. First, it is indicated which circular design strategies are recommended per project parameter, after which the effects on the relevant management aspect are achieved.

By combining the data, it is now possible to see which circular design strategy or multiple circular design strategies are recommended for the set of project parameters. These circular design strategies are then recommended because it is a better option to apply and because it has a positive or neutral

effect on the relevant management aspect. As soon as the project parameter is shown in red, the particular circular design strategy is not recommended to be applied to the respective project parameter or it has a negative effect on the relevant management aspect.

In the final table, all the data comes together, which is difficult to read at first glance. For this reason, it was decided to use this data as input for a model. The data is used as the basis for the model and a user-friendly model has been built around it. This process is described in the next chapter.

Project parameter		Cost	Time	Quality
Project size	Big >10000m2	+ ...	+ ...	+ ...
		/	/	/
		- ...	- ...	- ...
	Small <10000m2	+ ...	+ ...	+ ...
		/	/	/
		- ...	- ...	- ...
Project type	New construction	+ ...	+ ...	+ ...
		/	/	/
		- ...	- ...	- ...
	Renovation	+ ...	+ ...	+ ...
		/	/	/
		- ...	- ...	- ...
	Temporary construction	+ ...	+ ...	+ ...
		/	/	/
		- ...	- ...	- ...

*the entire table is shown in Appendix K

Parameter		Circular Design Strategies	Reason
Project size	Big >10000m2	1, 2, 3, 5, (4, 6 more difficult)	...
	Small <10000m2	6, 5, 4 is done more 1, 2, 3 always	...
Project type	New construction	1, 2, 3, 6 (focus on 3) (4, 5 more difficult)	...
	Renovation	Everything (focus on 1, 4)	...
	Temporary construction	...	...
Duration	Long > 2.5 year	...	...
	Short < 2.5 year	...	...
Investment size	Wide budget	...	...
	Tight budget	...	...

*the entire table is shown in Appendix M

	Designing for prevention		Designing for teh reduction of life cycle impact		Designing for future-proofing		Designing with reused objects		Designing with secondary raw materials		Designing with renewable raw materials	
Cost	Project size	Bigger	Project size	Bigger	Project size	Bigger	Project size	Bigger	Project size	Bigger	Project size	Bigger
		Smaller		Smaller		Smaller		Smaller		Smaller		Smaller
	Project type	New construction	Project type	New construction	Project type	New construction	Project type	New construction	Project type	New construction	Project type	New construction
		Renovation		Renovation		Renovation		Renovation		Renovation		Renovation
		Temporary construction		Temporary construction		Temporary construction		Temporary construction		Temporary construction		Temporary construction
	Duration	Longer	Duration	Longer	Duration	Longer	Duration	Longer	Duration	Longer	Duration	Longer
		Shorter		Shorter		Shorter		Shorter		Shorter		Shorter
	Investment size	More	Investment size	More	Investment size	More	Investment size	More	Investment size	More	Investment size	More
		Less		Less		Less		Less		Less		Less
	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity	Complexity	High complexity
		Low complexity		Low complexity		Low complexity		Low complexity		Low complexity		Low complexity
	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More	Number of stakeholders	More
		Less		Less		Less		Less		Less		Less

*the entire table is shown in Appendix N

Figure 17: Synthesis results

4.4. MODEL CIRCULAR D ESIGN STRATEGIES AND EFFECTS ON COST, TIME & QUALITY

To reach the objective of this research, to give the project managers a clear model with the necessary information about circular design strategies to advise clients, the framework with the synthesis of all data has been converted into a model. By processing the results in a model, it has been made user-friendly for the project manager. By entering only the project parameters for the particular project, the model shows the recommended circular design strategies and the effects on the management aspects. Scores and weightings are linked to the data to get results from the model. After making the data complete, the data is processed in Excel and the model is made. This has resulted in an Excel model with a dashboard and the associated information.

4.4.1. STRUCTURE OF THE MODEL

The model is built from the table with the merged data. Based on this table it should be possible to give the project managers more information about applying circularity in the project. The project managers have a project with certain project parameters, for which they want to know two points: which circular design strategies they can best apply and what influence this has on the management aspects. To ensure that the project managers have to search through the entire table for the answers, a model has been made for the combined data. In the model, the input that must be given and the results are displayed on a sheet. The merged data is linked to the model. To make the model work, a score and a weighting are added to the data to arrive at a total score. In Figure 18, the process of processing the data into the necessary data for the model is shown in an overview.

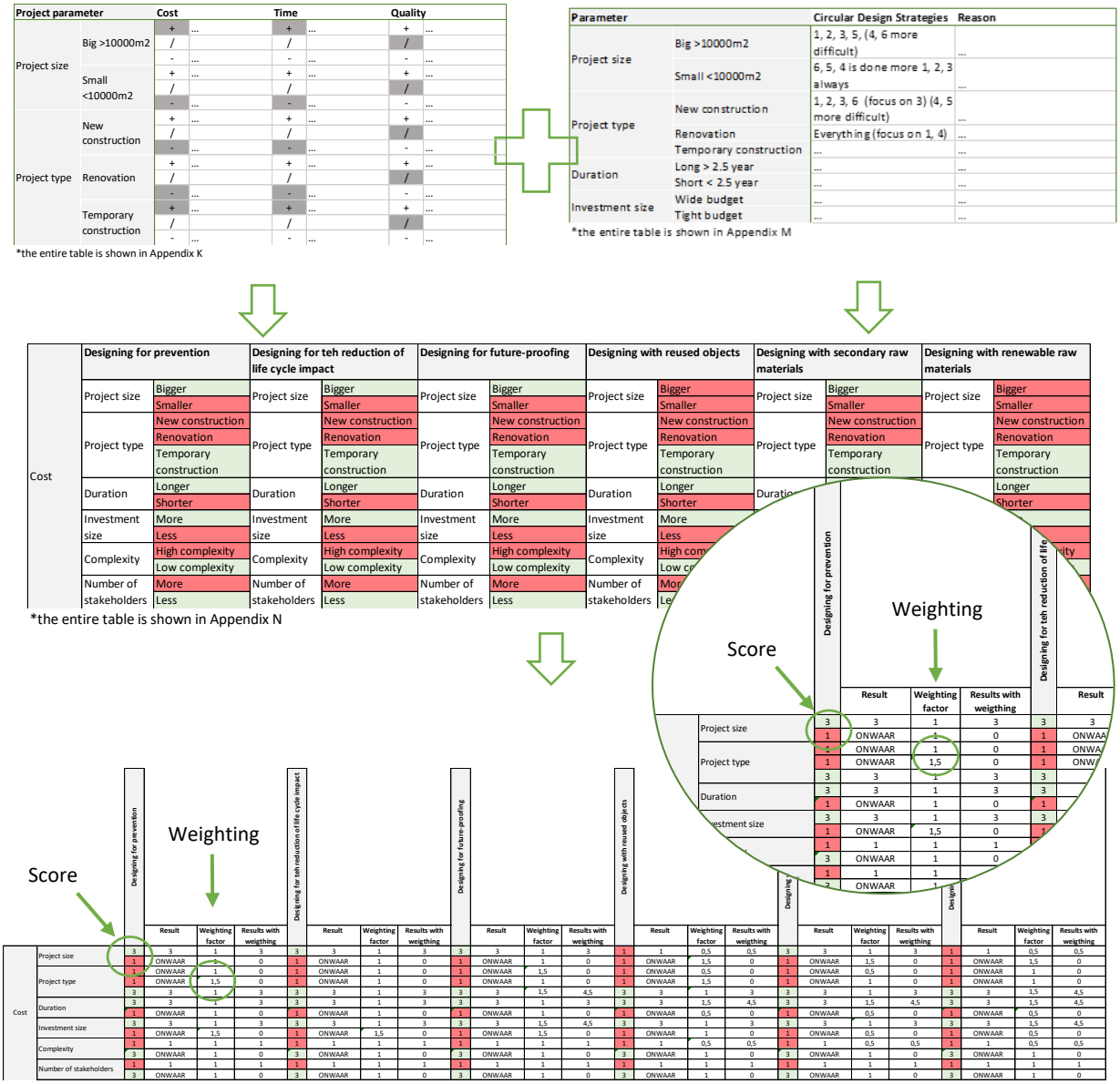


Figure 18: Process of making the data usable

4.4.1.1. SCORE

In the datasheet, it is indicated through colors whether it has a positive, neutral, or negative effect if the circular design strategy is applied to the specific management aspect. By assigning a score to the three different effects, a total score can be calculated. Based on the scores, a total score is calculated for each circular design strategy per management aspect. Based on this score, an overview is given for each management aspect of the effect if the specific circular design strategy is applied. An overall score is also calculated per circular design strategy. The overall score shows how positive it is to apply the specific circular design strategy to the project.

A score has been assigned to the three different effects. The score ranges from 1 to 3. The higher the score, the more positive. For this reason, a positive effect has been given a score of 3 and a negative effect a score of 1. Neutral is in between and gets a score of 2. This distribution has been chosen

because now all effects are included in the calculation and have an effect on the total score. Even if a negative effect would receive a score of 0, it is not included in the weighting and it always remains 0. By calculating with 1, the weighting can also have an effect on a negative effect. There is now also the same difference of 1 between the different scores.

Value	
Negative effect	1
Neutral effect	2
Positive effect	3

Figure 19: Scores

4.4.1.2. WEIGHTING FACTOR

A weighting factor is included in the calculation of specific parameters. It emerged from the interviews and the surveys that for a certain project parameter more focus can be placed on certain circular design strategies. This means that there is more chance for the named circular design strategy to be applied to the project. It has also emerged that a circular design strategy can be more difficult to apply for certain project parameters. This means that there is a reason that a certain circular design strategy is even more difficult compared to the other circular design strategies to apply to a certain project parameter.

If a focus/change is placed on a certain circular design strategy for a project parameter, it has been given a weighting factor of 1. If it is more difficult to implement a certain circular design strategy for a project parameter, it has been given a weighting factor of 0. If it remains neutral, and no attention was paid to it in the interviews, then it has been given a weighting factor of 0.5. This distribution of the weighting ensures that the score falls between the scope remains from 0 to 3. As soon as the highest weighting exceeds 1, the score will be out of bounds as it can go higher than 3. This score also creates a clear difference between the circular design strategies that have a focus/change or the ones that are more difficult to apply. As soon as there is a focus/change with a circular design strategy, which is the most positive situation, it gets the total score associated with the parameter. As soon as a circular design strategy is more difficult to apply, which is the most negative situation, it is not included in the calculation due to the score of 0. Once it remains neutral it will have an average score. These circular design strategies can still be improved, but can already be applied well to projects.

Weighting factor	
Focus/chance	1
Neutral	0,5
More difficult	0

Figure 20: Weighting factors

4.4.1.3. CALCULATIONS BEHIND THE MODEL

By filling in the project parameters in the model, the score on the project and per management aspect can be calculated for each circular design strategy, shown in Figure 21.

Calculation 1: measurement circular design strategies

The answers to the project parameters are linked to processes. Based on the project-specific parameters, a value is calculated per circular design strategy. Calculation 1 determines for each circular design strategy to what extent it is advantageous to apply the strategy in the construction project. The minimum and maximum scores are different for each circular design strategy, due to the weighting that differs per circular design strategy. The higher the score, the more positive effect the circular design strategy has on the construction project.

In the example, the value for circular design strategy 'designing for prevention' with the weighting is 21,33. This score is converted into a percentage that is displayed in the model. This calculation takes into account the maximum and minimum that the circular design strategy can achieve. The maximum is 100% and the minimum is 0%. In the example, the project scores 69%. This value indicates that the circular design strategy is recommended to apply to the construction project, the circular design strategy will have a more positive effect on the construction project.

Table 21: Example gauge chart

Designing for prevention				
Min.	Max.	Value	Pointer	End
11,17	25,83	69	2	91

Calculation 2: measurement management aspects

The same processes of calculation 1 are used for calculation 2. Based on the answers to the project parameters, a score is calculated for the effects of the circular design strategies on the management aspects cost, time, and quality of a construction project. Calculation 2 divides the total score for each circular design strategy into a score for cost, time, and quality. The minimum and maximum scores are different for each circular design strategy, due to the weighting that differs per circular design strategy. The higher the score, the more positive effect the circular design strategy has on the management aspect.

In the example, the value for circular design strategy 'designing for prevention' with the weighting on the management aspect cost is 1.41. This score is converted into signs that are displayed in the model. This calculation takes into account the maximum and minimum that the circular design strategy can achieve. The maximum is 100% and the minimum is 0%. In the example, the project scores 71% on the management aspect cost. This value indicates that is applying the circular design strategy has a positive effect on the management aspect of the construction project.

Table 22: Example cross table

	Designing for prevention		
	Cost	Time	Quality
Max.	0,66	0,63	0,78
Min.	1,72	1,56	1,66
Value	71	63	68
Sign	+	+	+

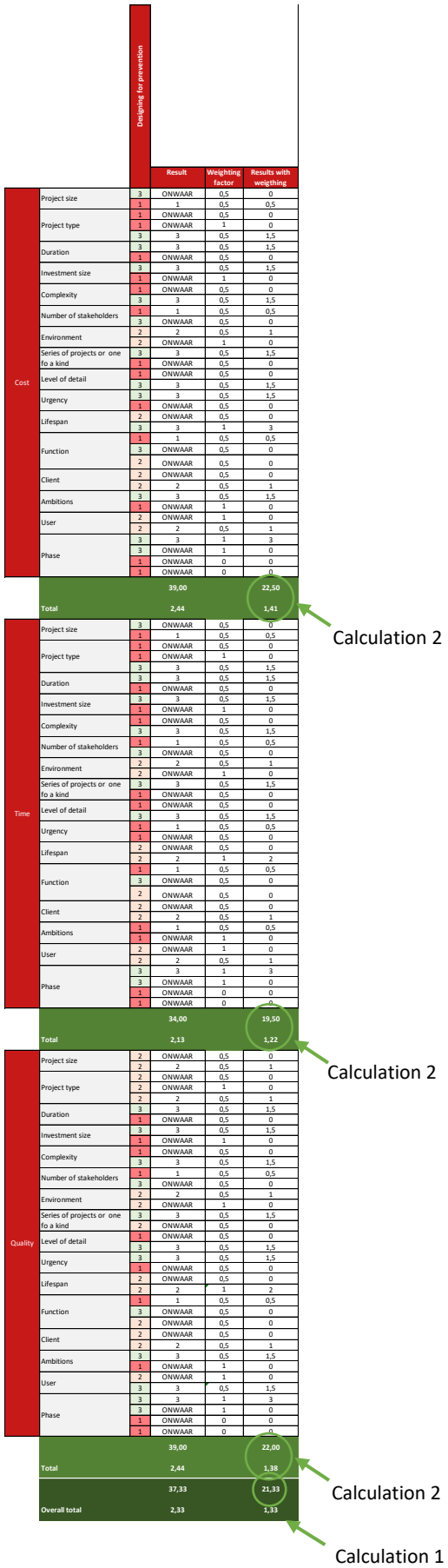


Figure 21: Example calculations

4.4.2. STEP BY STEP THROUGH THE MODEL

Step by step the project manager can go through the model. In Figure 22 the step-by-step plan is shown.

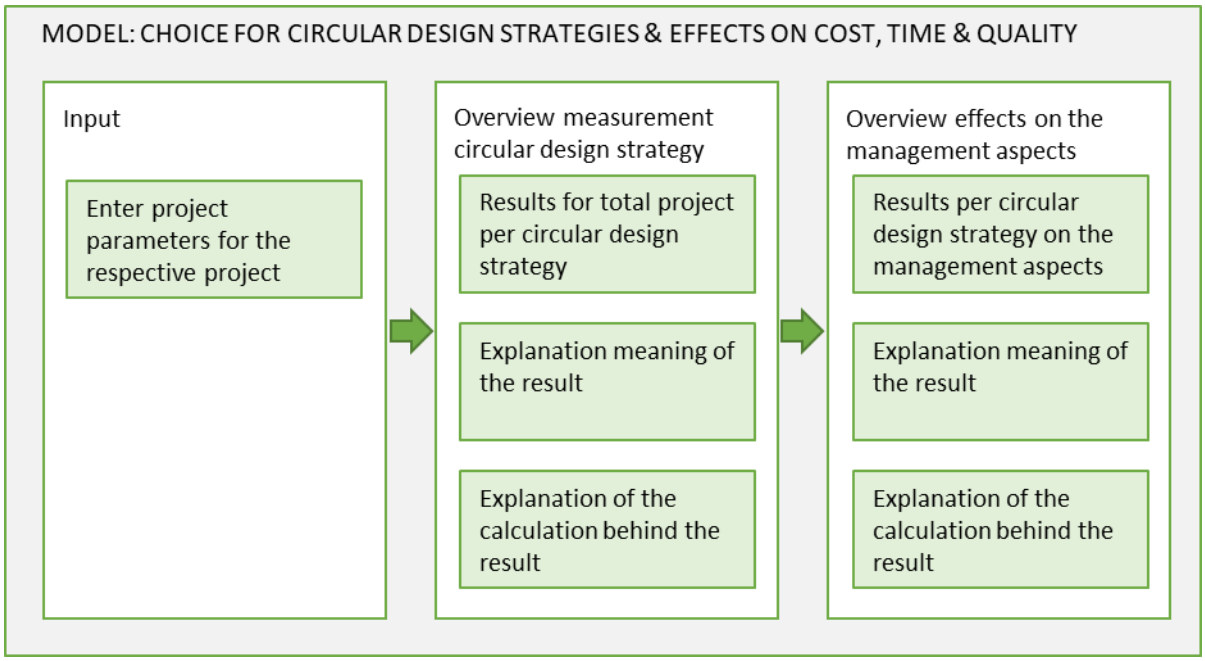


Figure 22: Schematic representation step-by-step plan

4.4.2.1. STEP 1. INPUT

The first step in the model is to provide input for the results. Based on the selection menu, a choice can be made between the different values of the project parameters. A completed input schedule is shown in Figure 23. Using the reset button, the input schedule is cleared and can be filled in again for a relevant project. Adjustments can be made at any time per project parameter. Each adjustment will produce a different result.

INPUT

RESET

Project parameters	
Project size	Bigger
Project type	Temporary construction
Duration	Longer
Investment size	More
Complexity	High complexity
Number of	More
Environment	Urban area
Series of projects or	Series
Level of detail	High
Urgency	High
Lifespan	Long >75 year
Function	Living
Client	Private sector
Ambitions	High
User	Rentals
Phase	Initation/definition phase

*Further explanation per project parameters is shown in tab 'Explanation'

Figure 23: Example input project parameters

4.4.2.2. STEP 2. OVERVIEW MEASUREMENT CIRCULAR DESIGN STRATEGY

Step 2 displays the first part of the results. The results are displayed through diagrams. A diagram has been made for each circular design strategy. The arrow in the diagram indicates the score. The diagram is divided into five boxes. Each box has been given a color where the greener means the more positive, orange means neutral, and the redder the more negative. The six diagrams provide an overview of which circular design strategies have a more positive effect on the construction project and which circular design strategies have a more negative effect on the construction project. Figure 24 shows an example of the diagrams showing the results per circular design strategy.

Figure 24: Example results per circular design strategy

4.4.2.3. STEP 3. OVERVIEW EFFECTS ON THE MANAGEMENT ASPECTS

Step 3 displays the second part of the results. The results are presented in a table. The table shows the effect on the management aspects for each circular design strategy. Vertical are the management aspects displayed and horizontal are displayed the circular design strategies. The score is also divided into five ranges. The score is represented by ++, +, +-, -, -- and the colors green, orange, and red. The more positive, the greener, and the more pluses. The more negative the redder and the more minuses. Neutral is shown in orange and with the +- signs. The table provides an overview of the effect of the circular design strategies on the management aspects of cost, time, and quality. In Figure 25 an example is shown of the table showing the results of the effects on the management aspects.

Results per management aspect

Circular design strategies	Cost	Time	Quality
Designing for prevention	+	+-	+
Designing for the reduction of life cycle impact	+	+-	++
Designing for future-proofing	+	+-	+
Designing with reused objects	+	+	+
Designing with secondary raw materials	+	+-	+
Designing with renewable raw materials	+-	+-	+

Figure 25: Example result per management aspect

4.4.3. RESULT OF USING THE MODEL

The step-by-step plan describes the steps that must be followed in the model to arrive at the results. But what do the results mean and what do the results mean for the construction project in question?

The results per circular design strategy are shown by means of a score between 0 and 3. The score is divided into five ranges from negative effect to positive effect. The lower the score, the less good and vice versa, the higher the score, the better the circular design strategy is to apply to the construction project. Figure 26 shows the definitions of the different scores. From the diagrams, there can be found out what the score is and in the table, there can be searched for what the score means for the relevant construction project.

Meaning results circular design strategies

Score	Definition
≥ 80	The circular design strategy is recommended to apply to the construction project, the circular design strategy will have a more positive effect on the construction project.
≥ 60 - < 80	The circular design strategy is recommended to apply to the construction project, the circular design strategy will have a positive effect on the construction project.
≥ 40 - < 60	The circular design strategy can be considered to be applied to the construction project, the circular design strategy will have a neutral effect on the construction project.
≥ 20 - < 40	The circular design strategy is not recommended to be applied to the construction project, the circular design strategy will have a negative effect on the construction project.
< 20	The circular design strategy is not recommended to be applied to the construction project, the circular design strategy will have a more negative effect on the construction project.

Figure 26: Meaning of the score from the circular design strategy

The effects on the management aspect per circular design strategy are shown by means of pluses and minuses. The scores are divided into five ranges from negative effect to positive effect. The more minuses, the more negative the effect, and vice versa, the more pluses, the more positive the effect on the construction project. In Figure 27 the definitions of the different scores are described. From the table, with the results, there can be found what the score is, and in the table, with the definitions of the score, there can be searched what that means for the construction project in question.

Meaning results management aspects

Score	Definition
++	Applying the circular design strategy has a more positive effect on the management aspect of the construction project.
+	Applying the circular design strategy has a positive effect on the management aspect of the construction project.
+-	Applying the circular design strategy has a neutral effect on the management aspect of the construction project.
-	Applying the circular design strategy has a negative effect on the management aspect of the construction project.
--	Applying the circular design strategy has a more negative effect on the management aspect of the construction project.

Figure 27: Meaning of the score from the management aspects

The model provides the necessary information about circular design strategies that the project managers can use when advising the clients in making circular choices for the construction project in the definition phase. The model can be used to determine the effects of different options on the construction project. By filling in the project parameters of the relevant construction project, it becomes clear which circular design strategy can best be applied to the project and what the effects are on the management aspects when these circular design strategies are applied. The model can be used to determine which circular design strategies can best be included in the design. These circular design strategies can then be processed in advance in the Program of Requirements. It also becomes clear in advance what the effects are on the management aspects of cost, time, and quality. By having this mapped out in advance, this can also be taken as soon as possible into account in the construction project.

The project managers can also use this model in the conversations with the clients in the initiative/definition phase. By starting this early in the project, circularity can still be favorably included in the project. The project managers can use the model to arrive at the optimal option for circularity in the construction project. If the model is looked at early in the process, adjustments can still be made in the project. For example, project parameters can still be adjusted to arrive at the optimal option of circular design strategies. By adjusting project parameters in the input table, the result is immediately displayed. In this way, it can be seen if a changing project parameter has a more positive or negative effect on the circular design strategies and what the consequences are for the effects on the management aspects.

Furthermore, sheets with further explanations have been added to the model. This sets out the conditions why circularity will have a positive or negative effect and the reason why the proposed circular design strategies are named for a certain project parameter. Based on this additional explanation, it is also possible to look at how the most optimal combination of circular design strategies can be chosen. The extra explanation can also help to set the project parameters as best possible to ensure that the most optimal circular design strategies can be applied to the construction project.

4.5. VALIDATION OF THE MODEL

After developing the model, the model was tested by a focus group to determine whether the model works as expected and whether the model is clear to the target group who want to use the model in their projects. Additionally, the participants were asked to give their opinion on what they think of the model and if they have any additions to the model. Subsequently, the model was also validated through case comparison to determine whether the results of the model are related to the practice.

4.5.1. IDENTIFIED AND REQUIRED CHANGES

The model has been validated using two methods. The purpose of the validation sessions was to validate the developed model. The first validation method used a focus group working on the DSM project. The model was completed based on the DSM project to experience how the model works. This experience enabled the participants to complete the survey and validate the model. The second validation method used example cases to experience whether the results of the model corresponded to practice. Six example cases were used to perform a case comparison.

4.5.1.1. DSM PROJECT

For the first validation session, a survey was drawn up to gain insight into whether the model works well and whether it is clear to the target group that will use the model. After a short explanation of the model, the participants applied the model to the DSM project, in which the participants answered the validation questions. From the answers to the questions (Appendix O), points emerge that can make the model better, to make it more user-friendly and more suitable for the stated purpose. Table 23 gives an overview of the outcomes of the validation session:

Table 23: Validation of the model by the DSM project

	Identified change	**Validation**
Representations of the Model	I. Formulating SMART explanation of project parameters	To the user, all options for all project parameters were clear. The objective values (eg when is something a big or small project) are recommended to add, to formulate it SMART.
Use of the model	II. Fill in the more/other options for several project parameters	The input can be queried in a more SMART way. For several project parameters, there are no possibilities to choose the correct input.
Results of the model	III. Dividing the project parameter "phase" into four phases	More nuance is needed in the project parameter "phase". The phases that are added together, but also have a lot of impacts separately. To give complete input, these have to be taken apart.
	IV. Add that a recommendation is given from the model	The model provides an assessment framework but makes it even stronger if a first recommendation from the model is also put forward.
Expectations of the model	V. References to the explanation sheets	The underlying data and explanation are not yet easy to find. This will be looked at more quickly using references.

The answers to the questions in the "model expectations" part of the survey confirmed that according to the participants the model fits the purpose for which the model should be used by validating the model with the DSM project. The purpose of this research is the following:

"To help clients by taking the next step in the move from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies to advise clients in this process."

The validation indicates that the model can be used very widely because it can be used as a gauge for circularity at any stage. The participants will mainly use this model at the beginning of drawing up the Program of Requirements so that the model can help determine the circular choices for taking the next step in the process from circular ambitions to circular project requirements. It is indicated that this concerns the definition phase. These responses are fully in line with the aim of this research to create a model that helps with the move from circular ambition to circular project requirements in the definition phase. It is also indicated that the model can be used in both new construction and renovation of non-residential or residential construction. The participants would recommend the model to project managers and consultants who raise ambitions and requirements for a new project. According to the participants, this model will enable the project managers and advisors to provide more insight into the possibilities in the field of circularity and to form a better picture for the clients. This insight is given by the scores on the circular design strategies and the scores on the three management aspects. These responses fit in well with the second part of the goal to provide project managers with necessary information about circular design strategies to advise clients.

4.5.1.2. EXAMPLE CASES

For the second validation session, the example cases used in the literature study are validated in the model. To make the explanation in the literature study of the circular design strategies stronger, example cases have been used. These example cases have at least used one or two circular design strategies. To validate the model, the project parameters are entered for each example case and the results obtained from the model are examined. Does the model recommend the same circular design strategy or strategies as used in the project? As soon as advice is given that differs from the one that has been applied, it is examined whether this is due to the model or whether the project could have applied more circular design strategies. Based on this validation session, it is investigated whether the model advises what is actually done in practice.

To determine when circular design strategies are recommended for the project in question, the score is looked at. As soon as the score is higher than 60%, the circular design strategy is recommended. Once it is between 40% and 60%, it remains neutral and would have neither a positive nor a negative effect on the project. It is then not recommended, but will not have any bad consequences either. As soon as the circular design strategy scores lower than 40%, it is not recommended to apply the circular design strategy, because it has a negative effect on the project. In this way, the results of the management aspect are also interpreted. As soon as the circular design strategy turns green, it has a positive effect on the management aspect. Orange indicates that it is neutral, it has neither a positive nor a negative effect. With red, attention must be paid to the management aspect, since the circular design strategy has a negative impact on the management aspect.

EXAMPLE CASE A – RABOBANK DOMMELSTREEK

Table 24 shows what the example case entails, indicates the surface area, and shows the circular design strategies used in the example case. Based on the explanation, the project parameters for example case A have been entered in the model. The results are shown in Figure 28 and Table 25.

The model shows that the circular design strategies 'designing for the reduction of life cycle impact' and 'designing with reused objects' score positively for application to the project. 'Designing for prevention' can be considered to be applied to the construction project, but will have a neutral effect on the construction project. The circular design strategies 'designing with secondary raw materials' and 'designing with renewable raw materials' have a neutral to negative effect on the project. These two strategies are also not applied in example case A. The focus of the project has mainly been on the circular design strategies 'designing for prevention', 'designing for the reduction of life cycle impact', and 'designing for future-proofing'. The model shows that these circular design strategies have a neutral to a positive effect on the project. There is still an opportunity for the circular design strategy design for reused objects, which scores the second-highest of all six circular design strategies. This is also reflected in the results on the management aspects. In particular, the circular design strategies 'designing for the reduction of life cycle impact' and 'designing with reused objects' have a positive effect on quality. The circular design strategies 'designing for the reduction of life cycle impact' have a positive effect on time. This also shows that these two strategies can be applied well. It emerges that the circular design strategy 'designing for future-proofing' scores positively on quality. The management aspects confirmed that the circular design strategies 'designing with secondary raw materials' and 'designing with renewable raw materials' be less good at applying because they have a negative effect on certain management aspects. It can be concluded from the validation that the model is largely in line with practice, but there was still room for the project to reuse materials.

Table 24: Information example case A

	Case	**Explanation**	**Recommendation**
Example case A	Rabobank Dommelstreek	Rabobank Dommelstreek has redeveloped the existing office in Geldrop. Rabobank Dommelstreek has made a conscious decision not to go for new construction, but to redevelop the existing bank branch. At the location of the old advice center, the existing building has been stripped to its shell, renovated, and expanded.	Designing for the reduction of life cycle impact and Designing for reused objects
	Surface	1205m2 BVO	
	Applied circular design strategies	Designing for prevention, Designing for the reduction of life cycle impact, and Designing for future-proofing	

Project parameters	
Project size	Smaller ≤ 10.000 m2
Project type	Renovation
Duration	Shorter ≤ 2.5 years
Investment size	Thight budget
Complexity	Low complexity
Number of	Less ≤ 10 stakeholders
Environment	Urban area
Series of projects or	One of a kind project
Level of detail	Low level of detail
Urgency	Low urgency
Lifespan	Long >75 year
Function	Utility
Client	Private sector
Ambitions	Low ambitions
User	Owned
Phase	Initation phase

Figure 28: Output circular design strategies for example case A

Table 25: Output management aspects for example case A

Circular design strategies	Cost	Time	Quality
Designing for prevention	+-	+-	+-
Designing for the reduction of life cycle impact	+-	+	+
Designing for future-proofing	+-	+-	+
Designing with reused objects	+-	+-	+
Designing with secondary raw materials	-	+-	+-
Designing with renewable raw materials	-	-	-

EXAMPLE CASE B – TRIODOS BANK

Table 26 shows what example case B entails, indicates the surface area, and shows the circular design strategies used in the example case. Based on the explanation, the project parameters for example case B have been entered into the model. The results are shown in Figure 29 and Table 27.

Example case B is based on the circular design strategies 'designing for the reduction of life cycle impact', 'designing for future-proofing', and 'designing with renewable raw materials'. The advice from the model is partly in line with what is used in practice. No circular design strategy scores negatively for the project so all circular design strategies have a neutral or positive effect on the project and on the management aspects. Remarkably, the project has applied the circular design strategy 'designing with renewable raw materials'. The model shows that it scores worst with three others, so you would be a little less likely to choose it or apply a circular design strategy that scores better. It is still a neutral effect so the circular design strategy does not have any further consequences for the project or for the management aspect. The model shows that the other two chosen circular design strategies are also convincingly better to apply to the project, which is also reflected in the score on the management aspects. The two circular design strategies are recommended to apply in the project, which has also been done in practice.

Table 26: Information example case B

	Case	Explanation	Recommendation
Example case B	Triodos bank	The project has an exceptionally sustainable approach to the construction process, has a design inspired by nature and the bio-based material choices are unique. Light, air, water, and energy are provided as naturally as possible and the building is completely energy neutral. The building consists of wooden construction and floors and is built to be demountable so that at the end of its life, the materials can be disassembled and reused.	Designing for the reduction of life cycle impact, Designing for future-proofing
	Surface	13.000 m2	
	Project team	EDGE, RAU Architecten, J.P. van Eesteren, Arcadis, Aronsohn, BBN, Bosman Bedrijven, Copijn, DGMR, Deerns en Ex Interiors, and Lüning.	
	Applied circular design strategies	Designing for the reduction of life cycle impact, Designing for future-proofing, and Designing with renewable raw materials.	

Project parameters	
Project size	Bigger > 10.000 m2
Project type	New construction
Duration	Longer > 2.5 years
Investment size	Wide budget
Complexity	High complexity
Number of	More > 10 stakeholders
Environment	Rural area
Series of projects or	One of a kind project
Level of detail	High level of detail
Urgency	High urgency
Lifespan	Long >75 year
Function	Utility
Client	Private sector
Ambitions	High ambitions
User	Owned
Phase	Initation phase

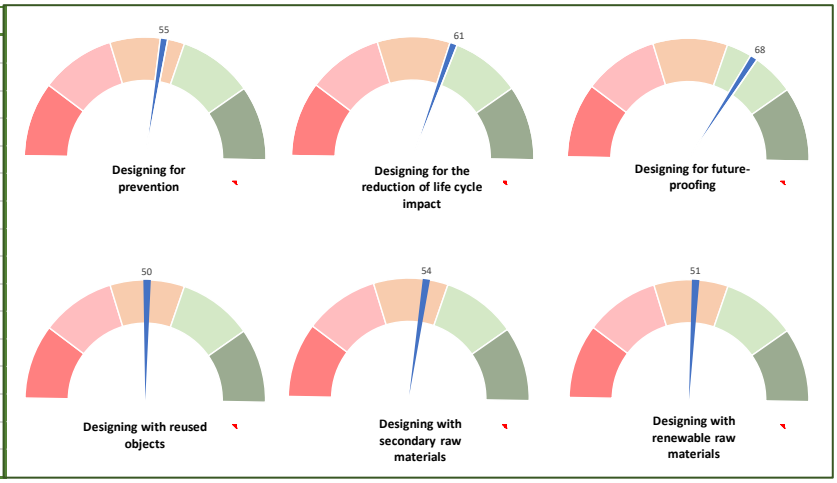


Figure 29: Output circular design strategies for example case B

Table 27: Output management aspects for example case B

Circular design strategies	Cost	Time	Quality
Designing for prevention	+-	+-	+-
Designing for the reduction of life cycle impact	+-	+-	+
Designing for future-proofing	+	+	+
Designing with reused objects	+-	+-	+-
Designing with secondary raw materials	+-	+-	+-
Designing with renewable raw materials	+-	+-	+-

EXAMPLE CASE C - DNB RENOVATION PROJECT

Table 28 shows what example case C entails, indicates the surface area, and shows the circular design strategies used in the example case. Based on the explanation, the project parameters for example case C have been entered into the model. The results are shown in Figure 30 and Table 29.

The project focuses on two circular design strategies, 'designing for future-proofing' and 'designing with reused objects'. Both of these also come out of the model well in comparison to the other strategies. Both circular design strategies have a neutral effect on the project according to the model. Only the circular design strategy design for the reduction of life cycle impact scores one percent higher, but also continues to have a neutral effect. Based on this outcome, none of the circular design strategies is recommended, because everything scores neutral or negative. The circular design strategies that have been applied in practice, do not have a negative effect on the project, so they can be applied without negative consequences. From the model, it is mainly recommended not to apply the circular design strategies 'designing with secondary raw materials' and 'designing with renewable raw materials', since they also score negatively on almost all management aspects. The two circular design strategies that have been applied in practice have had no impact on the project and the management aspects according to the model, but are also not recommended.

Table 28: Information example case C

	Case	**Explanation**	Recommendation
Example case C	DNB renovation project	After the renovation, the building is future-proof and can last for decades. Possible adjustments by future generations are constantly taken into account and a lot of attention is therefore paid to modular construction. The building is fully adaptable and demountable. The facades are replaced by prefabricated elements, which can be removed again. The same applies to the entire interior, such as the interior walls and floor finish. Wet, glued connections are avoided as much as possible and use dry connections that can be easily loosened again	-
	Surface	64.000 m2	
	Project team	Strukton, Stevens van Dijck & LSA, MECANOO, Valstar Simonis, dGmr en Pieters Technie	
	Applied circular design strategies	Designing for future-proofing and Designing with reused objects	

Project parameters	
Project size	Bigger > 10.000 m2
Project type	Renovation
Duration	Longer > 2.5 years
Investment size	Thight budget
Complexity	High complexity
Number of	More > 10 stakeholders
Environment	Urban area
Series of projects or	One of a kind project
Level of detail	High level of detail
Urgency	Low urgency
Lifespan	Long >75 year
Function	Utility
Client	Private sector
Ambitions	High ambitions
User	Owned
Phase	Initation phase

Figure 30: Output circular design strategies for example case C

Table 29: Output management aspects for example case C

Circular design strategies	Cost	Time	Quality
Designing for prevention	+-	+-	+-
Designing for the reduction of life cycle impact	+-	+-	+-
Designing for future-proofing	+-	+-	+-
Designing with reused objects	+-	+-	+-
Designing with secondary raw materials	-	-	+-
Designing with renewable raw materials	-	-	-

EXAMPLE CASE D – RENOVATION STADHUISTOREN EN STADHUIS

Table 30 shows what example case D entails, indicates the surface area, and shows the circular design strategies used in the example case. Based on the explanation, the project parameters for example case D have been entered into the model. The results are shown in Figure 31 and Table 31.

The circular design strategies ‘designing with reused objects’ and ‘designing for future-proofing’ have been applied in practice on this project. The model shows that there was a great opportunity in the circular design strategy ‘designing for the reduction of life cycle impact’. This circular design strategy will have a positive effect on the project when it is applied and has a positive effect on two of the three management aspects. It emerged from the interviews that this circular design strategy is often already applied because certain requirements must be met by the government. The requirements also had to be met in this project, so that this circular design strategy was automatically included in the project. However, more focus could be imposed here next time, because as the model says, this will have a positive effect. The model shows that the circular design strategies designed with renewable raw materials have a negative effect on the project and on all the management aspects, so it was good that this strategy was not applied in practice. This also applies to the circular design strategy ‘designing with secondary raw materials’, which scores in total neutral but scores negatively on the management aspect of time.

Table 30: Information example case D

	Case	Explanation	Recommendation
Example case D	Renovation Stadhuistoren and Stadhuis	The focus of this project was on the reuse of existing materials. Ceiling plates that have been incorporated into the facade as insulation material, existing metal ceiling panels that have been incorporated into the parapet as sound-absorbing panels, doors that have been used as walls, etc. Other materials have been offered via a materials platform for reuse elsewhere. Everything that is left (5%) is then disposed of via reputable recycling companies.	Designing for the reduction of life cycle impact
	Surface	>10.000m2	
	Project team	Brink, Door Architecten, DWA, Ballast Nedam, Rudy Uytenhaak, Kuijpers, and Municipality Eindhoven	
	Applied circular design strategies	Designing with reused objects and Designing for future-proofing	

Project parameters	
Project size	Bigger > 10.000 m2
Project type	Renovation
Duration	Shorter ≤ 2.5 years
Investment size	Thight budget
Complexity	Low complexity
Number of	Less ≤ 10 stakeholders
Environment	Urban area
Series of projects or	One of a kind project
Level of detail	High level of detail
Urgency	High urgency
Lifespan	Long >75 year
Function	Utility
Client	Public sector
Ambitions	High ambitions
User	Owned
Phase	Initation phase

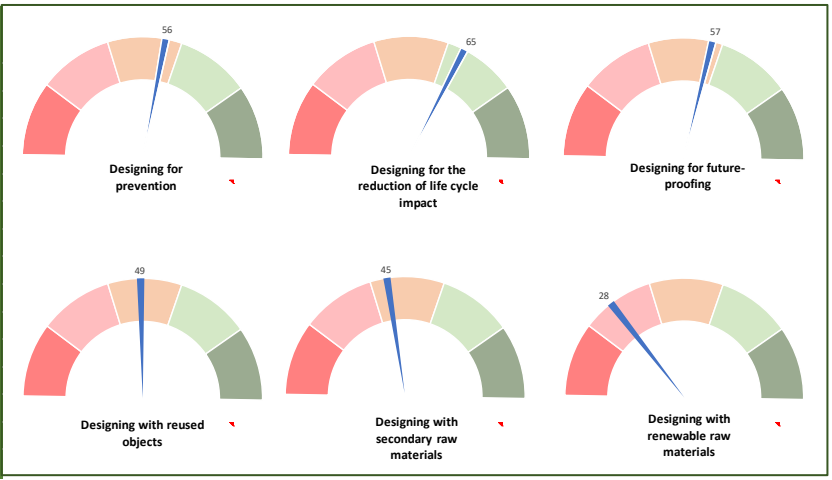


Figure 31: Output circular design strategies for example case D

Table 31: Output management aspects for example case D

Circular design strategies	Cost	Time	Quality
Designing for prevention	+-	+-	+
Designing for the reduction of life cycle impact	+	+-	+
Designing for future-proofing	+-	+-	+
Designing with reused objects	+-	+-	+-
Designing with secondary raw materials	+-	-	+-
Designing with renewable raw materials	-	-	-

EXAMPLE CASE E – NEW CONSTRUCTION HEEMBOUW OFFICE

Table 32 shows what example case E entails, indicates the surface area, and shows the circular design strategies used in the example case. Based on the explanation, the project parameters for example case E have been entered into the model. The results are shown in Figure 32 and Table 33.

In practice, the circular design strategies 'designing for the reduction of life cycle impact', 'designing with secondary raw materials', and 'designing with reused objects' have been applied. The model recommends, only from the circular design strategies applied in practice, the circular design strategy 'designing with reused objects'. The other two circular design strategies applied in practice, score neutral. These circular design strategies are not recommended by the model. The circular design strategy 'designing with reused objects' is not recommended because it scores neutral on both the project and all management aspects. Applying this circular design strategy will have no further negative consequences according to the model. However, according to the model, the circular design strategy 'designing with reused objects' could have a more positive effect on a new-build project when circular materials become available in large masses. The circular design strategy 'designing with secondary raw materials' against it scores negatively on management cost and time. This circular design strategy is therefore not recommended to be applied. According to the model, there is an opportunity for 'designing for future-proofing'. This circular design strategy will have a positive effect on the project but has not received much attention in the project. While according to the respondents, new construction projects should be built in a future-proof way.

Table 32: Information example case E

	Case	Explanation	Recommendation
Example case E	New construction Heembouw office	Recycled and biobased building materials have been used as much as possible in the new Heembouw office. Reduce, reuse and recycle is the guiding principle for the design of the interior. Circular concrete has been used in the foundation, by means of Freemont. For this project, a circular concrete foundation has been laid and the circular concrete foundation can later be the new raw material for new constructive concrete. Recycled wood has been used for the wooden paneling of the stairs and permanent furniture. The other furniture is made from recycled material.	Designing for the reduction of life cycle impact and Designing for future-proofing
	Surface	1,250 m2 office and 900 m2 industrial hall	
	Project team	Heevas B.V., Heembouw Architecten, and Heembouw	
	Applied circular design strategies	Designing for the reduction of life cycle impact, Designing with secondary raw materials, and Designing with reused objects	

Project parameters	
Project size	Smaller ≤ 10.000 m2
Project type	New construction
Duration	Shorter ≤ 2.5 years
Investment size	Thight budget
Complexity	Low complexity
Number of	Less ≤ 10 stakeholders
Environment	Urban area
Series of projects or	One of a kind project
Level of detail	Low level of detail
Urgency	Low urgency
Lifespan	Long >75 year
Function	Utility
Client	Private sector
Ambitions	High ambitions
User	Owned
Phase	Initation phase

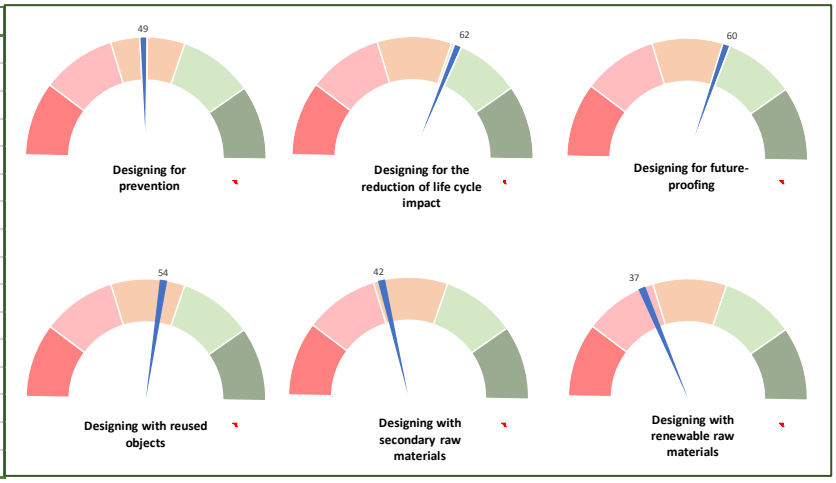


Figure 32: Output circular design strategies for example case E

Table 33: Output management aspects for example case E

Circular design strategies	Cost	Time	Quality
Designing for prevention	+-	+-	+-
Designing for the reduction of life cycle impact	+-	+-	+
Designing for future-proofing	+-	+-	+
Designing with reused objects	+-	+-	+-
Designing with secondary raw materials	-	-	+-
Designing with renewable raw materials	-	-	+-

EXAMPLE CASE F – FLOATING OFFICE ROTTERDAM

Table 35 shows what example case F entails, indicates the surface area, and shows the circular design strategies used in the example case. Based on the explanation, the project parameters for example case F have been entered into the model. The results are shown in Figure 33 and table 34.

The model shows that all circular design strategies have a positive effect on the project. Remarkably, this includes the circular design strategy ‘designing with reused objects’, which scores very positively. This circular design strategy scores so highly mainly because it is a smaller project, for which sufficient materials should be available at the moment. When the project gets bigger, this circular design strategy will also score less well. In practice, this would have been different, because the circular design strategy was not included in the development of the project. Much attention has been paid to the circular design strategies, ‘designing for the reduction of life cycle impact’, ‘designing for future-proofing’, and ‘designing with renewable raw materials’. These three circular design strategies came out of the model positive. In this project, any choice will be good and all choices can be applied in practice. This also applies to the management aspects. All circular design strategies score positive on the management aspect quality and except for a circular design strategy on the management aspect cost. Only on the management aspect time is scored neutral by almost all circular design strategies. During the project, more focus could have been placed on this management aspect.

Table 34: Information example case F

	Case	Explanation	Recommendation
Example case F	Floating Office Rotterdam	The project complies with a strict code of conduct for BREEAM certification, which means that sustainability, energy savings, and the environment are taken into account on all fronts during the design and construction. The building is largely built of wood and can be completely dismantled. In CLT (Cross Laminated Timber) a complete pinewood hull is built up of 3 layers. This hull consists of laminated pine uprights, beams, cross-glued thick upper floors, and roof. The facades will be largely filled with structural glazing and partly with Platowood cladding on HSB elements. Using wood as the main construction material significantly reduces the building's CO2 footprint	Designing for prevention, Designing for the reduction of life cycle impact, Designing for future-proofing, Designing with reused objects, Designing with secondary raw materials, and Designing with renewable raw materials
	Surface	3607 m²	
	Project team	Municipality Rotterdam, Powerhouse Company, RED Company, GCA, DWA, and Brink	
	Applied circular design strategies	Designing for the reduction of life cycle impact, Designing for future-proofing, and Designing with renewable raw materials.	

Project parameters	
Project size	Smaller ≤ 10.000 m2
Project type	New construction
Duration	Longer > 2.5 years
Investment size	Thight budget
Complexity	Low complexity
Number of	More > 10 stakeholders
Environment	Urban area
Series of projects or	One of a kind project
Level of detail	Low level of detail
Urgency	High urgency
Lifespan	Short < 20 year
Function	Utility
Client	Private sector
Ambitions	High ambitions
User	Owned
Phase	Initation phase

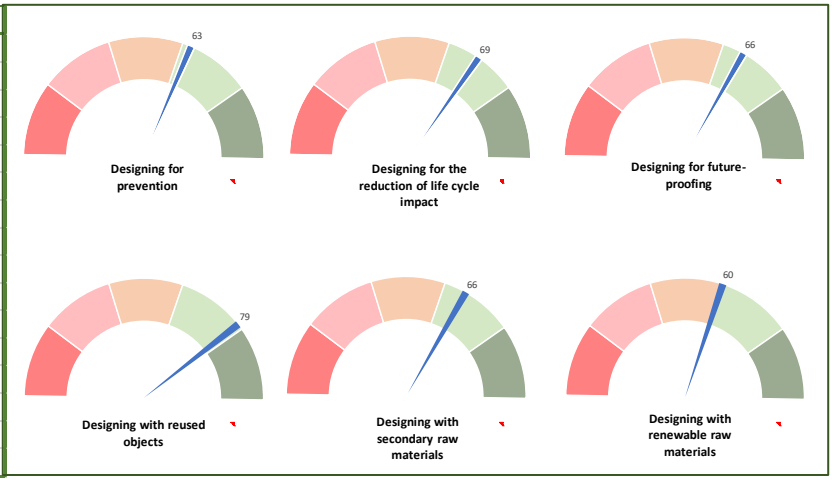


Figure 33: Output circular design strategies for example case F

Table 345: Output management aspects for example case F

Circular design strategies	Cost	Time	Quality
Designing for prevention	+	+-	+
Designing for the reduction of life cycle impact	+	+-	++
Designing for future-proofing	+	+-	+
Designing with reused objects	+	+	+
Designing with secondary raw materials	+	+-	+
Designing with renewable raw materials	+-	+-	+

4.5.2. CHANGES OF THE MODEL

Following the validation sessions, the model has been adjusted on several points. These are the main points to improve the model in terms of user-friendliness. There are also a number of points that have come out of the validation session that has been accepted. These are the main points that require more data to be able to adjust it. These points will be included in the recommendations for further research.

4.5.2.1. DSM PROJECT

The points that came from the validation session with the participants of the DSM project have been converted into action points for adjustments in the model. For each action point, it was checked whether it is feasible, whether it is necessary, or whether there are no possibilities to adapt it. If not modified, the identified change is accepted. These points will be included in the recommendations for a follow-up study. Table 36 gives an overview of changing points that came out of the validation session.

Table 35: Changing points of the model from the validation session by the DSM-project

	Identified change	**Changings in the model**
Representations of the Model	I. Formulating SMART explanation of project parameters	The table with the definitions of the project parameter has been modified in the sheet: "Explanation". Objective values have been added for a number of project parameters and the explanation has been adjusted.
Use of the model	II. Fill in the more/other options for several project parameters	Accepted, to realize this, more data need to be collected.
Results of the model	III. Dividing the project parameter "phase" into four phases	The table with the definitions of the project parameter has been modified in the sheet: "Explanation", "input sheet", and "calculation scheme". The phases are divided into four separate phases. The data of the four separate phases have been adjusted and added to the "calculation scheme".
	IV. Add that a recommendation is given from the model	Accepted, to realize this, more data need to be collected.
Expectations of the model	V. References to the explanation sheets	With the results, a "*" indicates in which sheets the underlying data and explanation can be found.

For the identified change: dividing the project parameter "phase" into four phases, the analysis of the data obtained from the DM was re-examined. The data from the expert interviews and the surveys have been re-analyzed for the project parameter Phase. The data for all four phases were extracted from this and processed in the model. The other adjustments were mainly in the model itself.

4.5.2.2. EXAMPLE CASES

Through the validation session with the example cases, it quickly emerged that the score behind the circular design strategy 'designing with secondary raw materials' was incorrect. The circular design strategy mainly continued to score negative or orange, which was not expected in all situations. This was because a much larger maximum had been entered, which means that the score could never reach the maximum. By entering the correct maximum, the circular design strategy often scored positively. This was a type of error revealed by the validation session. Furthermore, the validation session with the example cases only found confirmation that the model complies with what has been performed in practice.

4.5.3. FINAL MODEL

The final model has been added to this report as Appendix P. In Figure 34 can be seen which adjustments have been made in the dashboard. Figure 35 shows how the phases are divided, based on the literature study and the Delphi research. Finally, the type of error is shown in Figure 36.

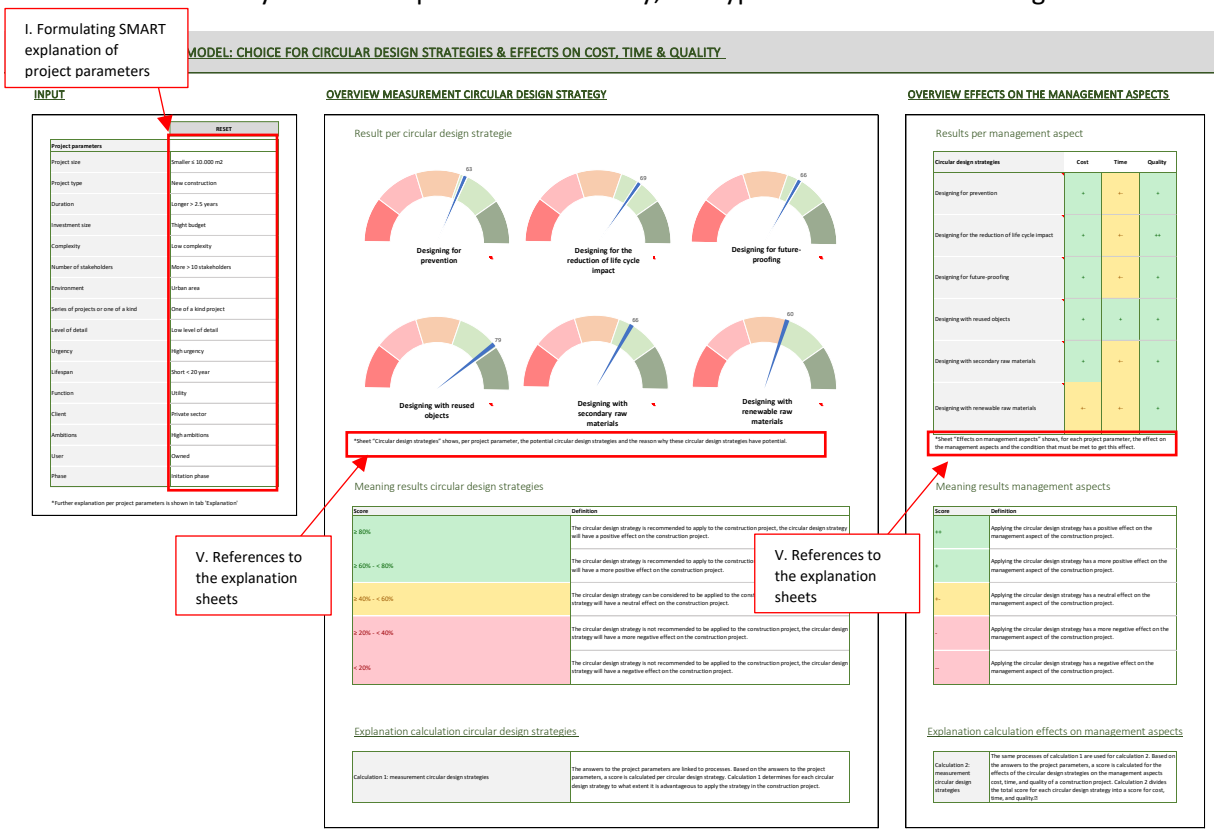


Figure 34: Adjustments dashboard

Phase	3	Initation phase	Phase	3	Initation phase	Phase	3	Initation phase	Phase	3	Initation phase	Phase	3	Initation phase	Phase	3	Initation phase	Phase	3	Initation phase
	3	Definition phase		3	Definition phase		3	Definition phase		3	Definition phase		3	Definition phase		3	Definition phase		3	Definition phase
	1	Design phase		1	Design phase		1	Design phase		1	Design phase		1	Design phase		1	Design phase		1	Design phase
	1	Realisation phase		1	Realisation phase		1	Realisation phase		1	Realisation phase		1	Realisation phase		1	Realisation phase		1	Realisation phase

III. Dividing the project parameter 'phase' into four phases

Figure 35: Adjustment data

Gauge chart															
Value															
20	20	20	20	20	100										
Designing for prevention					**Designing for the reduction of life cycle impact**					**Designing for future-proofing**					
Min.	Max.	Value	Pointer	End	Min.	Max.	Value	Pointer	End	Min.	Max.	Value	Pointer	End	
11,39	26,34	62	2	138	11,22	23,28	69	2	131	12,58	30,08	66	2	134	
Designing with reused objects					**Designing with secondary raw materials**					**Designing with renewable raw materials**					
Min.	Max.	Value	Pointer	End	Min.	Max.	Value	Pointer	End	Min.	Max.	Value	Pointer	End	
6,48	23,09	80	2	120	8,51	23,28	68	2	132	7,83	28,38	61	2	139	

~~26.34~~ = 23,28

Figure 36: adjustment calculation

CHAPTER 5.

DISCUSSION

CHAPTER 5. DISCUSSION

In the previous chapter, a model is created which gives insight into the influence the project parameters have on the management aspects of cost, time, and quality and what the consequences are of the project parameters on the choice of circular design strategies. The findings of the research could be used by project managers and advisors in de definition phase. This chapter will focus on the most important findings for different applications and the limitations of this research.

5.1. FINDINGS METHODOLOGY

Academic understanding has been created by quantifying the relationship between project parameters and the effect of circularity on the management aspects and between project parameters and the recommended circular design strategies. A fundamental understanding of circularity in the AEC industry is scientifically relevant as the concept of circular economy is now getting global momentum. The knowledge gap has been filled by not only quantifying the effects of circularity on the management aspects and the recommendations for circular design strategies but also combining these to create insight into the interconnection of these elements.

It has been decided to use the design science research for this research, which has led to an iterative process that consists of the four phases explore, synthesize, create and evaluate. The explore phase has ensured that nine explorative interviews and fifteen expert interviews were held and that surveys were completed by ten experts. Experience tells that finding the right respondents with experience is still difficult because a limited number of people in the construction sector have 'conscious' experience with circular design strategies or circular projects. If the circular concept were already used more in the construction field, that would lead to more experience with this topic. With more experience with circular projects in practice, the respondent could indicate more precisely what the effects will be and which circular design strategies can best be applied. The limited number of people with experience with circularity did not pose a problem for the research, as three respondents from each role were found who met the criteria.

It is experienced that an online survey has not been the optimal option in this regard, because it is more difficult to get everyone enthusiastic about participating fully in this part of the research via an online platform. This was mainly reflected in the results of the survey because ten of the fifteen respondents completed the survey, from which two respondents partly responded. As a result of which the role of the client is represented by only one person. The other roles were still represented by at least two people. To keep everyone excited an interview would have been a better method.

For the explorative interviews, there is chosen to use two groups of respondents to view the questions from two different sides. The difference between the groups is also reflected in the data obtained from the explorative interviews. It can be seen that the group with more knowledge of circularity is also chosen for other project parameters. The difference between the groups is of added value for this research because the second group has optimized the list of parameters. By interviewing more groups, it is expected that this list could have been optimized even more because they also look from a different angle to the questions. By analyzing the data from the expert interviews, it appeared that the different roles between the different respondents did not influence the results of the research.

In the synthesis phase, the data collected through explorative interviews were analyzed using binary data. To determine whether something is accepted or rejected, calculating the average by converting the data into binary data has been a way with added value. By choosing to calculate the average, it has become clear in one overview what has been accepted and what has been rejected. Other methods

involved a great deal of other data, which will make the overview unclear. By converting the data into binary data, some data has been lost. This is not a problem in this research, since only the averages are needed and the surrounding data is of less importance.

For the second part of the data, the average was used to perform statistical analysis. Because of the two different types of data coming from the expert interviews, it has been chosen to perform both quantitative and qualitative analysis. The quantitative analysis is number-based and has resulted in averages. These averages have been used in the model, which means that this method fits well to achieve the expected results. Determining the average is sufficient because the data is supplemented with the qualitative part of the interview. The qualitative part of the data was analyzed using thematic analysis with latent codes. By looking for the underlying statements, a lot of useful and additional information has emerged.

Surveys have been used to create consensus about the data, which was part of the Delphi Method. Based on the surveys, the most frequent response had to become clear in one overview, so there is chosen to use The Mode. Based on this choice, it became clear in one overview of whether the respondents agreed or disagreed. This data was supplemented by a second question, so that data was also collected about why respondents disagreed. This analyzing technique was necessary, to obtain the extra information if the majority did not agree with it and so that consensus could be reached about the data from the interviews. To make the data complete, it is important to ask the reason why they agree. In this case, this extra questions would make the survey too long.

The model was validated in two different sessions. By using two different types of validation processes, information has been collected on how the model is used by the experts and on how the model fits in practice. The validation could be optimized if more information was known about the example cases that were used. If this were known, more precise conclusions could be drawn. It turned out that the planned methodologies to conduct the research were useful and helped to achieve the research aim.

5.2. THEORETICAL FINDINGS

In order to help clients by taking the next step in the move from circular ambitions to circular project requirements, a decision support tool should be used, to develop an overview with all the necessary information about circular design strategies, in order to advise clients in this process. This research has developed a decision support tool with an overview of the important information about circular design strategies.

Every construction project is unique, which means that each project will have to build circular in a different way, making standardization difficult. The decision support tool created in this research contributes to giving parties in the construction sector a foothold. Based on the decision support tool, better decisions can be made about which circular design strategies can best be applied to a particular project and what effects this has on management aspects. The model contributes to making it easier to choose circularity in a construction project by providing more insight into the important information about circular design strategies. Without this model, clients choose less often, to a lesser extent, or not at all to add circularity to their projects.

The model has been developed to create an overview with important information about the six circular design strategies. By translating circularity into the six circular design strategies, transparent data is provided, allowing for better-informed decisions, a structural change in the system, and the transparent data is used for standardization and spreading information. The developed model indicates which choices can be made in the field of applying the circular design strategies and can be shared with all parties involved. This necessary information about the six circular design strategies

from the model reduces the barriers lack of awareness, lack of knowledge, and change resistance, which is cited as a first step to enable the adoption of a circular economy model in the AEC industry.

To be able to provide insight into which circular designs strategies best fit for each unique project, the model is based on the specific project parameters. The design science research, however, did point out some differences with practice concerning a suggestion described in the literature study. Twelve project parameters emerged from the literature study that could categorize the construction projects. The project parameters do not all correspond to what is applied in practice. As a result of explorative interviews, sixteen project parameters emerged that are used in practice by project managers to categorize projects. Using these project parameters from practice contributes to the research because in this way each unique construction project in practice can be realized circularly and a tailor-made strategy can be made.

The findings of this design science research confirmed most of the suggestions in literature and mainly contributed to giving more guidance in steering and creating awareness about circularity in construction projects. The design science research agrees, as recommended by the literature study, that there is a role for the project manager in steering and raising awareness of circularity in a construction project and that the most important steps can be made by the project manager in the definition phase where the three management aspects are weighed up. The respondents and the validation indicated that the model mainly applies in the definition phase because the later this model is integrated into the process, the more expensive and time-consuming it becomes to add circularity. The respondents also agreed that it is important that the project manager uses the model because the literature review has made it clear that it is the project manager's job to create awareness about circularity. By providing the necessary information about the circular design strategies to the project manager and the client in the definition phase of a project, a circular building project becomes a less risky project. As a result, many more clients will opt for circularity and there will be an increasing movement towards the circular economy, which will narrow the circularity gap.

5.3. MEMORABLE FINDINGS

The research has resulted in some memorable findings, which contribute to the current scientific knowledge that is available. A remarkable outcome from the design science research is that the six circular design strategies can be divided into two groups. While the literature review indicates that all six circular design strategies can be regarded as equally important and can be applied depending on the project, it appears that a distinction can be made between the six circular design strategies. According to the respondents, the six circular design strategies can be divided into two groups. The first group consists of the strategies: ‘designing for prevention’, ‘designing for the reduction of life cycle impact’, and ‘designing for future-proofing’. This group consists of circular design strategies that are currently (unconsciously) often applied in projects and which more knowledge is already available. The second group consists of the other circular design strategies: ‘designing with reused objects’, ‘designing with secondary raw materials’, and ‘designing with renewable raw materials’. These are the strategies that are newer in the built environment and even less knowledgeable about. This difference between the six circular design strategies is reflected in the results from the model.

The results from the model, therefore, show that a combination can often be made between the circular design strategies ‘designing for the reduction of life cycle impact’ and ‘designing for future-proofing’. The circular design strategies ‘designing with secondary raw materials’ and ‘designing with renewable raw materials’ also score fairly the same. These two remarkable points can be linked back to what is indicated by the respondents: the circular design strategies can be divided into two groups because of the degree of knowledge and experience with the circular design strategies. The circular

design strategies ‘designing for prevention’ and ‘designing with reused objects’ deviate slightly from this. This is because some project parameters have a major influence, through the attached weights, on these circular design strategies. For example, the project parameters ‘project size’ and ‘duration’ have a major influence on the circular design strategy ‘designing with reused objects’. The reason that two groups have emerged between the circular design strategies is interesting for science. This research has established the link that has not been established before in the scientific field between the amount of knowledge that is known about the circular design strategy and the extent to which the circular design strategy is recommended.

The fact that circular design strategies can be divided into two groups is also reflected in the effects on management aspects. For example, the first group more often scores positively, while the other group more often scores negatively or neutrally on the management aspects. Also notable about the management aspects is that all circular design strategies more often score neutral on quality. While applying circularity to a project more often has a positive or negative effect on the management aspects of cost and time. The respondents indicated that the quality does not have to change when circularity is added to the project and will therefore remain neutral more often. Quality often stands for standards that must be achieved in a construction project, which is also the case if you have to build circularly. This is the reason why the management aspect quality scores are neutral for more parameters. Based on this information it can also be added to the scientific field that the extent to which the circular design strategy is known influences the effect on the management aspects.

A number of key parameters emerge from the research. These are parameters that have a lot of influence on the final result and therefore the most important interactions. The following parameters are indicated as key parameters: ‘duration’, ‘investment size’, 'complexity’, ‘number of stakeholders’, ‘level of detail’, and ‘phase’. This is also expected because these parameters have a negative or positive effect on almost all circular design strategies and every management aspect. With these key parameters, extreme scores can be achieved. Some of the key parameters also have a higher or lower weighting, whatever influences the final result. It is important to keep a close eye on these key parameters because as soon as they change, it has major consequences for the results. Remarkably, these key parameters did not come up in the explorative interviews when asked to rank the project parameters. After this research and by providing the respondents with more information, it will be expected that they will look at the ranking differently. Identifying the key parameters is important for follow-up investigations so that more focus can be placed on the key parameters.

The project parameters ‘environment’, ‘client’, and ‘user’ are project parameters that have less influence on the results. This is expected because these are project parameters that score neutral in all cases. Only the project parameters ‘environment’ and ‘user’ give a difference to the results. By means of the difference in the weighting. The project parameter client has no difference in weighting and scores completely neutral, because of this score and weighting it was expected that this parameter does not influence the result of the model. The responses during the interview also show that many respondents do not expect these types of clients makes a difference in the results. In the interviews, the respondents were presented with only two types of clients. There is a chance that the respondents think that different types of clients, more specific types of clients, can make a difference. By doing further research into this, it can be found that the project parameter 'client' does influence the model.

A score has been linked to the results of the circular design strategies and the management aspects. Each circular design strategy can achieve a different maximum and minimum score at each management aspect. In this study, the score was normalized, after which a percentage or a sign was attached. By opting for one maximum and one minimum, the other circular design strategies can no longer score the maximum or minimum. To prevent this, it has been decided to normalize the scores,

so that each circular design strategy achieves the maximum and the minimum. What is important here is that each circular design has a different score for a certain percentage. This applies to both the calculation linked to the results of the circular design strategies and those linked to the management aspects.

5.4. APPLICABILITY RESEARCH OUTCOME

The outcome of this research can contribute to the entire building sector since the developed model is designed following the information gathered from the AEC industry. This research has been conducted to create a model for the project managers to assist in advising the clients. However, the model is also interesting for other advisors or parties from the construction team in the building sector since the project has to be done circularly with the entire construction team. The model can be applied in almost every phase of the project but has the greatest impact in the definition phase. The participants will mainly use this model to be able to make circular choices for the construction project in the definition phase. It is indicated in the literature study that this concerns the definition phase.

The output of the model provides more awareness and more knowledge about circularity in the AEC industry. The output also provides insight into which circular design strategies can best be applied to the project in question and what effect the application of the circular design strategies has on the management aspects of cost, time, and quality. Using a percentage, the model shows in what measure it is positive or negative to apply a circular design strategy to the project in question. The model also shows to what extent the circular design strategies have a positive, neutral, or negative effect on the management aspects by using plus and minus signs.

Based on the output, the project managers can provide the clients with better advice about the effects of circularity choices on their construction projects. Based on the information provided by the output of the model, the next step can be taken in the process from the client's ambitions to the project requirements. Based on the extra information in the model, it is also possible to investigate how the project can be optimized on certain project parameters in order to make the project score better on certain management aspects and certain circular design strategies. So by providing the project manager with these new insights, the project manager must have more power when steering towards circularity.

5.5. LIMITATIONS

A few limitations have been identified during the performance of this research. Although sufficient answers were given to the research questions of this research, there are some limitations to be mentioned. Limitations have been found in the method, as well as in gathering the data. Based on the limitations and research outcomes, recommendations will be given regarding future research.

First, the Delphi Method was used to arrive at the data. Fifteen respondents with five different roles in the built environment were interviewed. To gain consensus about the data collected in the interviews, a survey was conducted with the same group of respondents. Due to the length of the survey, not all respondents could find the time to complete the survey. As a result of which the role of the client is represented by one respondent. The research is still valid because this has been taken into account in the analysis of the results, by indicating that the concerning results were argued by one respondent. The other roles are still represented by at least two respondents.

The research looks at the management aspects: cost, time, and quality. To manage and control construction projects, the construction sector often uses the GROTIK method. This method controls the aspects "Cost", “Risk”, "Organization", "Time", "Information" and "Quality". Project managers often use this to manage construction projects. The three important ones used in the definition phase

are cost, time, and quality and are therefore used in this research. Doing research into the effects of circularity on the other management aspects would be extremely valuable since this would not only create a more complete result but could also give more information to the project manager and the client.

In this research, objective values are linked to the project parameters. There has been no opportunity during this research to validate these objective values in practice, as the project parameters have been validated by the expert interviews. As a result, the research lacks some objective values that are considered in practice and larger ranges arise in these cases. Due to the larger ranges, each construction project falls under one of the objective values, so the model is still suitable to apply to any construction project.

For this research, a linear distribution has been used. This means that the effects based on the project parameters work linearly. As a result, the effects pile up, resulting in a score. This result does not include combinations between parameters. It is expected that combinations of project parameters can lead to an extra effect. Within the project parameters, there will be independent and dependent variables, in which important interactions arise. This research shows the effects, which forms a basis for further research into the extra effects through combinations between project parameters.

It must be taken into account that developments in the field of circularity are currently moving quickly, which means that the collected data may change over the years. Once the data changes, it may require some adjustments to the model's data.

CHAPTER 6.

CONCLUSION

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The research results in a better understanding of the circular choices that can be made for the construction project in the definition phase. The research included a literature study, explorative interviews, expert interviews, surveys, and related analysis. The research components aimed at answering the sub-questions. The synthesis of the multiple research components aimed at answering the following main research question:

"How can a project manager advise clients in making circular choices by using circular design strategies in the definition phase for the construction project?"

The research question desires to gain more insight into the underdeveloped field of research and has the aim to reach the following research objective:

"To help clients by taking the next step in the move from circular ambitions to circular project requirements, by providing project managers a model with the necessary information about circular design strategies to advise clients in this process."

6.1. SCIENTIFIC/SOCIETAL RELEVANCE

As found in the literature review, the construction sector is still the world's largest consumer of raw materials and accounts for 25-40% of global carbon dioxide emissions, while only an estimated 20-30% of these materials are recycled or reused at the end of life of a building. A new paradigm, circular economy, is now gaining momentum and it promises to overcome the contradiction between economic and environmental prosperity. The role of the built environment, therefore, is crucial, due to its high environmental impacts, which also conversely offer significant opportunities for reductions in energy use, greenhouse gas emissions, and waste production. With a global economy that is only 9.1% circular, there is a massive circularity gap. Closing the gap will not only be a matter of reducing material input and cycling more, it will also be crucial to optimize and extend the lifetime of what has already been built. Then the world is moving from a linear to a circular economy. The circular economy, as opposed to the current linear economy, is seen as a sustainable economic system where economic growth is decoupled from resource use, through the reduction and recirculation of natural resources. Whereas the concept of circular economy is getting global momentum in politics, business, and academia, the knowledge and tools for bringing it into practice still largely need to be developed. There is a lack of information about the benefits and the approach of the circular economy. The further development of the circular economy is challenged by the lack of good examples and broad experience with circular solutions. By providing more information about the various circular design strategies about the management aspects of cost, time, and quality, it is possible to provide better assistance in advising clients and to encourage clients to opt for circular design.

Clients do often have the ambition to build circularly, but these ambitions are often diluted or decisions are taken by clients on other arguments because it might be easier, cheaper, better known, or more reliable. The complicating factors of the implementation of circularity in the AEC industry are different barriers. Barriers with a lot of impacts are the lack of awareness, lack of knowledge, and change resistance. If the public sector and AEC stakeholders understand the circular economy and its value, the obstacle will be reduced and it will be easier to implement circularity in the AEC industry. Through correct management, several barriers to applying circularity in the AEC industry will be overcome. A construction project is managed throughout the entire process on several management aspects. It is indicated that the project managers experience many changes in the management aspects of cost, time, and quality in a construction project when applying circularity. By incorporating circularity into

these aspects, better considerations can be made for certain choices and circularity can be controlled throughout the project. It is important to make all parties in the right phase aware of circularity and the action points which go along with circularity. There is a role for the project manager in steering and raising awareness of circularity in a construction project, through informing the client about circular options and adhering to the circular choices the client made. The most important steps can be made by the project manager in the definition phase where the three management aspects are weighed up. Everyone involved in the project must understand the implications of the chosen circular design strategy so that everyone knows what they are opting for, especially the client. Understanding all implications will reduce the barrier of lack of awareness.

It becomes clear that the circular economy is a promising approach to help reduce our global sustainability pressures and the project managers can play an important role in the definition phase. One enabler for the adoption of a circular economy model in the built environment is access to transparent data to make easier, faster, and more informed decisions. By accessing transparent data, among other things, the barrier resistance to circularity in the AEC industry will be reduced and the transition will be faster. To get the structural changes into the system and provide AEC stakeholders with the right transparent data, it is important, to translate circularity into circular design strategies.

The advances in circular design strategies were that they provided the most complete and up-to-date description of design considerations for a circular economy. Circular design strategies make clear the changes in the characteristics of the built environment caused by circular construction. The six circular design strategies form the basis for developing and sharing knowledge and provide guidelines by making choices based on the recommended circular design strategies in how circularity can be integrated into the project. Every construction project is unique and requires a tailor-made strategy based on the parameters of the project. To create a tailor-made strategy, sixteen project parameters have been integrated into the model. The list of project parameters has been prepared from the parameters that are applied in the current situation. The value of the project parameters will be different for each project, which means that each project will have to build circular in a different way. This group of six circular design strategies can be used to arrive at a tailor-made strategy. To clarify when which circular design strategy can best be applied, more information is needed, which is given by the model developed in this research. All this information together, can give the project manager more guidance in steering and creating awareness about circularity in construction projects.

Insight into what the consequences are of the project parameters on the choice of circular design strategies and into the influence the project parameters have on the management aspects of cost, time, and quality gives more information to make the step to a circular design. More insight into the consequences and effects of circularity has reduced the lack of knowledge and the change resistance. Based on the synthesis of the results, project managers can advise clients in making circular choices for the construction project, by providing a model with the necessary information about circular design strategies. In this research, based on the project parameters, it is indicated per circular design strategy whether it is recommended to apply at the construction project. The effects of applying the circular design strategies on the management aspects of cost, time, and quality have also been mapped out. In the model can also be found the reason why certain circular design strategies are or are not recommended and what the conditions are for a certain effect on the management aspects. Based on this information, the lack of knowledge has been reduced and insight is given into which circular design strategies can best be applied to a construction project with the given project parameters. The model combines all the data and shows per project parameter what the consequences are for the choice of circular design strategies and what the effects are on the management aspects. The model gives the

project managers a clear overview with the necessary information about circular design strategies that can be used to consider the best way to build circularly for the construction project in question.

The results of this research provide the necessary information about circular design strategies that the project managers can use when advising the clients in making circular choices for the construction projects in the definition phase. The model can be used to determine the recommended circular design strategies and the effects on the management aspects of the construction project. By having the recommended circular design strategies and the effects on the management aspects mapped out in advance, this information can in advance be taken into account in the construction project. By starting this early in the project, circularity can still be favorably included in the construction project. The project managers can use the recommended circular design strategies and the effects on the management aspects in the conversations with the clients in the definition phase. By using the model, the project managers can arrive at the optimal 'circular' option for the construction project and can advise the client by taking the next step in the move from circular ambitions to circular project requirements in the definition phase of a construction project. The information provided by the results from this research will ensure that many more clients will opt for circularity and there will be an increasing movement towards the circular economy, which will narrow the circularity gap.

6.2. RECOMMENDATION

The validations and limitations that are indicated brought forward recommendations for future research regarding implementing circularity in the project requirements.

- Further research should be the focus on the financial part of circularity on construction projects. There is a great demand from the construction sector for the financial aspects of circularity. The research has shown that the management aspect cost can be linked to the circular design strategies and that this link can map the effect on the cost of a particular construction project in the definition phase. To expand the information about circularity in the definition phase even further, it is interesting to conduct research into the cost units of the circular design strategies. By doing more research on this topic, even better considerations can be made and more complete advice can be given by the project managers to the clients in the definition phase.
- Since the research lacked knowledge in the effects of combinations between project parameters, it is suggested to do further research in the effects resulting from combinations between the project parameters. The combinations of certain project parameters are expected to enhance or weaken the effects, allowing further research can create a more complete picture of the effects. These effects can be given through regression analysis and the determination of independent and dependent project parameters. There is also an opportunity for a similar type of follow-up research into the effects of combining circular design strategies. The research has shown that often several circular design strategies can be applied. But the effect of the combination of these circular design strategies on the management aspects has not been investigated in this research.
- The research has shown that circular design strategies can be divided into two groups. The two groups were created by the degree of knowledge and experience that there is about the different circular design strategies. As long as this does not change, it will remain a circle operation in which the differences between knowledge and experience are increasing. Further research is recommended into how the difference in the application of the different circular design strategies arose and what needs to change so that these differences no longer exist.
- A small topic that can be investigated to improve the results of this research is which objective values are missing and the effects of the missing object values on the circular design strategies

and the management aspects. The validation has shown that the objective values of the project parameters are not always complete. This ensures that not all projects optimally match the options that are now given in the model.

- To improve the model it is recommended to include a follow-up step in the model. This will allow users to immediately take a step based on the results, which has a positive effect on how often circularity is applied to construction projects. To realize this, more research is needed in the first steps that have to be taken after you have established the requirements based on the model.
- To take the step to convert the information out of the model into project requirements is not part of this research but would be an interesting step for further research. This research has been the intermediate step in translating circular ambitions into circular project requirements. The information generated from the model is the ingredients for the project requirements. With follow-up research on this topic, more complete information on how circularity can best be applied to the project in the definition phase will be provided.

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APPENDICES

APPENDIX A. CIRCULAR DESIGN STRATEGIES LINKED TO THE LAYERS OF BRANDS.

Applying the characteristics and thus the circular design strategies can vary in which layer of a building it is applied. For this, the characteristics can be placed next to the Layers of Brands. In this appendix, an explanation about the Layers of Brands is given and an overview of the characters linked to the Layers of Brands is shown.

LAYERS OF BRANDS

The shearing layers overview by Brand (1994) describes the different building layers from inside out, combined with the expected lifespan of each layer. A brief elaboration of each layer is described by Brand (1994) in the figure. The overview is very generic and it does not require specific definitions for everybody to classify a building material (van Vliet, 2018), which makes it an applicable overview for defining circular design strategies characteristics to layers. Based on the assumption that these layers have different life cycles, design decisions can also be made regarding their end-of-life scenarios (van Vliet et al., 2019).

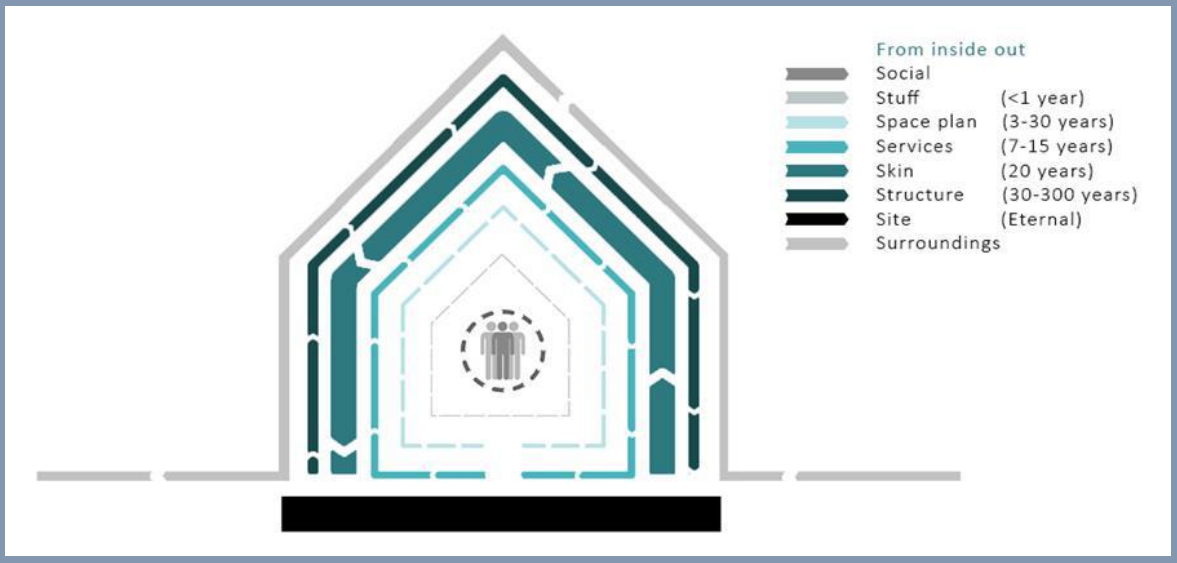


Figure 1: layers of brand (van Vliet et al., 2019)

***Site**: This is the geographical setting, the urban location, and the legally defined lot, whose boundaries and context outlast generations of ephemeral buildings. "Site is eternal"*

***Structure:** The foundation and load-bearing elements are perilous and expensive to change, so people do not. These are the building. Structural life ranges from 30 to 300 years (but few buildings make it past 60, for other reasons).*

***Skin**: Exterior surface now change every 20 years or so, to keep up with fashion or technology, or for wholesale repair. Recent focus on energy costs has led to re-engineered skins that are air-tight and better-insulated.*

***Services:** These are the working guts of a building: Communications wiring, electrical wiring, plumbing, sprinkler system, HVAC (heating, ventilating, and air conditioning, and moving parts like elevators and escalators. They wear out or obsolesce every 7 to 15 years. Many buildings are demolished early if their outdated systems are too deeply embedded to replace easily.*

***Space Plan*:** The interior lay-out – where walls, ceilings, floors and doors go. Turbulent commercial space can change every 3 years or so; exceptionally quiet homes might wait 30 years.

Figure 1: Layers of Brands (Brand, 1994)

CHARACTERISTICS DIVISION LAYERS OF BRANDS

The characteristics of the circular design strategies are linked to the layers of Brand, based on the literature study to the circular design strategies. The Layers of brand indicate in which layers of a building the characteristics of a design strategy can be applied. In table ... all characteristics per circular design strategy are shown with the layers of Brand. For example, the circularity strategy refuse can only be applied to the skin and the structure and less well to the other layers. While with flexibility the service and the space plan can best be applied because flexibility revolves around being able to give the building a different function and this is mainly done from the inside of the building. In this way, each characteristic is considered and linked to the layers to which it can be applied.

Table 1: Circular design characteristics linked to the Layers of brand

Circular design strategies	Characteristics
Designing for prevention	Refuse
	Less material use
	Minimalist construction
	Reduce (Combining functions)
	Re-use (objects)
Designing for the reduction of life cycle impact	Environmental impact (use phase / end of life)
	Material/object life cycle
	End of life cycle
	Lifespan
	Detachable (modulair and remontabel design)
	Rethink
Designing for future-proofing	Flexibility (Spatial-functional adaptive)
	Adaptability
	Re-use
	(Technnical) Lifespan
Designing with reused objects	Re-use
	Detachable
	(Technical) Lifespan
Designing with secondary raw materials	Secondary raw materials
	Recycle (upcycling, downcycling)
	Repurpose
	Remanufacture
	Detachable
	Re-use
Designing with renewable raw materials	Renewable raw materials
	Detachable
	Compostable
	Material/object life cycle

Space plan Services Skin Structure Surroundings

APPENDIX B. INTERVIEW PROTOCOL – EXPLORATIVE INTERVIEW

INTERVIEW PROTOCOL

Graduation project: How circular design strategies can help project managers advise clients on circularity of construction projects in the definition phase.

Date :

Time :

Location :

Company :

Interviewee :

Interviewer :

Survey Section Used:

___ A: Background/Current situation

___ B: Topics

___ C: Circular construction projects

INTRODUCTORY PROTOCOL

First of all, thank you for taking the time to contribute to this research. Before we start the interview, I would like to ask if it is possible to record this conversation.

The interview will not last longer than 20 minutes. During this time, I have several questions that I would like to cover.

INTRODUCE

- Master Construction Management and Engineering to Eindhoven University of Technology.
- The research is carried out in collaboration with Brink Management en Advies.
- What is your position within your organization? How long have you been working for your organization?

You have been selected to speak with me today because you have been identified as someone who falls under the target group for this interview. At the moment it is not yet clear how clients move from circular ambitions to circular project requirements. The goal of this research is to help clients move from circular ambitions to circular project requirements, by providing project managers a framework with the necessary information about circular design strategies to advise clients in this process.

Part of this research is to gain insights into the parameters that can categorize construction projects. To gain insight into the various parameters that can categorize construction projects, it was decided to conduct semi-structured interviews at different levels.

RESEARCH GOAL

PURPOSE OF THE INTERVIEW

The purpose of the conversation is to gain insight into the parameters that can categorize construction projects.

STRUCTURE OF THE IINTERVIEW

The interview consists of three parts. The first part will mainly focus on the interviewee's experience with construction projects and the interviewee's role in the construction process. Subsequently, the second part will consist of topics that correspond to setting parameters for categorizing construction projects. Finally, questions will be asked about your experience with circular construction projects.

I would like to discuss with you how you look at the differences between the construction projects and how you would categorize construction projects. It is important that during the conversation we will find out which parameters there are to be able to categorize a construction project. These will be plotted on the A4 paper I brought with me.

EXPLANATION THEORETICAL FRAMEWORK

A literature study has shown that every construction project is unique, which makes standardization difficult. Because every construction project is unique, it is necessary to apply a tailor-made strategy based on project parameters. In order to tailor the strategies, it is important that the project parameters are mapped.

INTERVIEW

A. Background/Current situation

1. What role do you have in the process of a construction project?
2. How long have you been in the profession?
3. What are your experiences with different construction projects?
4. Do you think that every construction project is unique?
   - or does it have many similarities?

B. Topics construction projects

5. When you think about project parameters, what do you think about?
6. Is there a way that you distinguish projects from each other?
   - to categorize projects?
7. What parameters are you thinking about right now?
8. I have drawn up these parameters so far, are there any parameters missing here?
9. I have drawn up these parameters so far, are there any parameters that do not belong here?
10. Do you think that the terms cost, time and quality also belong to the parameters or do they have a different function?
11. Which parameters do you think categorize projects well?
    - Which parameters do you think categorize projects less well?

C. Circular construction projects

12. Do you currently have projects that incorporate circularity?
13. Do you currently have projects that have been/are being approached in a circular manner?
    - Are there any clients, advisors or contractors in this project who are interested in an interview?
14. Have you had projects with a circular approach?
    - Are there any clients, advisors or contractors in this project who are interested in an interview?

End

15. This was the end of the interview, is there anything else you would like to say?

Thank you for your time and participation. You will receive a copy upon completion of the research.

PARAMETERS

V/X	Number	Parameters
		Project size
		Project type
		Duration
		Investment size
		Complexity
		Number of stakeholders
		Environment
		Productivity
		Series of projects or one of a kind
		Level of detail
		Urgency
		Lifespan

V/X	Number	Parameters
		Costs
		Time
		Quality

APPENDIX C. INTERVIEW PROTOCOL – EXPERT INTERVIEW

INTERVIEW PROTOCOL

Graduation project: How circular design strategies can help project managers advise clients on circularity of construction projects in the definition phase.

Date :

Time :

Location :

Company :

Interviewer :

Survey Section Used:

___ A: Background/Current situation

___ B: Effects

___ C: Circular design strategies

INTRODUCTORY PROTOCOL

First of all, thank you for taking the time to contribute to this research. Before we start the interview, I would like to ask if it is possible to record this conversation.

The interview will not last longer than 60 minutes. During this time, I have several questions that I would like to cover.

INTRODUCE

- Master Construction Management and Engineering to Eindhoven University of Technology.
- The research is carried out in collaboration with Brink Management en Advies.
- What is your position within your organization? How long have you been working for your organization?

RESEARCH GOAL

You have been selected to speak with me today because you have been identified as one of the target audience for this interview. At the moment it is not yet clear how clients move from circular ambitions to circular project requirements. The aim of my research is to help clients move from circular ambitions to circular project requirements, by providing project managers with a framework with the necessary information on circular design strategies to advise clients in this process.

Part of this research is to identify the effects of circularity on projects, based on project parameters. To gain insight into the effects of circularity on the projects, it was decided to conduct semi-structured interviews with various experts.

PURPOSE OF THE INTERVIEW

The purpose of the conversation is to gain insight into the effects that project parameters have on circular projects and the effects of the choice for circular design strategies on a project.

STRUCTURE OF THE IINTERVIEW

The interview consists of three parts. The first part will mainly focus on the interviewee's introduction and the interviewee's experience with construction projects. The second part will consist of questions about the effects of project parameters of circular projects on the parameters Money, Time and Quality. Finally, questions will be asked about the choices for circular design strategies based on characteristics.

I would like to discuss with you how you experience the effects on circular projects compared to a traditional project. It is important that during the conversation we experience what effects circularity entails on projects, in order to be able to clarify what is chosen in a circular project.

EXPLANATION THEORETICAL FRAMEWORK

A literature study has shown that every construction project is unique, which makes standardization difficult. Because every construction project is unique, it is necessary to apply a tailor-made strategy based on project parameters. In order to be able to tailor the strategies, it is important to have insight into the effects of a circular choice per project parameter.

INTERVIEW

A. Background/Current situation

16. Could you introduce yourself? (age, company, position, etc.)
17. How long have you been in the business? (experience)
18. What are your experiences with circularity in construction projects?

B. Effects

The table can be completed by indicating per parameter whether it has a positive, negative or no effect on a circular project compared to a traditional project. Please explain per question why it gives this effect.

19. Can you answer the following question per project parameter: What effects does the parameter project size have in a circular project on the parameters Money, Time and Quality and on the project?

Example: The longer the project takes, the more use can be made of re-used materials. This has a negative impact on time, because finding the materials can be a lengthy process. Attention must be paid to the quality of recycled materials, which can have a negative effect. Because there will be worked with recycled materials, this costs less money, which has a positive effect on money.

Parameter		Money	Time	Quality	Reason
Project size	Big >10000m2				
	Middle 2000m2 - 10000m2				
	Small <2000m2				
Project type	New construction				
	Renovation				
	Temporary construction				
Duration	Long > 5 year				
	Middle 2,5 year - 5 year				
	Short < 2,5 year				
Investment size	Big > 10 million				
	Middle 2 million-10 million				
	Small < 2 million				
Complexity	High complexity				
	Low complexity				
Number of stakeholders	> 10 stakeholders				
	≤ 10 stakeholders				
Environment	Urban area				
	Rural area				
Series of projects or one fo a kind	Series of projects				
	One of a kind project				
Level of detail	High level of detail				
	Low level of detail				
Urgency	Within 2 year				
	After 2 year				
Lifespan	Long >75 year				
	Middle 15-75 year				
	Short < 20 year				
Function	Living, health, office, accommodation, education, recreation, etc.				
Client	Private sector				
	Public sector				
Ambitions	High ambitions				
	Low ambitions				
User	Rentals, buyers, etc.				
Phase	Initiation phase				
	Definition phase				
	Design phase				
	Realisation phase				
	Maintenance phase				

C. Circular design strategy

Which circular design strategy characteristics would you choose and why for these characteristics? The table can be completed by filling in the characteristics appropriate to the project parameter and giving the reason why these characteristics are chosen.

20. Can you answer the following question per project parameter: What effect does the parameter project size have on the choice for a circular design strategy?

Example In a project that is very large, it would be good to be flexible, so that the building can easily be adapted to another function if the function no longer meets the requirements. To adapt the building, it is also useful to pay attention to adaptability.

Parameter		**Characteristics**	**Reason**
Project size	Big >10000m2		
	Middle 2000m2 - 10000m2		
	Small <2000m2		
Project type	New construction		
	Renovation		
	Temporary construction		
Duration	Long > 5 year		
	Middle 2,5 year - 5 year		
	Short < 2,5 year		
Investment size	Big > 10 million		
	Middle 2 million-10 million		
	Small < 2 million		
Complexity	High complexity		
	Low complexity		
Number of stakeholders	> 10 stakeholders		
	≤ 10 stakeholders		
Environment	Urban area		
	Rural area		
Series of projects or one fo a kind	Series of projects		
	One of a kind project		
Level of detail	High level of detail		
	Low level of detail		
Urgency	Within 2 year		
	After 2 year		
Lifespan	Long >75 year		
	Middle 15-75 year		
	Short < 20 year		
Function	Living, health, office, accommodation, education, recreation, etc.		
Client	Private sector		
	Public sector		
Ambitions	High ambitions		

	Low ambitions		
User	Rentals, buyers, etc.		
Phase	Initation phase		
	Definition phase		
	Design phase		
	Realisation phase		
	Maintenance phase		

End

21. This was the end of the interview, is there anything else you would like to say?

Thank you for your time and participation. The interview is elaborated and the statements are summarized. I feed back the summary of all respondents, after which I come along for the second interview. You will of course receive a copy upon completion of the investigation.

Toevoeging: Kenmerken circulaire ontwerpstrategieën

Circular design strategies	**Characteristics**
Designing for prevention	Refuse Less material use Minimalist construction Reduce (Combining functions) Re-use (objects)
Designing for the reduction of life cycle impact	Environmental impact (use phase / end of life) Material/object life cycle End of life cycle Lifespan Detachable (modulair and remontabel design) Rethink
Designing for future-proofing	Nurturing (esthetic choices) Flexibility (Spatial-functional adaptive) Adaptability Re-use (Technnical) Lifespan
Designing with reused objects	Re-use Detachable (Technical) Lifespan
Designing with secondary raw materials	Secondary raw materials Recycle (upcycling, downcycling) Repurpose Remanufacture Detachable Re-use
Designing with renewable raw materials	Renewable raw materials Detachable Compostable Material/object life cycle

APPENDIX D. INTERVIEW PROTOCOL – SURVEY VALIDATION

VALIDATION PROTOCOL

Graduation project: How circular design strategies can help project managers advise clients on the circularity of construction projects in the definition phase.

Date :

Time :

Location :

Company :

Interviewer :

Survey Section Used:

___ A: Appearance/Views of the Model

___ B: Use of the model

___ C: Results of the model

___ *D: Expectations of the model*

INTRODUCTORY PROTOCOL

First of all, thank you for taking the time to contribute to this research. Before we start with the survey, I would like to ask if it is possible to record this conversation.

The survey will not last longer than 30 minutes. During this time I have some questions that I would like to address and you will try the model.

INTRODUCE

- Master Construction Management and Engineering to the Eindhoven University of Technology.
- The research is carried out in collaboration with Brink Management en Advies.
- What is your position within your organization? How long have you been working for your organization?

RESEARCH GOAL

You have been selected to speak with me today because you have been identified as one of the target audience for this survey. At the moment it is not yet clear how clients move from circular ambitions to circular project requirements. The aim of my research is to help clients move from circular ambitions to circular project requirements, by providing project managers with a framework with the necessary information on circular design strategies to advise clients in this process.

Part of this research is the validation of the model that has been built on the basis of the research. A survey was drawn up to gain insight into whether the model works well and whether it is clear to the target group that will use the model.

PURPOSE OF THE SURVEY

The purpose of the survey is to gain insight into whether the model works as expected and whether the model is clear to the target group who want to use the model in their projects.

STRUCTURE OF THE INTERVIEW

The survey consists of four parts. The first part consists of questions about the representations of the model. Then the use of the model is discussed. It also discusses whether the results are expected and clear. Finally, it is discussed whether the model meets the purpose for which the model was built.

It is important that during the survey we will find out whether the model is clear, works well, and works as expected. It is also important to find out whether the results are as expected.

EXPLANATION THEORETICAL FRAMEWORK

A literature study has shown that every construction project is unique, which makes standardization difficult. Because every construction project is unique, it is necessary to apply a tailor-made strategy based on project parameters. In order to be able to tailor the strategies, it is important to have insight into the effects per project parameter.

ENQUÊTTE

A. Representations of the Model

1. Is the model obvious at first glance?
2. Are the results clearly displayed?
3. Is it clear where the explanation of all concepts can be found?
4. What could be improved in the appearance of the model?

B. Use of the model

5. Are the steps you need to take to get the result clear?
6. Is it clear what and where you need to give the input?
7. Does the model work as expected?
8. What could be done better in dealing with the model?

C. Results of the model

9. Is it clear what the results from the model mean?
10. Did you expect the results from the model?
11. Is it clear how you can incorporate the results into the project and how would you go about doing that now?
12. What could be done better in displaying the results of the model?

H. Expectations of the model

13. In which situation do you see this model as good to use?
14. Who would you recommend using this model to?
15. At what stage would you recommend using this model?
16. Does the model help in advising the client on circularity?
17. What can be added to make the model more suitable for advising the client on circularity?

APPENDIX E. SUMMARY – EXPERT INTERVIEW

Samenvatting interviews

De samenvatting van de interviews geeft weer welke informatie er uit alle interviews gekomen is.

Per project parameter wordt weergeven wat het effect is op geld, tijd en kwaliteit. Dit is gebaseerd op wat door de meeste respondenten gezegd is.

De keuze voor bepaalde circulaire ontwerpstrategieën wordt in de paragraaf eronder beschreven. Dit is ook een samenvatting van wat de verschillende respondenten gezegd hebben.

Effecten

Projectgrootte:	
Groter	Geld: +
Hoe groter een project wordt hoe meer massa en omzet je biedt aan een partner waardoor het aantrekkelijker wordt voor hem om te innoveren. Er wordt nu rekening gehouden met een bepaald percentage wat hoger is op de bouwsom bij circulaire projecten. Je moet een stuk leergeld betalen en als je dat heb gedaan dan wordt het daarna makkelijker. Dat leergeld is wel vrij constant, dus als je dat kan uitspreiden over een groter project, dan is dat relatief dus goedkoper en heeft het minder effect bij een groot project. Voor innovatie kan het voordeliger zijn dat de schaal groter is. Als je een nieuw product wil ontwikkelen van nieuwe werkmethodiek wil ontwikkelen, dan is het ook altijd handiger als het op grotere schaal kan, zodat de investering of de onderzoekskosten eerder terugverdiend. Circulariteit is in de huidige markt altijd iets duurder, dat kan zich wel terug verdienen in de exploitatiefase. Maar je bent ook weer afhankelijker bij een groot project. Bij een groot project zijn de kosten beter te verdelen maar brengt het ook meer risico's met zich mee. De kosten is ook hee afhankelijk van welke strategie je toepast. Hergebruik van materialen kan ervoor zorgen dat je heel lang aan het zoeken bent, omdat het niet op voorraad is, dan kan het een negatief effect hebben.	
	Tijd: +
Investering in tijd is noodzakelijk, maar bij een groot project heb je vaak langer de tijd om dingen goed uit te zoeken. Grote projecten duren vaak langer en hoe langer een planning is, hoe meer mogelijkheden je hebt om daarin wat te compenseren. De extra tijd zit vooral in de ontwerpfase Als je een product kiest waar een lage voorraad van is of lastig te vinden is, dan kan je langere levertijden hebben of extra tijd nodig hebben om het te vinden.	
	Kwaliteit: /
In aller tijden voegt een circulair project kwaliteit toe. Hout bijvoorbeeld geeft een goede uitstraling, warmte en fijn gevoel wat positief voor de kwaliteit is. Binnen de aannamen dat er meer geld is bij een groot project, dan kan je ook meer kwaliteit realiseren. Bij een nieuwe manier van bouwen wordt wel gefocust op een hoge kwaliteit. Bij slechte kwaliteit wordt het vaak niet meer gedaan. Hoe groter het project hoe groter de circulaire behoefte naar producten, maar moet dat wel beschikbaar zijn en met de juiste kwaliteit. Het wordt ook spannender gevonden om een vernieuwende bouwtoepassing te gebruiken, op risico's, de impact is veel groter bij een groot project.	
Kleiner	Geld: -

Bij een kleiner project is het relatief duurder, in verhouden met de omvang. Bij een kleiner project heeft de extra investeringskosten grotere impact. Het circulaire gedeelte heeft dan een groter aandeel op de bouwkosten. Wat ook als leergeld en leertijd gezien kan worden, wat bij klein project grotere impact heeft. Ook komt bij een klein project meer handwerk, vakmanschap en vakkundigheid aan de orde.
Tijd: -
Hoe kleiner het project hoe meer energie het kost wat in tijd en geld terug komt. Maar zodra er een aannemer komt die weet hoe die dit moet aanpakken, dan kan het juist weer effectief zijn. Investering in tijd is noodzakelijk en kleine projecten moeten vaak ook snel gebeuren, wat ervoor zorgt dat je minder tijd heb om alles af te wegen. Kleine projecten doe je meestal in kleine hapjes, wat voor meer verliesuren zorgt. Het zal voor meer voorbereidingstijd kosten, want je moet in de voorbereiding meer doen om te zorgen dat het circulair is.
Kwaliteit: /
Kwaliteit maakt niet uit, de normen zijn goed vast gelegd, dus dat wordt niet heel erg beïnvloed. Bij een klein project wordt circulariteit wel sneller toegepast. Je heb bij kleinere projecten vaak wat minder risico of zijn de risico's beter te overzien. Of het niet lukt, is het ook wat minder groot probleem.

Project type:	
Nieuwbouw	Geld: -
Het voordeel van nieuwbouw is dat je geen rekening hoeft te houden met wat er al staat, dus je bent daarin gewoon vrijer. Bij nieuwbouw begin je met een clean sheet. Bij nieuwbouw heb je wel te maken in beperking in aanbod. Bij nieuwbouw is de hele keten opgebouwd om nieuwe materialen toe te passen. Op dit moment zijn veel circulaire materialen nog niet in grote massa aanwezig, waardoor het productie proces duurder is en dus ook de prijs om de materialen te kopen. Bij circulaire nieuwbouw zit meer detaillering in, wat terug komt in geld en tijd. Losmaakbaar maken kan bijvoorbeeld voor meer droge verbindingen zorgen en je moet biobase materialen gebruiken.	
	Tijd: -
Het probleem bij nieuwbouw is dat je veel meer behoefte (in materialen en producten) heeft. Zodra die behoefte er niet is, dan heb je een probleem in tijd en dan misschien ook wel in geld. Het kost meer tijd om circulair te bouwen, omdat alles nog uitgezocht moet worden. Er zit nog een heel groot aspect van leren in. Er is nog maar een topje van de ijsberg bezig met circulariteit.	
	Kwaliteit: /
Kwaliteit kan je managen, maar kan wel afhangen van hoeveel geld en tijd er is. Al is bij nieuwbouw de kwaliteit beter te beheersen. Op kwaliteit is circulariteit positief en dan is het vooral de kwaliteit voor de eindgebruiker. Circulair en biobased bouwen is meestal dampopen, wanden die ademen, in plaats van alles dichtmaken. Deze materialen ademen vanuit zichzelf en reguleren de vochthuishouding, wat heel fijner is voor de gebruiker. Nieuwbouw is ook bijna altijd geprefabriceerd in de fabriek, wat kwalitatief heel hoog is. Als later een data base is en je kan zien wat wanneer beschikbaar komt. Als je weet wanneer iets beschikbaar komt dan ga je op dat moment pas wat doen. Dat is de rethink en reuse. Ik ga op dit moment niet doen want nu is er niks beschikbaar, maar over 5 jaar komt het wel beschikbaar, dus ga je het over 5 jaar doen.	
Renovatie	Geld: -
Renovatie is meer circulair dan nieuwbouw, omdat je bestaande onderdelen hergebruikt. Negatief effect op geld omdat je echt meer moeite moet doen. Ook zijn bij renovatie de gebouwen nog niet	

zo goed vastgelegd, dus je hebt vaak geen goed 3D model je weet niet precies welke materialen je tegen gaat komen, dus dat heeft hem zowel op tijd als op geld kan dat negatief beïnvloed worden Bij renovatie heb meestal bestaande materialen die je wilt verbeteren wat al vaker wordt gedaan met hergebruikte materialen. Bij renovatie is het gangbaarder en daardoor ook goedkoper, tenminste niet duurder. Hergebruik is ook dingen laten zitten, alles wat je kan behouden moet je zien te behouden. Daar bespaar je kosten op. Waar je makkelijk over gaat op sloop bij andere projecten, zou je nu ook een scan kunnen doen en dat je zorgt dat je meer dingen laat zitten.	
	Tijd: -
Je moet rekening houden met een bestaande situatie. Dat kost wel wat meer tijd om dat uit te zoeken. Je zit met een pand waar je allemaal dingen uit gaat halen, die nooit bedacht zijn om her te gebruiken of te recyclen. Daar moet je nog heel veel leren en wat kan je er nog mee wat je eruit haalt. De nieuwe dingen die je erin stopt moet je wel een beetje aanpassen aan het gebouw wat er al is. Dat is even passen en meten. Voor al die types moet je ook uitzoeken hoe je circulaire principes kan toepassen. De afhankelijkheid van je randvoorwaardes is heel groot. Bij renovatie moet je altijd kijken hoe je de puzzel oplost. Je moet rekening houden met wat er al is. Je moet toch al dingen uitzoeken, je bent er toch al mee bezig, dus heeft het positief effect op tijd.	
	Kwaliteit: /
Voor de kwaliteit hoeft het niet uit te maken	
Tijdelijke bouw	Geld: +
Het hangt af hoe je naar geld kijkt. Op het moment dat je tijdelijk bouwt heb je bijvoorbeeld 4 keer 10 jaar profijt van het gebouw. Dan kost het misschien de eerste keer wat meer maar de tweede, derde en vierde keer heb je er profijt van. Door een tijdelijk gebouw te maken die je daarna uit elkaar kan halen, dan heb je ook dat financiële voordeel wat circulariteit ook biedt. Dan heeft het na 10 jaar heeft het ook nog weer een bepaalde waarde wat je terug kan keren. Je hoeft niet alles af te schrijven. In het begin kost het meer om iets helemaal demontabel te maken.	
	Tijd: +
Het kost tijd om het goed uit te zoeken. Het is niet zo dat je door een catalogus kan bladeren en alles kan uitkiezen. Maar als je bij tijdelijke bouw ook veel denkt in units en standaardisatie dan is het ook soort een product wat je ontwikkeld. De product ontwikkeling kost tijd, maar op het moment dat het ontwikkeld is, heb je profijt. De ontwikkelfase is langer maar de uitwerking is positief. Het is van belang dat je op tijd begint. Als je al weet dat de kans is dat die hergebruikt gaat worden, dan kun je die tijd die je aan de voorkant nodig heb veel makkelijker uitsmeren. Je heb meer tijd nodig, maar die kan je al in het tweede leven alloceren Als het maatwerk is dan kost het meer tijd. Modulaire systemen kunnen juist heel snel zijn.	
	Kwaliteit: /
Op tijdelijke bouw mag je niks meer doen wat niet circulair is. De kwaliteit hoeft het niet te beïnvloeden, maar hangt het heel erg vanaf van wat je kiest. De materialen moeten wel hergebruikt worden anders is het totaal niet circulair. Er moet minder verschil tussen permanent en tijdelijk gemaakt worden. Een permanent gebouw wordt ook niet voor honderden jaren gebouwd. Dat is ook vaak, maar voor 30, 40, 50 jaar. Maar uiteindelijk biedt denken over tijdelijke gebouwen wel al voordeel, omdat je dan meteen begint met nadenken over hoe het weg gehaald zou moeten worden. Maar eigenlijk zou je dat met een permanent gebouw ook moeten doen, want je weet dat het uiteindelijk ook weer weg gaat. Kwaliteit is minder, je moet losse verbindingen maken die kwalitatief minder zijn.	

Looptijd	
Langer >2,5 jaar	Geld: +
Op geld heeft het een positiever effect, omdat je meer tijd heb om alles uit te zoeken, zoals een kosten/kwaliteit analyses uit te voeren. Je heb de tijd om meer opties te overwegen, ook op het gebied van kosten. Het heeft ook een beetje met de grootte te maken. Hoe langer het project is, zegt vaak ook iets over de omzet en de ruimte die er dan onderstaat. Meer omzet betekend vaak ook meer handjes en is er ook meer kennis beschikbaar. Over het algemeen zijn langere projecten ook kostbaarder, want tijd is geld. Er zijn heel veel partijen die betaald moeten worden over de gehele doorlooptijd.	
	Tijd: +
Je heb net wat meer tijd nodig om bijvoorbeeld hergebruikte producten te zoeken, of om je afweging te maken over welk product je toepast. Bij een langere doorlooptijd kan je meer dingen gaan afwegen en je scope verbreden, wat ook ten goede van de circulariteit komt. Ook heb je meer de ruimte om te zorgen dat iedereen goed is aangehaakt en iedereen het doel van circulariteit goed begrijpt.	
	Kwaliteit: +
Als je lang de tijd heb dan kan je goed sturen op geld, tijd en kwaliteit. Als er meer tijd is voor een project draagt dat altijd bij aan de kwaliteit van een project. Een project wat langer duurt kan je ook informatie verliezen, doordat er door het project heen mensen zullen weggaan en bijkomen wat voor verlies van informatie kan zorgen.	
Korter < 2,5 jaar	Geld: -
Hoe korter het proces, hoe minder mogelijkheid je hebt om nieuwe dingen uit te proberen of te onderzoeken. Als het echt heel snel moet, dan hebben traditionele bouwmethodes altijd voorkeur, daar komt men minder verrassingen tegen en minder risico's. Al zijn er wel circulaire ambities dan moet er vaak extra geld vrij gemaakt worden om de ambities te kunnen realiseren.	
	Tijd: -
Als je circulariteit toe wilt passen, kan het bij de vergunning aanvraag al heel veel tijd kosten, want daar is de gemeente helemaal niet klaar voor. Ook wordt het lastiger om in een korte looptijd circulariteit toe te passen. Als projecten onder tijdsdruk zitten, dan kan je vaak niet al te innovatief zijn. Het kost dan ook vaak meer tijd om wel innovatief te zijn.	
	Kwaliteit: -
Korte doorlooptijd geeft een negatief effect, dan vallen de ontwerpende en bouwende partijen toch weer in de standaard oplossingen die ze kennen. Snelheid heeft vaak meestal nadelig effect op implementatie van onderdelen waar je nog niet zoveel over weet. Je heb dan de neiging om te kiezen voor wat je weet, omdat je wilt gaan voor een afgesproken kwaliteit en een afgesproken tijd. De uitstapjes naar circulariteit die je dan kan maken zijn vaak beperkt. Op kwaliteit zal het dus ook negatiever zijn omdat je minder de tijd neemt om alle mogelijkheden uit te zoeken. Bij korter heb je minder dubbel gebruik van locatie etc. wat wel meer circulair is en bij een kort project heb je één team wat het afmaakt, dat positief is voor de kwaliteit.	

Investering grootte	
Groter = Ruim budget	Geld: +
Bijna alle duurzaamheidsaspecten vragen hogere investeringskosten, waar een ruimer budget positief bij is. Bij een groter budget / grotere aanbestedingen zal er meer gediscussieerd gaan worden, want er moet ook meer verantwoording over het grote budget worden genomen. Je ziet	

bij deze projecten dat er al meer verwacht wordt om er iets mee te doen, dan is daar ook meer ruimte voor. Dan kan er ook makkelijker met geld, tijd en kwaliteit geschoven worden.	
	Tijd: +
Als er veel geld is kan er ook wat langer de tijd genomen worden. Indien je langer de tijd heb dan kan je goed je materialen uitkiezen, je losmaakbaarheid beter overdenken en betere samenwerkingen aangaan. Hoe groter een project hoe minder makkelijk dingen kunnen, omdat je in de molen vastzit. Er zitten veel meer mensen op het project die goedkeuring moeten geven, daar kan het op vast lopen.	
	Kwaliteit: +
Met een hogere investering blijft er altijd meer over voor betere materialen. Al heb je een ruim budget heb dat kun je creatiever denken en circulariteit makkelijker toevoegen aan het project. Bij een ruimer budget kan je ook nieuwe technieken toepassen die nog hoog in de productie kosten zitten en die hoger scoren op gebied van circulariteit dan de bekende technieken.	
Kleiner = Krap budget	Geld: -
We hebben in de huidige situatie meer budget nodig om circulair te zijn en om beter kwaliteit te leveren. Bij kleine investering moet je echt op elk detail kijken hoe je het gaat doen met het budget. Als er geen mogelijkheid is om extra budget vrij te maken voor circulariteit, dan heeft dit negatieve effecten op alle aspecten. Bij een klein project moet je heel goed omgaan met geld en alle financiële voordelen uit hergebruik halen bijvoorbeeld. Bij een klein budget worden er minder risico's genomen, waardoor er ook minder circulariteit toegepast wordt.	
	Tijd: -
Bij een kleinere investering zit je altijd krap en moet het altijd sneller. Bij een klein project kan je als team heel creatief na denken, wat je dan wel kan doen, wat voor extra tijd zal zorgen.	
	Kwaliteit: -
Bij een kleinere investering zit je altijd krap en moet het altijd sneller, wat er voor zorgt dat de kwaliteit heel erg afgewogen wordt bij elk element. In de huidige situatie hebben we meer budget nodig om circulair te zijn en om betere kwaliteit te leveren. Er is niet de ruimte om de juiste afwegingen te kunnen maken. Als je echt gemotiveerd bent dan kan je misschien wel tot meer inventieve oplossingen komen. Als er niet meer budget is, maar iedereen wel heel gemotiveerd is dan wordt je creatiever.	

Complexiteit	
Hoog	Geld: -
Het is de kunst van de architect om een nieuwbouw project niet te complex te maken. Hoe hoger de complexiteit, hoe minder de kwaliteit en hoe slechter geld en tijd te sturen zijn. Bij complexe projecten heeft elke beslissing die je neemt meerdere consequenties. Dat maakt het lastiger om het te overzien. Bij een project met een hoge complexiteit zijn er ook hele strenge eisen waaraan je moet voldoen. Je kan daar geen risico's hebben met wat voor materialen je toepast en waar je ze toepast. Vaak wordt er bij hoge complexe projecten met maatwerkproducten gewerkt, wat het ook lastiger maakt. Bij hoge complexiteit wil je de risico's minimaliseren. Circulariteit wordt als een extra risico gezien. Maar als de risico's goed beheerst worden dan hoef het geen effect op geld te hebben.	
	Tijd: -
Hoe complexer, hoe complexer je moet zoeken (wat meer tijd kost), dan is dit wel moelijker toepasbaar. Het kost veel meer tijd om alles uit te werken, te overwegen en uit te zoeken. Tijd is bij een complex project lastiger om te sturen en maakt het lastig om het overzicht te houden. Als	

je dan nog een extra complexiteit factor naast de aanwezige complexiteit zet, dan krijg je een stukje weerstand erin. Prefab bouwers zijn heel goed in bepaalde prefab maten, maar zodra je andere maten of een bestaande omgeving heb, wordt het heel lastig om daar de prefab modules in te passen. Alles waar een prefab bouwer van moet afwijken, kost geld en tijd. Bij een complex gebouw moet je in ieder geval rekening houden met meerdere parameters om het goed te doen. Uiteindelijk zijn je risico's bij een complex gebouw altijd wat groter. Dus zijn de kansen dat je tijd, geld, kwaliteit, negatief beïnvloed wordt, zijn ook groter.
Kwaliteit: -
Het kan zijn dat een circulair product bij een hoge complexiteit niet de kwaliteit levert of de volle kwaliteit levert die je wilt hebben, omdat het precies moet aansluiten. Het zit ook heel erg in de eisen van het bouwbesluit, waarbij sommige dingen wel ingewikkelder worden als je een complex gebouw heb. Bepaalde eisen bijvoorbeeld zorgen ervoor dat je soms andere materialen nodig heb met een bepaalde kwaliteit, en die moeten dan wel beschikbaar zijn bij een circulair project. Ook zijn bepaalde ruimtes en situaties, waarin garantie die je moet geven als makende partij dusdanig hoog zijn dat je daar liever voor een nieuw product kiest. Hoge complexiteit kan ook een positieve effect hebben op kwaliteit, als er naar de schaal en de aantal stakeholders die betrokken zijn bij het project gekeken wordt. Meer schaal en meer stakeholders brengen veel meer mogelijkheden en kennis met zich mee. Ook wordt er dan veel meer nagedacht over circulariteit bij het project.
Laag Geld: +
Bij een project met lage complexiteit wordt er ook vaker gevraagd om circulariteit. Projecten met een lage complexiteit zijn projecten waar niet zoveel mis kan gaan en de risico’s minder zijn. Lage risico’s geeft een positief effect en zorgt ervoor dat vaker voor circulariteit gekozen wordt.
Tijd: +
Zodra het logischer is en het werkt, dan maakt het makkelijker om circulariteit toe te passen. Bij lage complexiteit is er al meer kennis en kost het minder moeite. Hoe lager de complexiteit hoe makkelijker het bijvoorbeeld prefab gebouwd kan worden, wat een positief effect op geld en tijd heeft. Bij een project met lage complexiteit zijn er gewoon veel minder aspecten. De keuzes die je dan moet maken, kunnen sneller gemaakt worden en je weet ook sneller wat de consequenties zijn
Kwaliteit: +
Bij lage complexiteit kun je heel makkelijk veel verschillende dingen doen op het gebied van circulariteit. Dan kan je de circulaire producten die nu al op de markt zijn, gaan toepassen. Dan kan je kijken hoe je juist met die producten een simpel project kan opbouwen. Bij een project met een lage complexiteit wordt er niet voor aparte oplossing gegaan. Bij projecten met lage complexiteit denkt de project groep niet van te voren al goed over circulariteit na en willen ze het achter af, wat het heel lastig maakt om het toe te passen.

Aantal stakeholders
>10 stakeholders Geld: -
Hoe meer stakeholders, hoe meer meningen, hoe meer belangen, hoe meer verwarring en hoe meer verschillende uitgangspunten. Dit maakt het lastiger om iedereen op een lijn te krijgen. Vaak moet je elke partij een voor een overtuigen dat circulariteit wel belangrijk is en wat je precies onder circulariteit verstaat. Je kan niet snel/geen beslissing nemen, beslissingen worden uitgesteld door de verschillende meningen, dan moet je meer geld uit geven om het nog in te passen. Maar die stakeholders hebben soms ook een positief effect, omdat ze dat circulariteit eisen gaan ze dat ook bevorderen om het toe te kunnen passen.

	Tijd: -
Hoe meer stakeholders hoe meer meningen en hoe meer moeite het kan kosten om iedereen mee te krijgen. Je moet wel allemaal dezelfde visie op duurzaamheid hebben. Als twee partijen het een ingewikkelde weg vinden, het is niet de weg van de minste weerstand, moet je twee partijen ook wel mee krijgen. Hangt ook heel erg vanaf hoe de stakeholders naar circulariteit kijken. Meer stakeholders betekend ook meer netwerk. Heb je ook meer mogelijkheden om dingen in bepaalde netwerken of branches uit te kunnen zetten. Wat je ook juist weer kan helpen.	
	Kwaliteit: -
Het hangt ervan af wat voor soort stakeholder je heb. Al bijvoorbeeld een conservatieve groep hebt, dan moet je eerst die hele groep overtuigen waarom je circulariteit wilt toepassen. Zodra je een grote groep moet gaan overtuigen dan wordt het lastiger om circulariteit goed toe te passen. Ieder heeft zijn eigen mening, wat vaak niet ten goede van de kwaliteit is. Het is lastig communiceren met meer mensen, ook bij traditioneel bouwmethode. Als je alle partijen los verzameld dan heb je heel veel werk om iedereen in dezelfde richting te krijgen en te laten begrijpen wat ze moeten doen. Dat heeft echt invloed op geld, tijd en kwaliteit. Op de kwaliteit, omdat bepaalde mensen dan mee gaan die er geen kennis over hebben. Maar bij een duurzaam gebouw dan moet je vaak wel wat meer stakeholders betrekken, dat komt te goede van de oplossingen die je bedenkt. Dan kost dat wel wat meer tijd, maar heeft het een positief effect op je kwaliteit, door het delen van kennis.	
≤10 stakeholders	Geld: +
Als er minder stakeholders zijn, hoef je minder mensen te overtuigen, dan kan je beter inspelen op het team die samen iets nieuws willen bereiken. Hoe minder stakeholders hoe minder tijd je nodig heb om ze op een lijn te krijgen en dus ook minder geld.	
	Tijd: +
Je hoeft minder energie erin te stoppen om mensen mee te krijgen en op een lijn te krijgen. Hoe kleiner de groep hoe makkelijker het wordt om iedereen mee te krijgen en op een lijn te krijgen.	
	Kwaliteit: +
Het kost minder tijd om iedereen op een lijn te krijgen, wat terug te zien is in geld en kwaliteit. Het heeft ook met de complexiteit te maken. Minder stakeholders betekend ook een lagere complexiteit.	

Omgeving	
Stedelijk gebied	Geld: -
Bouwen in de binnenstad is altijd complexer. Die afweging heb je al gemaakt. Of je circulariteit nou toepast op moment dat in de stad wat al duurder is dan heeft het niet perse effect op geld, tijd en kwaliteit. In een stedelijk gebied is er minder ruimte om te experimenteren, door de omstandigheden. Als je hergebruikte materialen op een kleine locatie toepast, heb je opslag nodig voor je materialen, dan moet je daar een externe locatie voor zoeken, wat meer kosten levert. Bij een circulair project is er nog veel onbekend en kan er nog verandering in het project komen. Bijvoorbeeld wat voor materialen toegepast kunnen worden. Dat voldoet niet altijd aan de eisen dat vooraf alles al bedacht moet zijn om gecontroleerd te worden. Midden in de stad heb je minder ruimte om te bouwen. Op het moment dat jij grote modules aankomt, dan wordt dat op sommige plekken heel lastig. Dat kan wel maar kost meer geld.	
	Tijd: /
Een stedelijke omgeving geeft geen impact op het aspect tijd. Een stedelijke omgeving is soms ingewikkelder, omdat die projecten vaak kleiner zijn. Ook kan het zo zijn dat als je in een stedelijke	

omgeving zit er een hogere druk is om sneller te bouwen. Meestal val je bij sneller bouwen toch weer in het traditionele bouwen, dus ook minder circulair. Vaak kost werken in de stad meer tijd, want je moet de hele binnen stad afzetten om de producten aan te voeren, je heb dan veel meer voorbereidingstijd nodig.	
	Kwaliteit: /
Als de omgeving complex is dan heeft het negatieve gevolgen. Maar waar het gebouwd wordt heeft het niet direct invloed. Het kan wel zo zijn dat bij stedelijk eerder voor circulariteit gekozen wordt, vanuit profilering. Een ontwikkelaar die een statement wilt maken kom je eerder in een stad tegen dan op het platteland. Je footprint in de stad op een bestaande locatie heeft minder impact dan buiten te stad op een nieuwe locatie. Ook is in de stad de mobiliteit veel beter. Bij stedelijke gebieden is de kwaliteit belangrijker, omdat het erg zichtbaar is.	
Landelijk gebied	Geld: /
Als de omgeving complex is dan heeft het negatieve gevolgen. Maar of het in een landelijk of stedelijk gebied gebouwd wordt, heeft niet direct invloed. Bij landelijk zijn er minder eisen waar je aan moet voldoen. Op beide gebieden zijn ze circulair bezig maar op een andere manier. Niet dat de ene locatie positief of negatief is. In een landelijk gebied heb je wel minder beperking qua bouw. Je bouwplaats kan wat groter en de toegankelijkheid is beter. Dat heeft positieve impact op geld en tijd omdat het makkelijker gaat.	
	Tijd: /
Bij landelijk zijn er minder eisen waar je aan moet voldoen. Er wordt tijd bespaart omdat je niet iets een extra keer hoeft te transporteren. De reistijd kan wel langer zijn.	
	Kwaliteit: /
Er zit verschil in de bereikbaarheid van de locatie. Want je kan een super circulair gebouw ontwikkelen, maar als iedereen de auto moet pakken omdat het ver uit de stad ligt dan heeft het alsnog een slechte invloed. In een landelijk gebied is het voordeliger om dingen uit te proberen op het gebeid van circulariteit, wat terug te zien is in de kwaliteit. Bij landelijk heb je meer opslag plek op de locatie zelf en heeft dat een positief effect op de kwaliteit. Je heb de ruimte en minder beschadigingen.	

Reeks van projecten of een van een soort	
Reeks van projecten	Geld: +
Een reeks van projecten is interessanter en makkelijker, omdat je dan de tijd heb om dingen te ontwikkelen. Je kan zien of het goed ging en je kan het verbeteren. Je begint bij de eerste gebouwen dan ga je alles uitzoeken. Bij de tweede reeks aan gebouwen gaat het makkelijker, sneller en de kwaliteit gaat omhoog, omdat je continu aan het verbeteren. Als je aan de voorkant iets maar een keer hoeft de bedenken en je kan dat goed doen en de tijd ervoor nemen, dan brengt dat op dat moment wel een bepaald budget en tijd met zich mee. Maar je kunt dat dan afschrijven over al de hele reeks aan projecten. Beginnersfout maak je vaak maar een keer, als je je product nog 20 keer kan herhalen dan zit de beginnersfout bij de vijfde keer er echt niet meer in, wat je veel kosten bespaart. Bij seriematig heb je ook meer potentie om goedkoper te zijn, omdat je een product meerdere keren toepast.	
	Tijd: +
Als je aan de voorkant maar een keer iets hoeft de bedenken en je mag dat goed doen en de tijd ervoor nemen, dan brengt dat op dat moment wel een bepaald budget en tijd met zich mee. Maar je kunt dat dan afschrijven over al die projecten. Door de reeks heen krijg je meer ervaring, weet je de juiste personen te vinden en weten de mensen jou makkelijker te vinden. Dan wordt het minder een zoektocht naar wat er wel en wat er niet kan of beschikbaar is. Maar als er nieuwe ontwikkelingen zijn, worden die in seriematige projecten vaak niet meer toegepast. Door de jaren heen verouderen de strategieën die aan het begin van de reeks	

toegepast zijn. In het begin heeft het positief effecten, door de tijd heen kan het negatief worden. Omdat naar mate de tijd vordert, worden nieuwe innovaties vergeten en niet meegenomen.	
	Kwaliteit: +
De impact wordt groter als je gaat repeteren. Je hoeft maar één keer de oplossing te bedenken die je daarna heel vaak kunt herhalen. Je kan je blijven verbeteren, waardoor je verder ontwikkelde standaarden creëert, wat je terug ziet in kwaliteit. In Nederland zien we een woning of kantoor ook wel als een mode gevoelig luxe product, dan doet seriematig bouwen afbreuk in de beleving van heel veel gebruikers, doordat het niet meer een unieke of eigen uitstraling heeft. Circulariteit kan daar juist wel weer een oplossing voor bieden. Als je op bijvoorbeeld bij een woning een gevel van hergebruikt hout ontwerpt. Dan ziet elke woning er als nog anders uit. Er wordt continu het zelfde ontwerpprincipe toegepast, maar de uitstraling is elke keer anders.	
Een van een soort	Geld: -
Bij een uniek gebouw is elk hoekje anders en uniek. Een uniek gebouw is op detail ontworpen, wat voor een langer ontwerpproces zorgt. Op detail ontwerpen is dan negatiever omdat het lastiger is om later her te gebruiken. Bij een uniek project ben je toch nog heel zoekend naar wat er wel en niet kan. Ook is het weer opnieuw zoeken naar welke partijen hierbij kunnen helpen. De impact op geld en tijd is maar voor een project en kan niet over meerdere projecten verdeeld worden.	
	Tijd: -
Bij een uniek project moet je veel meer nadenken over hoe je het circulair gaat aanpakken en wie je daarvoor kan vragen. Het ontwerpproces is langer, je moet iets opnieuw bedenken en je kan het niet herhalen als het gebouw uniek is.	
	Kwaliteit: /
Een uniek project zal wat meer kosten en wat langer duren, maar de kwaliteit kan heel goed zijn. Het vraagt alleen wat meer aandacht. Bij een uniek project kan je met wat meer moeite meer circulariteit bereiken. Bij elk uniek project heb je elke keer een nieuw start punt en kijk je dan wat de ontwikkelingen zijn, waardoor je altijd de nieuwste ontwikkelingen kan toepassen. Bij een uniek proces is wel het risico op kwaliteitsverlies groter.	

Detaillevel	
Hoog detaillevel	Geld: -
Hoe hoger detail level hoe duurder. Als je een detail heel ingewikkeld gaat maken, wordt de losmaakbaarheid lastiger. Terwijl losmaakbaarheid een heel positief effect kan hebben op je circulariteit. Een hoger detail level heeft meer aandacht nodig wat meer kost. Het hoeft niet altijd veel meer te kosten, het is meer uitzoeken maar misschien is het product wel goedkoper. Met een hoog detaillevel en goede aandacht kan er een hogere kwaliteit opgeleverd worden want je behoudt een hogere waarde. Dan wordt je eind levenswaarde hoger.	
	Tijd: -
Als je het goed wilt doen op gebied van circulariteit, moet je van te voren niet te veel vast zetten. Hoe meer er vast staat hoe ingewikkelder het wordt om alles te vinden. Als iets met precies bepaalde maten of detail moet gaan vinden, dat gaat je heel veel tijd en uiteindelijk ook geld kosten. Of je moet van te voren heel goed weten wat voor producten je heb, hoe ziet het eruit en wat voor eisen heeft het. Om dit van te voren allemaal te weten, moet er goed onderzoek gedaan worden, wat meer tijd kost. Het kost dus meer tijd om een losmaakbaar detail te ontwikkelen. Maar als je ook het demonteren mee neemt, dan kost een losmaakbare verbinding minder tijd.	
	Kwaliteit: -
Als iets heel complex, specifiek en ingewikkeld is dan is het de vraag hoe goed kun je het hergebruiken. Hoe creatief kun je nog omgaan met het canvas dat je heb gecreëerd. Op dit moment is het vaak hoe moeilijker de details, hoe minder circulariteit toegepast wordt. Hoog detail level vraagt vaak oplossingen die al bewezen zijn en dat zijn vaak geen circulaire oplossingen. Als je over het detail niet verder nadenkt, dan slijten materialen sneller, moeten ze	

sneller vervangen worden, wat niet circulair is. Bij een hoge detaillering is er vaak wel veel over na gedacht, dat is positief voor de kwaliteit	
Laag detaillevel	Geld: +
Eenvoudige aansluitingen zijn goedkoper. Als het detailniveau simpel is dan is het makkelijker om hem demontabel te maken en het object later her te gebruiken. De kracht van een goed bouwconcept is dat je eigenlijk zo min mogelijk verschillende details heb. Elke aansluiting van een wand moet een uniforme oplossing hebben. Iedereen weet dan hoe het gebouwd moet worden, waardoor de kwaliteit hoog te houden is. Hierdoor kunnen er geen fouten ontstaan wat terug slaat op geld en tijd.	
	Tijd: +
Laag detail level heeft een positief effect op tijd, omdat met de huidige techniek het makkelijker is om circulaire projecten te realiseren. Je heb minder uitdagingen en minder strenge eisen om aan te voldoen. Lager detail level betekent minder uitzoeken wat een positief effect op tijd heeft.	
	Kwaliteit: +
Als je het simpel houdt dan is het makkelijker om de kwaliteit goed te houden. Het is makkelijker om het object demontabel te maken en her te gebruiken. Door zo min mogelijk verschillende details te creëren worden er minder fouten gemaakt en is de kwaliteit beter. Een laag detail level kan een ambitie missen in de uitwerking. Bij lage detaillering kan het ook zo zijn dat er minder over circulariteit na gedacht, wat een negatiever effect levert op de kwaliteit.	

Urgentie	
Hoog	Geld: +
Urgentie wordt pas ervaren als het persoonlijk binnenkomt. Het is interessant wat jou en een opdrachtgever er toe beweegt om iets wel urgent te vinden. Dat zijn vaak dingen die effect hebben op de portemonnee. Als het urgent is, dan moet het, dan geeft het vaak meer ruimte. Dan gaat het meer geld kosten, maar dan is het, omdat het urgent is, vooraf al in de raming meegenomen. Als urgentie ook sneller betekend, kost het ook minder. Hoe korter het project, hoe minder tijd en hoe minder geld. Het kost meer geld omdat de circulaire strategieën misschien nog niet voor handen is. Maar als het urgent is dan ben je bereid om er geld in te investeren.	
	Tijd: -
Als je een hoge urgentie heb dan krijg je als het goed is ook meer parameters om het project mogelijk te maken. Dan krijg je vaak meer tijd. Dat helpt vooral om de gewenste eindresultaat te halen, maar niet dat bij een hoge urgentie minder geld en tijd nodig is. Het kost meer tijd, omdat veel nog niet bedacht is, want je merkt dat de bouw nog helemaal niet ingesteld is op circulariteit. Die urgentie moet nog veel meer naar voren komen, zodat de werkmethodes gereset worden en de een standaard manier op los gelaten kan worden. Zodra er een urgentie is, dan zal er een verandering in de methodes gaan komen en zal het allemaal een positiever effect krijgen. Partijen zijn meer tijd kwijt om het in het ontwerpproces waar te maken. Het duurt wel langer maar het levert ook veel meer op, dat zie je terug in je kwaliteit.	
	Kwaliteit: +
Je heb enige urgentie nodig om met elkaar ervoor te gaan. Als er urgentie gevoeld word dan wordt de kwaliteit hoger. Maar indien hoge urgentie ook sneller betekent, is er een kans dat er sneller keuzes gemaakt worden en circulariteit minder wordt mee genomen. Ook maakt dat het lastiger om al je materialen te oogsten in die korte tijd. Door hoge urgentie krijg je als het goed is ook meer parameters om het project circulair te maken, wat je terug ziet in de kwaliteit. Je moet de ontwikkelaar eigenlijk de tijd geven om tot een zo goed mogelijk project te komen.	

Laag	Geld: -
Bij hoge urgentie is het voor iedereen veel duidelijker waarom iets moet. Als die hoge urgentie er niet is, geeft dat negatieve invloed. Bij lage urgentie is niemand gemotiveerd en wordt er ook geen geld en tijd vrij gemaakt. Als lage urgentie ook meer tijd betekend dan moet je er ook niet te lang over doen, dan blijf je terug komen op het feit tijd en tijd is geld. Het kan goed zijn dat je meer de tijd heb om je producten te oogsten, maar dan moet je plan verder wel gewoon af zijn. Alles wat je ook oogst moet je ook opslaan, dat kost ook weer geld.	
	Tijd: -
Bij lage urgentie is niemand gemotiveerd en wordt er ook geen geld en tijd vrij gemaakt om circulariteit toe te passen in het project. Als het wel toegepast wordt dat kost het altijd meer tijd, omdat er nog geen standaard werkmethode is ontwikkeld.	
	Kwaliteit: -
Als de urgentie er niet is dan gaan mensen er niet zoveel over nadenken en doen alleen wat voor de hand liggend is of makkelijk om te realiseren. Bij lage urgentie zal je minder circulaire kwaliteit hebben. Bij lage urgentie zal er ook niet snel gevraagd worden naar circulariteit. Maar als lage urgentie langer de tijd betekend dan heeft het positieve invloed, want heb je wel meer tijd om alles uit te zoeken.	

Levensduur	
Langer >75 jaar	Geld: /
Lange levensduur dan zijn er bepaalde keuzes die je nu maakt, zoals hogere investeringskosten, logischer te verantwoorden. Je kan dan over de hele levensduur verspreiden. Als je levensduurkosten analyse maakt en je kan 75 jaar lagere exploitatie kosten meerekenen, dan helpt dat. De levensduur heb op zichzelf geen invloed. Dat heb je bij de andere parameters al ondervangen. Eigenlijk moet het niet uitmaken of een gebouw 5 jaar staat of 100 jaar. Het moet op dezelfde manier circulariteit in zich hebben. Het enige over 5 jaar vooruit kijken, dat is nog wat makkelijker dan over 60 jaar vooruit kijken. Maar over het algemeen zou je gebouwen altijd moeten ontwerpen voor permanente tijdelijkheid. Als ze blijven staan dat ze dan kunnen blijven veranderen op die plek. Als ze niet meer nodig zijn dat ze makkelijk ergens anders naar toe kunnen verhuizen, dat ze demontabel zijn.	
	Tijd: /
Je gebruikt materialen, waarvan je weet dat die de 10 jaar bijvoorbeeld gaan halen. Dus je moet wel kijken, hoelang is het al gebruikt en hoelang heb ik het nog nodig, of wanneer zou ik het moeten vervangen en is dat de juiste oplossing. Daar moet je goed naar kijken, maar dat valt vooraf af goed in kaart te brengen. Als je het vooraf goed afstemt hoeft het geen effect te hebben op geld, tijd en kwaliteit. Projecten die voor heel lang neer gezet worden, de kern van zo'n gebouw dat is meestal nog steeds altijd beton, omdat je weet dat beton zeker goed blijft de gehele periode. Dat is ook niet heel erg, want je kan het over zoveel jaar verdelen. Maar dat komt ook door het feit dat er nog niet zoveel inzicht is in de kwaliteit van hout bijvoorbeeld. Een andere materiaal keuze maken moet je aandurven, want nu zijn de risico's nog te hoog. Wel komt er verandering in, dat onderdelen die niet zo lang mee gaan, makkelijk vervangen kunnen worden. Het hangt heel erg van het soort project, de grootte en de omgeving af en minder van de levensduur.	

	Kwaliteit: /
Bij een lang project zet je in op kwalitatieve hoogwaardig materialen die lang mee kunnen gaan. Dan zet je in op circulariteit dat materialen lang mee kunnen gaan zonder kwaliteit verlies. Bij een project die lang blijft staan moet je investeren in een hoge kwaliteit die ook herbruikbaar is. We gaan anders naar materialen kijken. We moeten gaan kijken naar hoe je materialen weer kunt hergebruiken, hoe je het aftakelt. Het hele begrip veranderd. Je moet het project anders ontwerpen. Als dat goed is ontworpen en het gebouw kan op verschillende manier gebruikt worden, dan gaat het goed. Maar als het in de weg staat voor andere ontwikkelingen dan is het niet circulair. Afhankelijk van wat voor functie het heeft hoeveel moeite je moet doen om het te kunnen toepassen. Lange levensduur blijft neutraal, want het gebouw blijft langer staan dus is het bij definitie circulair. De kwaliteit hoeft geen verschil te maken.	
Korter <20 jaar	Geld: +
Als je een tijdelijk gebouw neerzet moet die juist circulair zijn. Dan zou het in kosten positief zijn als je hem circulair maakt. Meest bouwkundige producten hebben een levensduur van minstens 50 jaar of langer. Als je na 20 jaar het gebouw uit elkaar gehaald wordt, dan kun je de onderdelen weer hergebruiken voor nog eens 30 jaar of zelfs het hele gebouw verplaatsen. Over de levensduurkosten zou dat een positief effect moeten geven. Maar als tijdelijke gebouwen op de vuilstort belanden dan zijn het weg gegooide materialen en geld. Alleen als je die gebouwen zo ontwerpt dat het later een andere functie kan krijgen, kunnen ze circulair zijn. Het moet wel losmaakbaar ontworpen worden wat aan het begin voor extra kosten kan zorgen, maar zodra het aan het eind levensduur weer iets oplevert kan het goedkoper zijn.	
	Tijd: /
Korter project is wat makkelijker aan te rekenen, omdat als je de staalprijs moet voorspellen voor de komende 5 jaar is dat makkelijker dan je dat moet spelen over de komende 50 jaar. Daarin kost het wat minder moeite en tijd. Bij korte levensduur zet je in op makkelijkere strategieën zoals hergebruik en demonteerbaarheid. Dit heeft minder effect op tijd. Als je een goed gebouw maakt met een korte levensduur, dan haal je alle materialen eruit en zet je het ergens anders weer neer.	
	Kwaliteit: /
Op korte termijn projecten, waarvan je weet dat ze over 20 tot 25 jaar weer terug gaan naar de leverancier, hebben een positieve invloed. Die leverancier denken er dan ook over, dat ze straks hun product weer terugkrijgen en wat ze er dan mee kunnen doen. Die denken al in kringlopen. Ook wordt de kwaliteit beter als je losmaakbaar bouwt. Als materialen of objecten niet meer voldoen aan de kwaliteit kun je er onderdelen uit halen en vervangen voor iets wat wel voldoet.	

Functie	
Wonen	Geld: -
Wonen is vaak wat minder complex en is vaak een reeks van projecten, wat een positief effect geeft. Maar bij woonfuncties wordt opgemerkt dat het toepassen van circulaire bouwmethodes nog een beetje te ver is. De bouwtechniek van woonprojecten is zo goed bedacht op een lineaire manier, daar kan je nog niet mee concurreren. Dat kost nu echt nog veel geld en tijd. Bij wonen hangt het ook heel erg van het segment af en stukje investeren. Corporaties maken woningen ook steeds beter, wat terug gekoppeld kan worden naar seriematige bouw, waardoor het positiever kan worden.	
	Tijd: -
Een circulaire bouwmethode kost op dit moment nog meer tijd om toe te passen vergeleken met de traditionele bouwmethode voor woningbouw. Door seriematig te werken geeft het wel meer positievere effecten.	

	Kwaliteit: /
Bij kwaliteit is niet echt een verschil te zien, er wordt altijd naar de eisen gewerkt. Bij kantoren worden de eisen opgesteld door de opdrachtgever, maar bij wonen worden ze bepaald door strenge vaste eisen. Hierdoor moet de kwaliteit altijd aan een bepaald niveau voldoen. Bij woningen heb je met heel veel stakeholders te maken en wil je kwaliteit borgen. Bij oplevering hebben de bewoners geen idee van circulariteit. Je moet een heel hoog afwerkingsniveau hebben maar de bewoner vinden snel alles goed.	
Utiliteit	Geld: +
Bij kantoor projecten beredeneren opdrachtgevers al een korter looptijd van een bepaalde functie, want kantoren veranderen heel snel. In kantoren zie je dat circulariteit op dit moment het beste toegepast kan worden en het voordeligst toegepast worden. Bij utiliteit is het interessant om een manier te vinden hoe je kan wisselen tussen de functies. Aanpasbaarheid speelt hier een grote rol in. Wat je nu vaak ziet is dat woningen in kantoren transformeren en andersom. Als je een gebouw ontwerpt dan kan je over die aanpasbaarheid van te voren na denken.	
	Tijd: +
Het kost minder tijd, minder geld en levert een hoge mate van kwaliteit op, als je een kantoor circulair maakt, dan bijvoorbeeld een woning. Doordat ze flexibel willen zijn.	
	Kwaliteit: +
Voor kantoor wordt er eigenlijk al veel met modulaire systemen gedaan, waardoor er al veel meer kennis is. Modulaire systemen worden in de fabriek gemaakt wat voor betere kwaliteit zorgt. Bij utiliteit moet alles redelijk afgewerkt worden, maar elk detail valt op. Tot te groot heeft het allemaal een positief effect.	
Onderwijs, gezondheid, recreatie, etc.	Geld: /
Vaak zijn bijzondere gebouwen wat complexer. Complexer leidt ook tot hogere kosten en meer tijd. Bij gezondheidzorg bijvoorbeeld duurt het langer en heb je meer investering nodig. Terwijl bij onderwijs heb je vaak weinig geld dus vaak veel complexer om de ambities waar te maken. De financiële middelen zijn hierin heel bepalend. Al kan het ook positief uitpakken zolang je er een team opzet die naar de circulaire mogelijkheden kijken.	
	Tijd: /
Ziekenhuis daar is al zo over de kwaliteit nagedacht voor de zorg die je moet verlenen, dat er opeens helemaal opnieuw over nagedacht moet worden als je het circulair wilt gaan uitvoeren. Dit is gekoppeld aan de complexiteit. Ook hangt het af van de ambitie van de opdrachtgever en de tijd en budget die de opdrachtgever er voor vrij wilt maken.	
	Kwaliteit: /
Voor kantoor wordt er eigenlijk al veel met modulaire systemen gedaan, onderwijs al wat minder en bij onderzoekomgevingen nog niet. Bij onderzoekomgevingen en ziekenhuizen draait het om de kwaliteit, al kan dat ondertussen ook best wel met modulaire systemen gedaan worden, maar misschien moet er nog wat extra afwerking gedaan worden. Bij kwaliteit is niet echt een verschil te zien, er wordt altijd naar de eisen gewerkt. Bij kantoren worden de eisen opgesteld door de opdrachtgever, maar bij wonen en zorg worden ze bepaald door strenge vaste eisen. Je zou eigenlijk willen dat je dat je minder naar die functies kijkt, dus dat je een gebouw maakt waar je de eerste 10 jaar in gaat wonen, waar je daarna na 20 jaar in gaat werken. Daarna weer woont, dus dat dat je juist die beetje loskoppelt van die functionaliteit.	

Type opdrachtgever	
Private sector	Geld: /
In de private sector wordt het meer en meer belangrijk alleen daar speelt een investering een grote rol, de ambities worden kleiner als het echt te duur uitvalt. Hier zijn de spanningsvelden ten aanzien van geld en tijd veel groter. Een private iemand kan er juist heel gepassioneerd over zijn en het geld ervoor over hebben. Ze zijn wel heel anders als opdrachtgever, maar kijkend naar circulariteit zou het geen onderscheid hebben. Er is ook verschil te maken in wat voor private opdrachtgevers. Op het moment dat het ontwikkelaars zijn, die trekken wat meer mee. Op het moment dat het bedrijven zijn is dat wat lastiger. Bij weinig ambitie gaat de private sector vaak eerder voor de goedkope oplossing dan voor de dure oplossing. In die zin zullen ze een negatief effect hebben op de circulariteit, geld en kwaliteit. Uiteindelijke kan een topspeler uit de private sector veel meer doen. Maar de motivatie is in de private sector nog minder. Intrinsieke motivatie en investering budget is hierin interessant.	
	Tijd: /
Bij private sector ben je afhankelijk van de wil van een opdrachtgever. Het hoeft geen negatief effect te hebben maar het wordt nog minder vaak toegepast. Als bij een private sector kan aantonen dat op de levenskosten het goedkoper is of op de investeringskosten korting kan krijgen. Dan kan je vaak veel meer voor elkaar krijgen op het gebied van circulariteit. Je krijgt dan meer tijd, wat ook een positief effect heeft op de kwaliteit van het gebouw. Als de private sector echt iets wilt, dan is het makkelijker om daarvoor de middelen vrij te spelen. Als die een voorbeeld project wilt neerzetten dan gebeurd dat en sneller dan bij een publieke sector. Als de private sector wilt dan kan de overheid ze niet bij houden. Die kunnen veel meer gaan investeren wat bij de overheid veel tijd kost.	
	Kwaliteit: /
Overheid partijen zijn vaak eerder geneigd om ambities op gebied van circulariteit voor te schrijven dan private partijen. Maar aan de andere kant gaan private partijen eigenlijk veel al veel verder, dan de overheden, in ambities op gebied van circulariteit. Het ligt meer bij de ambitie van de opdrachtgever. Je moet het doen omdat je er echt iets mee wilt. Het moet niet afhankelijk zijn van of iets private of publiek is. Het gaat er meer om, heb je iets met circulariteit. De private ontwikkelaars die het verschil willen maken, hebben een hoog ambitie niveau. Alles wat er tussen inligt doet er nog niks mee, en dat zit vooral in de woningbouw. Op het moment dat je verdienmodel zo is dat je maar iets op de markt hoeft te leggen en het al verkocht wordt, dan is het voor de snelle jongens niet interessant om aan circulariteit te beginnen. De ontwikkelaars die bewust het verschil willen maken en de socialere corporaties die zijn er wel echt al mee bezig, wat positief is voor circulariteit.	
Publieke sector	Geld: /
In de publieke sector nemen ze op dit moment de voortrekkersrol op zich. Daar worden circulaire projecten nu al vaker gedaan. Bij publieke sector is het nog niet voordeliger, maar door de voortrekkersrol die ze hebben, moeten ze daarop investeren. Ze voelen zich maatschappelijke verantwoordelijkheid of ze hebben al afspraken om zich aan bepaalde niveaus te houden, waardoor ze meer ruimte ervoor maken. Bij de publieke sector gaat het om publiek geld en daar moet je ook goed mee omgaan, maar het daadwerkelijke investeringsbudget is daar lager. Ze hebben een taakstellend budget en in dat budget gaat zoveel mogelijk uitgehaald worden.	
	Tijd: /
De corporaties en de publiek gerichte partijen hebben ook de ambitie. Bij corporaties krijgen je de vraag, willen meer uitstralen en meer vooroplopen op dat vlak. Vanuit maatschappelijke verantwoordelijkheid nemen ze meer de voortrekkersrol, waardoor er ook vaker voor gekozen	

wordt. De private sectoren heeft dus vaak een hoge ambitie, meer tijd en meer gericht op de kwaliteit.
Kwaliteit: /
De private partijen voelen zich iets meer verplicht. Ze voelen wat meer de druk vanuit doelstellingen. Je moet eigenlijk hier verschil maken in non-profit en profit. Non-profit projecten hebben een vast budget en daar moet je binnen blijven, je kan dan vaak niet veel meer doen. Qua tijd mag je niet uitlopen en je mag geen concessies doen op de kwaliteit. Ze willen zoveel mogelijk, maar dat moet wel binnen een bepaalde tijd en budget. Maar als er bij een publieke sector ambities gesteld wordt dan is het lastiger om die af te schalen.

Ambitie	
Hoge ambities	Geld: -
Over het algemeen hoog ambitie duurder dan lage ambitie, zeker op korte termijn. Elke circulaire ambitie heeft op dit moment een kostend verhogend effect, omdat er nog onvoldoende over de breedte kennis over is. Soms is er een hoge ambitie maar geen geld. Soms is er een hoge ambitie maar geen tijd. Eigenlijk zou een hoge ambitie ook voor voldoende geld en tijd moeten leiden. Bij een hoge ambitie zouden ze dan ook automatisch iets voor vrij moeten maken, dat zou een positief effect hebben. Als het op lange termijn is, moet een hoge ambitie meer opleveren dan een laag ambitie. Hoge ambitie kost op korte termijn meer, kan ook wel meer kwaliteit opleveren en uiteindelijk over de hele LCA minder kosten.	
	Tijd: -
Je moet wel een beetje ambitieus zijn, want voor het gemak moet je het niet doen, dan kom je er niet uit. Het kost je nou eenmaal net iets meet geld en net iets meer tijd en de kwaliteit heb jezelf in handen. Hogere ambitie betekend dat je er meer tijd in moet stoppen om te kijken wat je dan moet doen om het te kunnen realiseren. Daarvoor moet je ook meer investeren in advies alleen al in het ontwikkel traject, maar ook in de uitvoering, omdat je opzoek moet naar andere materialen of andere partijen. Je kan dan langer bezig zijn met de juiste partijen vinden. Bij hoge ambitie zijn ze meer bereid om er wat extra geld en tijd in te stoppen. Op het moment dat je vroeg met elkaar een hoge ambitie uitspreekt, hoeft het niet meer te worden. Het hangt ervan af hoe je de hele structuur aanvliegt. Als je een hoge ambitie op een vroeg stadium heb, dan is het positief op geld en tijd. Dan heeft het ook een zeer positieve invloed op kwaliteit. Iedereen is dan al eerder op de hoogte en is er meer mee bekent.	
	Kwaliteit: +
De keuze gaat eerder uit naar een opdrachtgever met een hoge ambitie dan een lage ambitie. Enerzijds omdat je er onderscheidend mee kan zijn en anderzijds omdat het belangrijk is om daarin te leren. Hoe meer ambitie hoe meer je kan doen op het gebied van circulariteit. Als iemand hoge ambities en realistische ambities heeft. Dan zie je dat een team zich daar naar vormt, wat een positief effect op de kwaliteit geeft. De kwaliteit van meer circulariteit zit in de toekomst waarde van je gebouw, maar ook op de gezondheid en het binnenklimaat.	
Lage ambities	Geld: -
Als je niet je best ervoor doet, dan gaat het niet lukken, of gaat het meer geld en tijd kosten. Bij een lage ambitie moet je veel meer aan de partijen trekken om wel wat voor elkaar te krijgen. Vaak wordt er bij lage ambitie geen of heel weinig circulariteit aan een traditioneel project gevoegd. Je blijft dan eigenlijk doen wat je altijd al heb gedaan. Om hierbij dan een beetje circulariteit te voegen kost meer geld en tijd. Al zijn de traditionele bouwmethodes wel goedkoper.	

	Tijd: -
Bij een lage ambitie ben je tijd aan het verspillen, doordat vaak te laat circulariteit toegevoegd wordt. Bij een lagere ambitie moet dan veel meer aan de partijen getrokken worden om wel wat voor elkaar te krijgen, wat voor meer tijd zorgt.	
	Kwaliteit: -
Bij een lage ambitie doe je vaker ondoordachte dingen, wat voor een slechtere kwaliteit kan zorgen. Als het wordt opgedrongen of als een opdrachtgever daar geen behoefte aan heeft, dan moet je het ook niet willen toepassen. Als je dat wel doet zie je dat terug in geld, tijd en kwaliteit. Bij lage ambities gaan de oplossingen die vaker toegepast zijn voor. Er wordt vaak voor een makkelijke weg gekozen, waardoor er weinig tot geen circulariteit toegepast wordt. Voor de kwaliteit van het project zelf moet je altijd minimaal aan een bepaalde kwaliteitsvoorwaarde voldoen. Bij een lage ambitie zullen ze die ook minimaal halen, maar zal dan ook zeker niet beter worden.	

Gebruiker	
Huurder	Geld: -
Er hoeft geen verschil te zitten tussen de verschillende soorten gebruikers. Bij huurders is er een business model, waarop de verhuurder kan terug verdienen. Bij huurders zie je dan een negatief effect, want het gaat meer geld en tijd kosten. Ook heeft het een negatief effect op kwaliteit want hij moet het ergens terug verdienen, kan ook voor een lagere kwaliteit zorgen. Of de opdrachtgever zal altijd de extra kosten die die eventueel kwijt is aan de circulariteit in de huurprijs verrekenen. Als het om woningen gaat en een burger moet dat neerleggen zal dat lastiger gaan. Al laat je er een commercieel bedrijf erin zitten, dan kan het een positief effect hebben, want die kan er mee pronken. Hangt van de type huurder af. Circulaire ontwerp principes kunnen ook gebruikt worden om goedkopere projecten uit te voeren, zoals preventie en hergebruik van materialen, dan kan de kwaliteit minder worden. Dit gebeurd sneller als er huurders in gaan. Dit is een hele gevaarlijke want daarmee kunnen de circulaire ontwerp principe slecht in het licht komen.	
	Tijd: /
Er hoeft geen verschil in tijd te zijn tussen de verschillende soorten gebruikers. Bij huurders is het belang er vaak wat minder. Dan is er meer nodig om het wel te gaan toepassen.	
	Kwaliteit: -
Op huurders zou circulariteit alleen maar positief moeten werken. Als het circulair is en dingen zijn losmaakbaar dan kan je heel makkelijk het project aanpassen naar de wensen van de wisselende huurders. Dit geldt ook ten opzichte van een koper, want dat gebruik veranderd ook. Als iemand een gebouw bouwt en hij gaat het verhuren dan heeft hij een langer termijn belang bij dat gebouw. Als hij dat gebouw dan verhuurt, dan is het zijn belang dat hij het gebouw langer kan verhuren dus probeert hij tijd en geld te investeren om het beter te maken. Dat is anders dan dat je een gebouw maakt en het over twee jaar verkoopt en het iemand anders probleem maakt. Een huurder maakt zich minder druk om slijtage. Je moet daarbij veel meer opletten op de slijtage en dit vooraf zoveel mogelijk beperken. Al is circulair niet gelijk aan minder robuust. Voor betere kwaliteit moet een gebruiker betrokken zijn, wat vaak bij huurders minder is. Als een gebruiker niet betrokken is zie je de circulariteit naar beneden gaan. Het heeft voornamelijk effect op de kwaliteit. Als de gebruiker er zelf bij zit en belang bij heeft, dan heeft dat een positief effect op de kwaliteit.	

Circulaire ontwerp principes kunnen ook gebruikt worden om goedkopere projecten uit te voeren en dan wordt de kwaliteit minder. Dit gebeurd sneller als er huurders in gaan. Dit is een hele gevaarlijke want daarmee kunnen de circulaire ontwerp principe slecht in het licht komen.	
Opdrachtgever	Geld: /
Er hoeft geen verschil te zitten tussen de verschillende soorten gebruikers. De opdrachtgever (gebruiker) kiest bewust wat die met het gebouw wilt bereiken, dat geeft een positief effect, omdat ze dan ook graag dat willen uitstralen waarvoor ze hebben gekozen. Een gebouw dat langer in het eigendom van de eigenaar is, dat draagt positief bij aan circulariteit. Dan wordt het nog waardevoller voor de eigenaar om te investeren in een circulaire oplossing. Er is dan vaak meer geld over voor circulariteit. Want om de ambities te halen kost het vaak ook meer.	
	Tijd: /
Een gebouw dat langer in het eigendom van de eigenaar is, dat draagt positief bij aan circulariteit. Dan wordt het nog waardevoller voor de eigenaar om meer geld en tijd te investeren in circulaire oplossingen. Iemand die geen eigen gebruiker is, die zal gewoon om de 5 of 10 jaar kijken van wat kan ik er aan doen. Terwijl de eigenaar als gebruiker er bij spreken elke dag ermee bezig is.	
	Kwaliteit: +
Bij een gebruiker veranderd er ook veel, waardoor circulariteit positief invloed heb, omdat je dan goed flexibel kan bouwen. Als iemand er zelf gebruik van gaat maken, dan heeft die een hogere ambitie. Als de ambitie er is zou het een positief effect hebben, want die ziet de meerwaarde van kwaliteit. Al maakt het dan niet perse uit of het dan voor huurders is of dat de opdrachtgever er zelf ingaat. Het is wel heel belangrijk dat de koper van het pand bekend is met de circulariteit in het pand en toegerust is om het op die manier te gaan gebruiken. De informatie overdacht is een hele belangrijke stap. Een gebruiker zou dan ook betrokken moeten worden bij het project.	

Fase	
Initiatief fase / definitie fase	Geld: +
In de fasering is het vooral van belang om helemaal in het begin de juiste uitgangspunten te nemen. Dus de beslissingen die de meeste invloed hebben op het gebied van circulariteit zo vroeg mogelijk nemen. Daarin zijn de initiatief fase en de definitiefase het belangrijkste, die hebben de meeste positieve invloed op de tijd, kwaliteit en geld. Het heeft hierin ook het meeste effect op de kwaliteit. In de begin fase heb je ook de opdrachtgever, eigenaar, etc. die veel invloed hebben. Omdat zij ook het budget beschikbaar stellen en de vraag formuleren.	
	Tijd: +
Als je het in je initiatief fase goed meeneemt zorg je der voor dat de mindset er ook is om op die manier naar het probleem te kijken en wordt het iets makkelijker om het mee te nemen. Hoe vroeger je circulariteit toevoegt, hoe minder impact dat heeft op tijd. Als je een proces inricht waarbinnen circulariteit valt dan kost het niks extra.	
	Kwaliteit: +
Heel belangrijk, je moet vanaf dag een bij het initiatief met circulariteit beginnen. Er moet goed mee begonnen worden, want het vergt een andere manier van ontwerpen etc. hoe eerder hoe positiever op de kwaliteit.	
Ontwerpfase/ Realisatie fase	Geld: -
Als je het in de initiatief/definitie fase niet goed meeneemt, dan krijg je het er niet meer voldoende in en kost het je meer geld. Hoe later hoe meer geld en hoe meer tijd het kost, omdat je dan een stap terug moet doen. Circulariteit vraagt ook wat meer van de ontwerp fase, qua kosten en tijd. Hoe later dan wordt het uiteindelijk vaak een traditioneel project, want dan kan er	

minder nog toegepast worden. Als je al in een ontwerpfase zit en je komt dan met circulariteit aan, dan is het erbij. Dan ga je het opzadelen met een extra ambitie en dan is het altijd duurder.	
	Tijd: -
Als je het er later in wilt fietsen moet je het gaan creëren en dat kost je altijd meer tijd. Later kost het je dus meer inspanning en kan het ook zijn dat het je meer kost.	
	Kwaliteit: -
Hoe later hoe minder circulariteit mee genomen wordt. In de ontwerpfase komen de volgende partijen, de architect etc. die de ambities van de opdrachtgever vertalen naar een concreet plan. Als die het op de juiste manier vertalen dan gaat dat goed. Als ze weinig ambitie hebben op circulariteit, dan zijn ze niet innovatief en dan kunnen ze het negatief beïnvloeden. In de realisatie fase komen de de leveranciers erbij. Als de leveranciers alleen maar producten leveren die niet circulair zijn dan, heeft de architect het nog moeilijk om het circulair te maken. Gebruik en beheer: als de gebruiker zorgvuldig met het gebouw omgaat dan gaat het lang mee dat is positief, maar als dat andersom is dan gaan er materialen verloren.	

Circulaire ontwerpstrategieën

In deze paragraaf wordt de samenvatting weergeven van de circulaire ontwerpstrategieën die het best toegepast kunnen worden per project parameter. De gekozen circulaire ontwerpstrategieën per project parameter zijn door de respondenten het vaakst benoemd.

De nummers verwijzen naar de volgende zes circulaire ontwerpstrategieën:

Circulaire ontwerpstrategieën	Kenmerken
1 Ontwerpen voor preventie	Refuse Minder materiaal gebruik Minimalistisch bouwen Reduce (combineren functies) Re-use (objects)
2 Ontwerpen voor reductie van levenscyclus impact	Milieu-impact Materiaal/object levenscyclus End of life cycle Levenduur Losmaakbaar (modulair and remontabel design) Rethink
3 Ontwerpen voor toekomstbestendigheid	Flexibiliteit Aanpasbaar Re-use (Technische) levensduur
4 Ontwerpen met hergebruikte objecten	Re-use Losmaakbaar (Technische) levensduur
5 Ontwerpen met secundaire grondstoffen	Secundaire grondstoffen Recycle (upcycling, downcycling) Repurpose Remanufacture Losmaakbaar (zuivere toepassing) Re-use
6 Ontwerpen met hernieuwbare grondstoffen	Hernieuwbare grondstoffen Losmaakbaar Composteerbaar Materiaal/object levenscyclus

Projectgrootte:	
Groter	Strategieën: 1, 2, 3, 5 (4 & 6 zijn lastiger om toe te passen)
Als het project groter is heb je meer mogelijkheden dus dan kan je eigenlijk gewoon meer strategieën toepassen en onderzoeken wat je allemaal kan doen. Als je een groot project heb dan moet je naar alles kijken. Je moet ontwerpen voor preventie maar ook ontwerpen met hernieuwbare grondstoffen waar dat kan. Ontwerpen voor preventie moet overal meegenomen worden. Je moet altijd nadenken over wat je nu wel gaat doen en wat je niet gaat doen. Ontwerpen voor reductie van levenscyclus impact moet je ook overal in meenemen, dat wordt ook al in de MPG voor het grootste gedeelte meegenomen. Als je niet ontwerp voor toekomstbestendigheid waar ben je het dan voor aan het doen. Je moet rekening houden met functie wijzigingen. Hergebruikte objecten kan lastiger worden, omdat een groot aantal van dezelfde objecten krijgen in de huidige markt lastig is. De beschikbaarheid is hierin het punt. Dit geldt ook voor hernieuwbare grondstoffen, al ligt daar ook een grote kans. Ontwerpen met hernieuwbare grondstoffen is nog heel nieuw in de bouw, dat is lastiger om toe te passen, dan moet de ambitie heel hoog liggen. Houtbouw wordt wel al steeds meer in projecten toegepast. Maar composteerbaar wordt nog minder toegepast. Ambities en doelen hebben invloed maar je kan alles wel toepassen. Als je een groot project doet dan heb je een bepaalde achtergrond. Een project kan bijvoorbeeld de achtergrond hebben dat het flexibel en aanpasbaar moet zijn zodat we dit pand over 10 jaar kunnen verplaatsen. Dan zal er meer gefocust worden op toekomstbestendigheid.	
Kleiner	Strategieën: 4, 5, 6 is makkelijker 1, 2, 3 altijd
Bij een kleiner project hoeft het een het ander niet uit te sluiten op heel veel onderdelen. Maar als het heel klein is heb je wel een ander vertrekpunt. Preventie, reductie van levenscyclus en toekomstbestendigheid moet je altijd doen. Uiteraard moet je het losmaakbaar, flexibel en aanpasbaar maken. Het gaat er niet alleen om dat je gebouw heel flexibel is, makkelijk van functie kan wijzigen, maar ook dat je de materialen die je er dan niet meer voor nodig heb voor een ander project gebruikt kunnen worden. Dan komen ze in de cyclus van ontwerpen met hergebruikte objecten terecht. Ontwerpen met hergebruikte objecten en secundaire grondstoffen zijn op dit moment nog meer voor kleinschalige projecten, omdat er nog niet heel veel aanbod is. Ook is het bij kleinere projecten beter te overzien en kan je makkelijker een scan maken naar wat er in de markt te vinden is. Hernieuwbare grondstoffen worden bij kleiner projecten vaker toegepast, omdat je kleine projecten als pilot kan gebruiken.	

Project type:	
Nieuwbouw	Strategieën: 1, 2, 3, 6 lastiger 4, 5
Bij nieuwbouw moet je alles doen. Het kost je dan in heel veel gevallen niks extra's, omdat dat dan je uitgangspunt wordt. Waardoor je dus veel beter gaat nadenken over de restwaarde. Alle strategieën kunnen meegenomen worden in het project, maar het hangt verder meer van de ambities en de beschikbare tijd en ruimte af. Start altijd met hernieuwbaar en ga daarna verder kijken. Preventie, reductie van levenscyclus impact en toekomstbestendigheid gaan goed en zal sneller toegepast worden. Deze drie leven al meer bij de partijen en zijn makkelijk toepasbaar bij een nieuwbouw. Ontwerpen voor toekomstbestendigheid is makkelijker, want bij nieuwbouw kan je nog alle kanten op. Ook ontwerpen voor preventie is makkelijker, want dan kan je ervoor zorgen dat je goed nadenkt over het materiaal die gebruikt worden en het minimalistisch gaat bouwen of dingen combineren. Ontwerpen met hergebruikte objecten wordt lastiger, omdat het afhankelijk is van welke materialen er beschikbaar zijn op de markt. Hetzelfde geldt voor secundaire grondstoffen. Het gebruik van hergebruikte objecten en secundaire grondstoffen zijn nog heel nieuw. Ook is het voor een eindafnemer nog nieuw en zitten vaak helemaal niet te wachten op	

een tweede handsdeur in een nieuwbouw project. Het is belangrijker om hoogwaardige kwaliteit gebouw neer te zetten, dat ze uit elkaar kunnen halen in verschillende cycli. Als ze het toepassen dan doen ze dat vaak in het interieur en laten ze het casco van het gebouw nieuw.
Renovatie | Strategieën: 1, 2, 5, 6, focus op 4, lastiger 3
Aandacht voor refuse, reduce en re-use. Wat moeten we nou echt doen en wat niet. Je moet ervoor zorgen dat je minder materialen gebruikt, minimalistisch werkt en dingen combineert. Ontwerpen voor reductie van levenscyclus impact moeten we altijd doen. Toekomstbestendigheid is bij renovatie lastiger. Renovatie heeft vaak al een kern en casco, materialen en onderdelen hebben al een bepaalde structuur, dat maakt het lastiger om toekomstbestendigheid toe te passen en om flexibel te zijn, dan bij nieuwbouw. De flexibiliteit en aanpasbaarheid is heel erg afhankelijk van het gebouw. Bij renovatie zitten nu vooral veel secundaire grondstoffen in, recycling. Dan gaat die wat dieper dan alleen preventie en reductie van levenscyclus impact. Bij ontwerpen met hergebruikte objecten ligt de focus, wat kan je allemaal nog gebruiken van het hergebruikte pand zelf en hoeveel moet je nog vervangen. Je heb hier al een canvas het is niet blanco, er staat al wat, waardoor je voornamelijk re-use toepast van hetzelfde gebouw. Alles wat je nieuw toevoegt bij een renovatie, moet je kijken welke stoffen pas ik toe en moet ik dat op die manier toepassen. Bij renovatie heb je meer te maken met de randvoorwaarde van het gebouw.
Tijdelijke bouw | Strategieën: Alles met focus op toekomstbestendigheid
Bij tijdelijke bouw moet je alles circulair doen, want je gaat het project heel snel weer afbreken. Je moet je ook afvragen waarom het een tijdelijk gebouw moet zijn. Kunnen we het niet tijdelijk in een bestaand gebouw doen, wat een stukje preventie is. De meest belangrijke is toekomstbestendigheid, omdat het om een korte tijd gaat. Hierbij wordt met toekomstbestendigheid bedoeld dat je het kan aanpassen of dat je het kan hergebruiken in de toekomst. Je technische levensduur is bij tijdelijke bouw ook heel anders. Je kan dingen gebruiken die nog maar 10 jaar te gebruiken zijn, omdat je voor een kortere duur bouwt. Je kan dan ook producten gebruiken die bijvoorbeeld al 10 jaar oud zijn. De flexibiliteit, aanpasbaarheid en levensduur moet heel precies afgewogen worden. Bij tijdelijke bouw wordt vaak gedacht hoe kan ik het zo goedkoop mogelijk neerzetten en makkelijk uit elkaar halen. Maar je moet juist naar levenscyclus impact, hernieuwbare grondstoffen en hergebruikte objecten kijken. Bij tijdelijke bouw zie je hernieuwbare grondstoffen steeds meer terug komen. Dat ze kijken naar biobased grondstoffen en materialen die misschien niet zo lang mee gaan maar wel gewoon afgebroken worden in natuurlijk proces, die geen negatieve impact op het milieu hebben. Dan is het niet zo erg als gevelbekleding maar 15 jaar mee gaat en daarna op gaat in het milieu.

Looptijd
Langer >2,5 jaar | Strategieën: Alles met kans voor 4, 5 en 6
Als het lang duurt is er meer tijd, wat betekend dat er meer onderzoek gedaan kan worden. Het toepassen van gebruikte materialen is niet zo eenvoudig als dat je naar de groothandel gaat en haalt wat je allemaal nodig hebt. Bij hergebruik heb je de tijd nodig om de objecten te verzamelen. Bij een langere doorlooptijd is er een grotere kans voor hergebruik, secundaire grondstoffen en hernieuwbare grondstoffen. Bij lange looptijd heb je de tijd om materialen te zoeken of te wachten tot materialen beschikbaar komen. Als je langer project heb kan je ze verder allemaal toepassen. Dan kan je de tijd nemen om goed de afweging tussen alle strategieën te maken. Het is wel afhankelijk van wanneer circulariteit in het project meegenomen wordt. Zodra je aan het begin van het project erbij zit, dan kan je alles overwegen. Meer tijd is geen garantie voor een hogere ambitie voor circulariteit.

Korter < 2,5 jaar	Strategieën: 1, 2, 3 lastiger 4, 5, 6
De druk die erop zit, dat beïnvloed je mogelijkheden om de strategieën toe te passen. Hoe korter de bouwperiode dan heb je minder de tijd om te onderzoeken of je hergebruikte materialen kan toepassen. Hergebruik van bestaande materialen kan lastiger zijn vanwege de beschikbaarheid in die korte tijd. Als het niet lukt dan ga je kijken kan dat met repurpose of remanifacture (secundaire grondstoffen). Als dat niet lukt dan moet je voor de biobased (hernieuwbare grondstoffen) gaan. Dat gaat wel anders worden als er een database gaat ontstaan. Bij korter projecten wordt er vaak meer gekeken naar toekomstbestendigheid, reductie van levenscyclus impact en preventie, die kunnen altijd toegepast worden, omdat daar minder aandacht aan gegeven hoeft te worden. Reductie van de levenscyclus is makkelijker, want dat is een kwestie van beslissingen maken. Dat kan wel nieuw materiaal zijn of ander materiaal, dat is makkelijker toe te passen. Preventie is daarin het zelfde. Het hangt ook van de reden van de korte doorlooptijd af. Als je weinig tijd heb dan is het niet zo makkelijk om alles uit te denken en te gaan vinden.	

Investering grootte	
Groter > 100 miljoen	Strategieën: Alles met meer kans voor strategieën die meer kosten
Als je ruim in je budget zit dan moet je alles doen of van alles iets doen. Hoe groter de investering hoe relevanter de strategieën worden. Sommige dingen zijn op dit moment nog prijziger, omdat het duurzame materiaal is. Deze materialen hebben in deze tijd soms nog meer waarde dan dat je het nieuw koopt. Er zijn bijvoorbeeld veel producten op de mark van hernieuwbare grondstoffen, maar hebben nog een redelijk hoge kost prijs, omdat ze nog niet in grote hoeveelheden te produceren zijn. Je ziet nu heel vaak dat het meer kost. Als je het materiaal moet oogsten ergens, dan moet je het ook opslaan en je heb materieel nodig om het ergens weg te halen, dus er komen ook hele andere soorten kosten bij. Bij hogere investering kan je ook eerder kijken naar toekomstbestendigheid, want flexibiliteit, losmaakbaarheid, etc. kan ook meer geld kosten, door andere technieken etc. Een groter budget zorgt er simpel weg wel voor dat je bepaalde dingen makkelijker kan doen, waardoor het misschien niet goedkoper wordt om op deze manier te bouwen maar het wel makkelijker wordt om het te realiseren. Alle strategieën zijn goed toepasbaar. Dan hangt het echt af van wat de belangrijkste doelstellingen zijn die bereikt moeten worden	
Kleiner < 100 miljoen	Strategieën: 1, 2, 3, 4 (loopt af van 6 naar 1)
Bij een lage investering moet je op voorrand heel goed nadenken. Onder andere om te kijken hoe je zo min mogelijk materiaal kan gebruiken, over het algemeen scheelt dat heel veel geld. Hergebruik van materialen scheelt op den duur ook in geld als daar niet te veel andere kosten bij komen kijken. Al moet er eerst meer kennis zijn, zodat de prijs en tijd omlaag gaan. Bij een kleiner project kan een extra adviseur bijvoorbeeld een groot percentage zijn. Als je krap in je budget zit dan ga je voor toekomstbestendigheid en kijken naar reductie van levenscyclus impact en minimalistisch bouwen. Als je krap in je budget zit moet je niet teveel geld uitgeven aan materialen. Preventie, reductie van levenscyclus en toekomstbestendigheid kan dan vanuit slimme detailleren en geen onnodige materialen toepassen. Een kleiner budget maakt je creatiever en zou je nog een hoop kunnen toepassen. Al is het vaak hoe minder geld, dan loopt het af van 6 (secundaire grondstoffen) naar 1 (preventie).	

Complexiteit	
Hoog	Strategieën: 1, 2, 3 lastiger 4, 5, 6
Circulariteit verhoogd op dit moment nog de complexiteit en dat in combinatie met een complex gebouw maakt het heel lastig. Dan valt hergebruikte objecten snel af. Hoe complexer, hoe specifieker, hoe lastiger het voor echt hergebruik van materialen wordt. Dan wordt er ook minder met secundaire en hernieuwbare grondstoffen gewerkt, omdat het lastiger is om passend te maken in een complex project. Losmaakbaarheid en flexibiliteit en aanpasbaar is de vraag of dat nog kan met hoge complexiteit. Dat hergebruikte objecten, secundaire grondstoffen en hernieuwbare grondstoffen minder worden toegepast heeft ook vaak te maken met garantstelling. Als je complexe details moet garanderen met hergebruikte materialen, dan ben je ook afhankelijk of jou leverancier dat wel doet. Vaak is daar nog te weinig kennis voor. Daar waar het niet wordt geaccepteerd, wordt het de bouwer zijn risico. Als sector zijn ze vaak risico mijdend. Hernieuwbare grondstoffen hebben vaak nog een hogere onderhoud cyclus nodig, wat meestal niet goed is voor een heel complex project. Het blijft meer bij preventie, reductie en toekomstbestendigheid. Alles kan maar die andere zaken vallen eerder af.	
Laag	Strategieën: Alles met kans voor losmaakbaarheid
Bij een lage complexiteit zou je alles kunnen overwegen. Dan kan je makkelijker wat aanpassen zodat een object of materiaal wel past of toepast kan worden. Bij een lage complexiteit blijft er meer aandacht over om na te denken over de volgende strategieën: hergebruikte objecten, secundaire en hernieuwbare materialen. Als je een lage complexiteit wilt creëren dan moet je het zo simpel mogelijk maken, dus preventie, en de term losmaakbaarheid zo simpel mogelijk houden.	

Aantal stakeholders	
>10 stakeholders	Strategieën: Alles (hangt van de kennis af of loopt van 6 naar 1 af)
Hoe meer stakeholders, hoe meer meningen je heb, hoe meer dingen overwogen worden. Ook hoe meer ontwerp strategieën de revue gaan passeren. Indien er meer stakeholders zijn met veel invloed maakt dit het soms wel complexer. De stakeholders kunnen absoluut de richting bepalen (naar welke strategieën er gekeken wordt), maar dat hangt per stakeholder af waar de interesse in ligt. Maar als iedereen vanuit circulariteit denkt, dan zou het niet uit moeten maken. Dan kan het zelfs makkelijker worden of versnellen. Hoe makkelijk de strategieën toegepast kunnen worden, heeft namelijk ook te maken met netwerk en materialen vinden. Maar vaak is het nog hoe meer stakeholders hoe simpeler je het wilt houden en dan kom je uit op: preventie, reductie van levenscyclus en toekomstbestendigheid. Dat het ingewikkelder wordt moet geen reden zijn om het niet te doen. Je zou wel alle opties kunnen overwegen. Als iedereen on board is dan zijn alle strategieën goed uit te voeren.	
≤10 stakeholders	Strategieën: Alles
Bij minder stakeholders kan alles makkelijker overwogen worden. Er zijn minder meningen waardoor het minder complex wordt. Wel kan het zijn dat er minder kennis en een kleiner netwerk is. Verder heeft voornamelijk de soort stakeholders invloed. Het is afhankelijk van de ambitie van de stakeholder. Hoe traditioneler de stakeholder is hoe meer die bij de eerste drie blijft. Hoe meer ambitie de stakeholder heeft, dan wordt alles overwogen.	

Omgeving	
Stedelijk gebied	Strategieën: Alles
In de stedelijke omgeving denk je meer na over de ruimte. Hier moet je al vaker rethink en refuse toepassen ten aanzien van je omgeving en heb je een beperkte footprint om op te werken. Preventie is in stedelijk gebied dan interessanter om te zorgen dat je minder overlast hebt en dat	

je minder bouwt met minder materialen. Ook kan bij stedelijke gebieden zijn dat je qua ruimte specifieker bent of meer te maken heb met welstand of andere randvoorwaarde voor de uitstraling. Het kan zijn dat in een stedelijk gebied meer herbruikbare en secundaire grondstoffen beschikbaar zijn. Je zit dan dichter bij al je bronnen. Dan zit het verschil echt in het gebruik van materialen. Voor de milieu impact is transport belangrijk, dan is het gunstiger dat we dichter bij elkaar wonen, met een hoge maten van verdichting, wat voor minder transport zorgt ook tijdens de bouw. Verder kan je eigenlijk alles overwegen. Het heeft vooral indirecte gevolgen.

Landelijk gebied	Strategieën: Alles, minder focus op preventie
Bij landelijk gebied is een valkuil dat als je meer ruimte heb waardoor je minder gepusht wordt om na te denken over het ruimtegebruik. Bij landelijke gebieden kan het zijn dat het makkelijker is om een grote oppervlakte beschikbaar te stellen, waardoor er meer land gebruikt wordt dan nodig is. Je bouwt dan sneller met meer volume en minder compact. Bij landelijk wordt dan minder naar preventie gekeken vergeleken met stedelijk. Bij stedelijk heeft preventie nog een aantal extra voordelen dan bij landelijk. In een landelijke omgeving is de impact van de footprint groter. Als het er mee te maken heeft waar je grondstoffen vandaan komen dan is hernieuwbare grondstoffen in een landelijk gebied makkelijker. In een landelijk gebied waar je wel de ruimte heb, passen secundaire grondstoffen en hergebruikte objecten makkelijker.	

Reeks van projecten of een van een soort	
Reeks van projecten	Strategieën: 1, 2, 3, 5, 6, focus losmaakbaar, 4 is lastiger
Seriematig kan je zulke grote stappen zetten. Als je dat van te voren goed uitdenkt, kan je het zo herhalen. Het nadeel is in welke maten je de architectonische vrijheid beïnvloed. Het hoeft niet te betekenen dat elk gebouw hetzelfde is. Hierbij kan je alle strategieën afwegen wat daarin de best optie is. Voor één project is het heel veel geld om dat helemaal uit te denken. Als je seriematig gaat werken kan je die kosten verspreiden over de hele serie. Hierdoor ontstaat er meer ruimte om alle strategieën te overwegen. Dan heb je de ruimte om meer naar hergebruikte objecten, secundaire en hernieuwbare grondstoffen te gaan kijken. De eerste drie worden wel al vaker gevraagd, dat zit al enigszins in de gene dat we daar al iets mee moeten doen. Hoe kan je met zo min mogelijk materiaal gebruik, zo laag mogelijke impact realiseren, zoveel mogelijke grondstoffen hernieuwbaar gebruiken om iets zo veel mogelijk circulair te bouwen. Maar als het er allemaal het zelfde uit moet komen te zien, dan moet je al die materialen voor handen hebben, dan wordt hergebruik van objecten lastiger. Hergebruik van objecten is op dit moment nog moeilijker, dat kan heel erg verbeteren als wet & regelgeving aangepast wordt er meer gebruik gemaakt gaat worden van databanken etc.	
Een van een soort	Strategieën: Alles
Als het een uniek project is kan je het makkelijker aanpassen. Hergebruik van objecten zou daardoor makkelijker toegepast kunnen worden. Ook heb je bij een uniek project vaak minder hergebruikte objecten nodig en kan je aan de voorzijde nog alle kanten op. Al bestaat ook de valkuil dat naar mate je het eenmalig doet, er minder diep op ingegaan zal worden en zal je meer gekeken naar preventie, reductie van levenscyclus en toekomstbestendigheid. Het hangt ook van de ambities van de opdrachtgever af en het projectbudget. Als de opdrachtgever ambities heeft en er geld voor over heeft dan kan veel toegepast worden. Het is ook vaak te overzien dus is er juist de ruimte om met hergebruikte objecten etc. te werken.	

Detaillevel	
Hoog detaillevel	Strategieën: 1, 2, 3, (minder 4, 5, 6)
Hoe ingewikkelder je het gaat maken, hoe moeilijker het wordt om het weer los te maken. Het wordt vaak veelte complex gemaakt, wat losmaakbaarheid nog lastiger maakt. Hoe ingewikkelder het wordt hoe meer strategieën je gaat uitsluiten. Hoge detaillevel maakt het heel specifiek en dan vallen er dingen af, zoals het hergebruik van objecten en secundaire grondstoffen, je moet daar maar net tegen aanlopen wat precies past. Materialen die hernieuwbaar of biobased zijn, dat zou toch nog wel moeten kunnen. Bij een hoog detail level zie je dat ontwerpen met hernieuwbare grondstoffen lastiger wordt, omdat die vaak ook minder strak zijn qua maatvoering en dergelijke. Traditionele grondstoffen hebben veel meer vaste bouwmaten wat makkelijker is om mee te werken. Maar op dit moment blijft iedereen nog eerder bij ontwerpen voor preventie, reductie en toekomstbestendigheid. Al zou het detail niveau niet veel uit moeten maken voor welke strategie je zou kiezen en hangt het meer van het detail zelf af.	
Laag detaillevel	Strategieën: Alles
De kracht zit in de eenvoud. Hoe eenvoudiger het blijft hoe beter het losmaakbaar is en hoe meer strategieën je kan toepassen. Al kan het ook zijn door tijdgebrek of een krap budget dat het oppervlakkig gehouden wordt en dan kies je voor de snelste methodes.	

Urgentie	
Hoog	Strategieën: Alles
Als circulariteit hoog in het vaandel staat dan kan je alles overwegen. Dan kan je ook bepaalde keuzes goed vertegenwoordigen, omdat dat nou eenmaal het vertrek punt is. Ook is er dan druk vanuit meerdere kanten. Het hangt ook van de motivatie van de opdrachtgever af en hoe vaardig de adviseurs zijn. Het hangt er ook heel erg vanaf met wie je samen werkt. Als er heel snel gebouwd moet worden, dan zijn er weer andere opties zoals module bouw. Het kan je weg beïnvloeden hoe je er gaat komen, maar je kan er nog steeds komen. Alles kan dan overwogen worden.	
Laag	Strategieën: Voornamelijk alleen nog 1, 2, 3 maar loopt af van 6 naar 1
Als circulariteit niet hoog op de agenda staat dan wordt het alleen maar ingewikkelder. Bij lage urgentie heb je sneller iemand die het maar gedoe en lastig vind, die zal het minder snel doen. Het is afhankelijk van hoe leuk iemand het vind, hoeveel energie die erin stopt. Bij lage urgentie gaat ook snel de prijs en tijd in de weg staan. Bij lage urgentie zullen preventie, reductie en toekomstbestendigheid aandacht krijgen en de overige niet. Minimalistisch bouwen, minder materiaal gebruik, dat je dus minder geld te besteden heb, dan zal je eerder voor die gaan. Deze zou je altijd moeten doen, maar als de urgentie er niet is wordt daar ook al niet naar gekeken. Er wordt dan gekozen voor waar de kennis er al is en wordt er geen moeite genomen om de andere te onderzoeken. Uiteindelijk vallen ze bij een lagere urgentie een voor een af. Tot hele lage urgentie dat er niks meer bij is.	

Levensduur	
Langer >75 jaar	Strategieën: 1, 2, 3, 5, 6
Bij een langere levensduur is de technische levensduur veel meer van belang. Je moet kijken hoe het gebouw zo lang mogelijk kan blijven staan, met zo min mogelijk te hoeven vervangen. Je gaat voor een veel robuustere constructie kiezen, zodat je verschillende functies kan gaan huisvesten. Meer focus op flexibiliteit en toekomstbestendigheid. Bij een langere levensduur wordt ontwerpen met hergebruikte objecten en secundaire grondstoffen minder. Objecten hebben al een leven gehad en gaan voor de tweede of derde of vierde ronde. Sommige dingen worden daar niet beter van. Hernieuwbare grondstoffen is hierbij ook belangrijk, als het heel lang staat en je gaat dan ook nog ontwerpen met hernieuwbare grondstoffen dan heb je een win win situatie. Al wordt het op	

dit moment nog niet vaak toegepast. Veel bouwprojecten willen toch een proven technologie hebben en zal er minder vertrouwen in de hernieuwbare grondstoffen omdat die nog in de kinderschoenen staat.	
Korter <20 jaar	Strategieën: Alles met focus op preventie, losmaakbaar en hernieuwbaar
Bij kortere projecten moet je echt heel erg op losmaakbaarheid gaan zitten en dat het allemaal hergebruikt kan gaan worden na de levensduur van het project. Als het gebouw heel kort staat en het daarna weer weg gaat, dan is milieu-impact heel belangrijk. De materialen hebben veel meer impact op het milieu, omdat het maar kort staat. Daarin is preventie ook belangrijk om te kijken hoe je minder materialen kan gebruiken. Bij een korter project zou hernieuwbare grondstoffen goed toegepast kunnen worden. Deze materialen zijn na de levensduur composteerbaar en makkelijker op te werken en je maak niet te veel afval. Je wilt bij korte levensduur zo min mogelijk slechte materialen gebruiken. Dan moet je zorgen voor reductie van de impact, hernieuwbare grondstoffen, secundaire grondstoffen, hergebruik van objecten en voor toekomstbestendigheid. Als je weet dat het maar 15 jaar staat moet je kijken wat erna met het gebouw gebeurt. Je moet geen keuze maken tussen deze principes, je moet ze altijd soms in hogere en soms in mindere maten toepassen.	

Functie	
Wonen	Strategieën: Alles maar minder losmaakbaarheid
Als je naar woningen kijkt, dan ga je niet je constructie zo robuust maken dat je er een productie omgeving in kwijt kan. Dan heb je met hele andere constructieve eigenschappen te maken. Je ziet dat je per functie op een heel andere manier zo'n project in gaat steken. Het verschil zit hem in de flexibiliteit van de toekomstbestendigheid. De ene functie, zoals een kantoorpand, zou meer flexibel moeten zijn dan een andere functie, zoals woningen. Woningen worden op langer termijn gebruikt, dus daar is preventie en reductie belangrijker, dat het lang mee gaat, makkelijk te onderhouden is en er minder kapot kan gaan. Al is het wel als het product standaard is, hoe makkelijkere het is om een diepere strategie toe te passen. Bij wonen is dat makkelijker dan bij een complexer gebouw. Bij wonen kan je dan meer kijken naar hernieuwbare grondstoffen, secundaire grondstoffen en aanpasbaarheid. Je gaat een woongebouw niet zo snel verplaatsen maar wel splitsen of samenvoegen. Bij wonen zie je op dit moment een hele beweging. Het onderzoeken van natuurlijke materialen. Dat heeft heel erg te maken met de opdrachtgever en de doelgroep. Het heeft op robuuste materialen na niet zo zeer met de functie te maken maar met de opdrachtgever en welke rol die heeft.	
Utiliteit	Strategieën: Alles, focus toekomstbestendigheid en al meer 5, 6
Per functie heb je met hele andere constructieve eigenschappen te maken. Je ziet dat je per functie op een heel andere manier zo'n project in gaat steken. Het verschil zit hem in de flexibiliteit van de toekomstbestendigheid. Utiliteit zou flexibel moeten zijn en klaar zijn om in een andere functie te kunnen transformeren. Utiliteit veranderd heel snel en moet daarom flexibel zijn. Op dit moment is dat al een standaard. Ontwerpen met secundaire grondstoffen en hernieuwbare grondstoffen wordt steeds meer overwogen maar hangt van de opdrachtgever af.	
Gezondheid, educatie, recreatie, etc.	Strategieën: Alles maar hoe complexer hoe minder toegepast wordt
Bepaalde functies hebben bepaalde voorwaarden. Functies brengen andere voorwaarde met zich mee. Het gaat en om wet & regelgeving, bij elke functie horen andere regels en wetten ook op materiaal etc., maar ook überhaupt wat mag wel en wat mag niet. Denkend aan ziekenhuizen, daar is het lastig om met hergebruikte objecten te ontwerpen. Ook in een gevangenis is dat lastig. Er zijn dan bepaalde eisen voor de materialen. Dit drukt vooral op hergebruikte en secundaire grondstoffen. Per functie moet je bekijken welke strategie wel of niet kan. Publieke gebouwen zijn	

meestal voor heel veel jaar gebouwd. Dan is toekomstbestendigheid en levenscyclusimpact heel belangrijk. Scholen en industriëlen gebouwen moeten juist robuust zijn. Dat werkt allemaal weer door in de exploitatie kosten. Dan wordt er met ontwerpen met hernieuwbare grondstoffen niet geëxperimenteerd. Bij biobased materialen heb je vaker dat ze niet kras vast zijn of breekbaarder zijn en die vallen dan af. Het werken met secundaire grondstoffen en met hergebruikte objecten kan wel zolang het robuuste materialen zijn. Bij heel veel functies wordt er bijna nog niet met circulariteit gewerkt en moet er nog begonnen worden met het onderzoeken wat er kan, zoals bij ziekenhuizen.

Type opdrachtgever	
Private sector	Strategieën: Alles met meer focus op flexibiliteit
Private sector wilt vaak niet voorop lopen maar ook zeker niet achter lopen. Dus ze krijgen wel steeds meer die duurzaamheidsdoelen. Ook omdat dat een hogere waarde geeft aan hun vastgoed en het als PR kunnen gebruiken. Maar dit hangt allemaal samen met de ambitie. Afhankelijk van wat de opdrachtgever wilt uitstralen naar de omgeving. Als de opdrachtgever circulair denkt dan zal die alles kunnen overwegen. Als de opdrachtgever er helemaal niet mee bezig is zal ontwerpen met hernieuwbare grondstoffen afvallen. Hoe minder belangrijk hoe meer strategieën van 6 naar 1 afvallen. Als je van te voren kiest of je circulariteit belangrijk vind of niet, dan maakt het niet uit of het private of publieke sector is. Zodra ze bijvoorbeeld het zelfde kunnen investeren kunnen ze het ook met dezelfde strategieën aanvliegen. Al wordt bij de private sector meer naar levensduur gekeken. Flexibiliteit, toekomstbestendigheid moet je dan heel goed naar kijken. Dat maakt de waarde van het gebouw vaak ook hoger. Preventie is daar minder aan de orde.	
Publieke sector	Strategieën: Alles
De type opdrachtgever zou niet uit moeten maken. Als je van te voren kiest of je circulariteit belangrijk vind of niet, dan maakt het niet uit of het private of publieke sector is. Zodra ze bijvoorbeeld het zelfde kunnen investeren kunnen ze het ook met dezelfde strategieën aanvliegen. De publieke sector voelt wel meer de voorbeeldrol vanuit maatschappelijke verantwoordelijkheid. Er is niet een bepaalde voorkeur strategie, ze zouden dan ook alle zes de strategieën overwegen. Uiteindelijk heeft dit ook allemaal met motivatie en ambitie te maken.	

Ambitie	
Hoge ambities	Strategieën: Alles
Een hoge ambitie is goed om te hebben. Circulariteit is niet de weg van de minste weerstand, want je maakt het je zelf in alle opzichten ingewikkelder. Je moet wel de ambitie hebben om op die manier te bouwen. Dan ben je bereidt om meer te investeren in het maken van andere keuzes. Bij een hoge ambitie kan je dingen die net iets meer moeite kosten of meer energie in moet steken sneller toepassen. Bij hoge ambitie moet je het hele spectrum proberen te benaderen en kijken wat kunnen we overal doen.	
Lage ambities	Strategieën: 1, 2, 3 of minder
Bij een lage ambitie moet je proberen om zo duidelijk mogelijk een richting te kiezen. Dan maak je beter duidelijk op welke manier circulariteit toegepast wordt. Dan kijk je wel naar de situatie, op welk strategie het best gefocust kan worden. Bij lage ambities zou minstens toekomstbestendigheid, reductie en preventie belangrijk moeten zijn. Die drie doen we eigenlijk altijd al. Aantal dingen zitten al verwerkt in de TCO, BENG, etc. Ook zijn deze drie strategieën vaak nog interessant voor de opdrachtgever. Dat is de ondergrens wat nu gedaan wordt. Bij een lage ambitie ga je al snel naar eenvoudige dingen en laat je deze strategieën al snel los. Je moet meer ambitie hebben om circulair te werken, anders is het al snel te duur of kost het te veel tijd, etc.	

Hoe lager de ambitie hoe meer er afvalt van 6 naar 1. Al kan je ook makkelijker terecht komen op secundaire grondstof gebruik, dus minder op de losmaakbaarheid. Meer dat ze laten zien hoeveel hergebruikt materiaal in het beton zit en daarmee laten zien hoe duurzaam ze zijn. Dan kijken ze meer naar recycling. Bij lage ambities moet je nog specifieker zijn om de klant mee te krijgen en meer aan het handje mee te nemen. Bij een hoge ambitie kan je breder in zetten.

Gebruiker	
Huurder	Strategieën: Alles, met focus op toekomstbestendigheid en robuustheid
Als je eigenaar bent vind je het fijn als het flexibel is, want dan kun je het aanpassen bij een gewijzigde behoefte. Maar dat is ook als je het verhuurd aan derde, want dat veranderd ook allemaal, dus is het ook fijn als je het kan aanpassen aan de veranderde behoefte. Dan ook vooral in de inrichting, verdeling van wanden en plafonds, maar eventueel ook in gevels en kozijnen. Zo kan de verhuurder het blijven verhuren, met minimale aanpassingen. Ook kan je hierdoor dingen makkelijker vervangen waardoor je het een stukje robuuster maakt. Bij huurders moet je veel meer over preventie en slijtage nadenken. Dat zeg niet dat je over die andere dingen niet na hoeft te denken. Wat heel belangrijk is, is de informatie overdracht. De overdracht is nu nog heel lastig van eigenaar naar nieuwe eigenaar of van huurder naar nieuwe huurder. Als je eigenaar bent van het gebouw en van de grondstoffen die daar inzitten en dat op een bepaalde manier heb gedaan, moet je dat wel goed overdragen naar de volgende eigenaar of huurders. Daarbij zou het van heel veel andere factoren afhangen en niet specifiek van deze parameter.	
Opdrachtgever	Strategieën: Alles
Als je eigenaar bent vind je het fijn als het flexibel is, want dan kun je het aanpassen bij een gewijzigde behoefte, daarin zit geen verschil. Voor de opdrachtgever zelf is toekomstbestendigheid, preventie en reductie belangrijk. Dat gaat op langer termijn beter zijn voor iemand die eigenaar is van een gebouw. Als een opdrachtgever zelf in gaan die kan alles overwegen en naar zijn eigen ambitie het maken. Vaak gebruiken ze het als showcase. Dan heeft het een bepaalde waarde, wat die over de tijd kan uitspreiden. Verder zal het van heel veel andere factoren afhangen en niet specifiek van deze parameter.	

Fase	
Initiatief/Definitie fase	Strategieën: Alles focus op 1, 2, 3
Je moet zoveel mogelijk vanaf de initiatief fase meenemen. In de fases hangt het ervan af hoeveel invloed je nog heb. Het is gradatie wijs. In het begin kun je breder insteken. Aan het einde zit je beperkter door de keuzes die je gemaakt hebt. Bij vroeg stadium kan je alles toepassen. Dan kan je alles nog veranderen in het proces. In dit stadium moet je heel goed de kansen opschrijven en kijken welke strategie je wilt volgen. Toekomstbestendigheid, reductie en preventie moeten eigenlijk al in de initiatief/definitie fase geformuleerd worden als doelen. Dit zijn gewoon basis vragen. De materialen zelf komen vaak in een later stadium, maar je moet in dit stadium er wel al van bewust zijn dat het losmaakbaar etc. moet zijn. Zodat je weet dat ten opzichte van je S-laag weet welke uitdagingen je krijgt en waar je aandacht aan moet geven in je volgende ontwerp fase. Je kijkt wat de potentie van de losmaakbaarheid en de levensduur en de milieu-impact van de materialen. Op basis daarvan weet je welke richting je op moet met je materiaaleigenschappen om hoog te kunnen scoren op die onderwerpen.	
Ontwerp fase	Strategieën: Alles focus op 4, 5 en 6
In de ontwerpfase zou je nog kunnen kiezen voor hergebruikte objecten, hernieuwbare of secundaire grondstoffen. Omdat deze drie over materialen gaan kunnen die ook in een latere fase	

nog. Bij de andere strategieën zit je aan je keuze vast. Al is het heel goed om re-use al in de initiatief fase te zeggen. Dan kan je kijken wat uit de sloop komt en wat er nog hergebruikt kan worden en wat kunnen andere hergebruiken. In de ontwerp fase moet het niet meer ingeplugd gaan worden, want dan ben je gewoon te laat. Dan wordt het als een plus gezien, dan wordt geredeneerd het ten kosten van andere kwaliteiten gaat. Naarmate het proces vordert moet overal op gestuurd worden maar wordt grondstoffen belangrijker.	
Realisatie fase	Strategieën: Materiaal niveau, 4, 5, 6
In de realisatie fase kan je nog kijken naar de strategieën die heel specifiek over de materialen gaan. Als je laat instap heb je nog de mogelijkheid om traditionele grondstoffen in te wisselen. Dan kijk je echt naar hergebruikte objecten, secundaire en hernieuwbare grondstoffen. Het wordt wel heel ingewikkeld als je al helemaal bedacht heb hoe het eruit gaat zien hoe je het gaat doen. Toekomst bestendigheid kan bijvoorbeeld niet meer aangepast worden. Daar heb je ook ervoor al over na gedacht en ga je nu niet meer aan zitten tornen. Hoe verder in het proces vallen er dingen af, omdat het te laat is.	

APPENDIX F. LINK – SURVEY

https://docs.google.com/forms/d/e/1FAIpQLSdj6zmdMUkiQ_cztGGEXU9iLX75WzN0A7XTe7pRC87kvc9hrA/viewform?usp=sf_link

APPENDIX G. RESULTS EXPLORATIVE INTERVIEWS

Parameters	Participant A	Participant B	Participant C	Participant D	Participant E	The average
Project size	1	1	1	1	1	**1**
Project type	1	1	1	1	1	**1**
Duration	0	1	1	1	1	**0,8**
Investment size	1	1	1	0	1	**0,8**
Complexity	0	1	1	1	1	**0,8**
Number of stakeholders	1	1	1	1	1	**1**
Environment	1	1	1	1	1	**1**
Productivity	1	1	0	0	0	**0,4**
Series of projects or one of a kind	1	1	1	1	1	**1**
Level of detail	1	1	1	1	1	**1**
Urgency	1	1	1	1	1	**1**
Lifespan	1	1	1	0	1	**0,8**

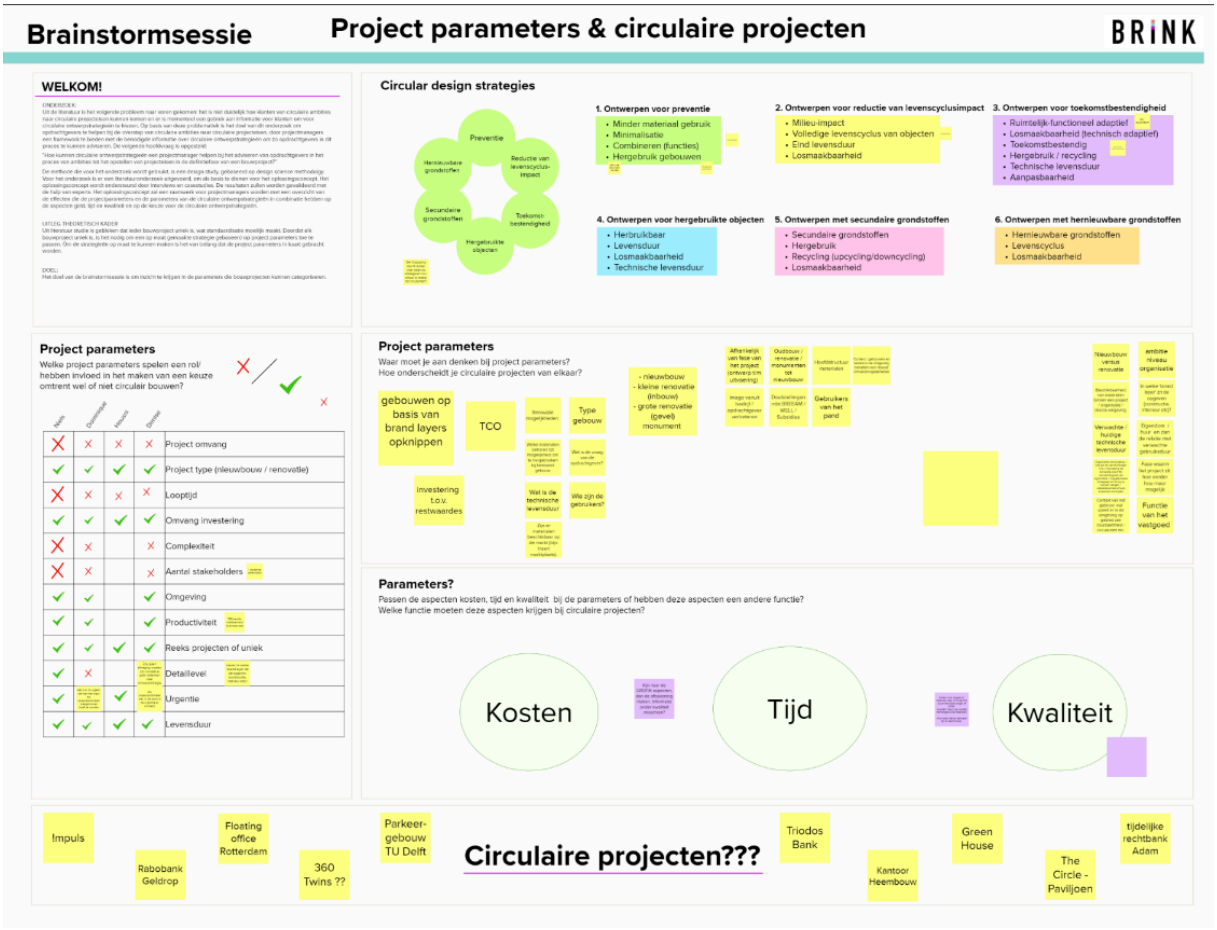
Costs	1	1	1	1	1	1
Time	1	1	1	1	1	1
Quality	1	1	1	1	1	1

Add	Participant A	Participant B	Participant C	Participant D	Participant E	The average
Function	1	1	1	0	0	**0,6**
Client (type client)	1	1	1	0	1	**0,8**
Fase	1	0	0	0	0	**0,2**
Needs	0	0	0	1	0	**0,2**
Mindset projectmanager	0	0	0	0	1	**0,2**
Knowledge projectteam	0	0	0	0	1	**0,2**
Market conditions	1	0	0	0	0	**0,2**

	Definitive parameters						
1	Project size	1	1	1	1	1	1
2	Project type	1	1	1	1	1	1
3	Duration	0	1	1	1	1	0,8
4	Investment size	1	1	1	0	1	0,8
5	Complexity	0	1	1	1	1	0,8
6	Number of stakeholders	1	1	1	1	1	1
7	Environment	1	1	1	1	1	1
8	Series of projects or one of a kind	1	1	1	1	1	1
9	Level of detail	1	1	1	1	1	1
10	Urgency	1	1	1	1	1	1
11	Lifespan	1	1	1	0	1	0,8
12	Function	1	1	1	0	0	0,6
13	Client (type client)	1	1	1	0	1	0,8

1	Costs	1	1	1	1	1	1
2	Time	1	1	1	1	1	1
3	Quality	1	1	1	1	1	1

APPENDIX H. BRAINSTORM SESSION



APPENDIX I. PROJECT PARAMETERS

Project parameters	Definition	
Project size	Bigger ≥ 10.000 m2	Denotes the number of tasks to be executed in a project and each task is measured in terms of quantities of work involved. Project size can be measured in several dimensions but the amount of surface (m2) or other scarce resources (skilled people, facilities, other) are the most tangible and obvious.
	Smaller < 10.000 m2	
Project type	New construction	Projects can be divided into three project types: new construction project, renovation project, or temporary project.
	Renovation	
	Temporary construction	
Duration	Longer ≥ 2.5 years	Depends upon the speed with which the project is to be executed. The duration defines the period from the initiation phase up to and including the realization phase.
	Shorter <2.5 years	
Investment size	Wide budget	Investment size ensure the financial stability of the construction project at various stages of its life cycle. At the pre-investment stage, the financial model and budget of the project are considered as a mechanism for ensuring the sustainability of the project (Mishlanova, 2019). The scope of the investment for circularity is important for this research. Is there room to focus more on circularity or does everything have to be researched within a tight budget?
	Tight budget	
Complexity	High complexity	Is a measure of variety like tasks to be executed. Complexity increases as the number of dissimilar task increase and it decreases if the tasks are repetitive (or similar). Managers of high complexity project rate the average importance, their success criteria, and the importance for the customer, supplier, and stakeholder satisfaction significantly higher than those of low complexity projects.
	Low complexity	
Number of stakeholders	More > 10 stakeholders	Stakeholders is the term used to describe those who have an interest in, or concern for, the activities of a project. Stakeholders vary depending on a wide number of factors therefore within a construction project there are many different possible stakeholders.
	Less ≤ 10 stakeholders	
Environment	Urban area	Every construction project influences the environment, but an environment also influences the construction project and especially the construction process. Is the building located in the middle of the busy city or on a stretched-out plot of land?
	Rural area	
Series of projects or one of a kind	Series	Serial building is seen as efficient and entails several advantages. With serial construction, the concept has been worked out down to the last detail and can be implemented again and again. With one of a kind project
	One of a kind	

		this efficiency is lower, the project still has to be fully thought out and elaborated, just to set up a project.
Level of detail	High level of detail	Level of detail refers to architecture. Is there a high level of detail in the design or is the design kept simple? The detail level looks at the complexity at the element level. Are the connections complex or kept simple, etc.
	Low level of detail	
Urgency	High urgency	How urgent something is, is the degree to which something is stringently desired or needed. Construction projects can differ in urgency. For this research, it is important to know whether circularity is urgent in the project or not. The urgency of circularity in a project is determined by the client.
	Low urgency	
Lifespan	Long >75 year	The lifespan of buildings is composed of a series of interlocking processes, starting from initial architectural and structural design, through to actual construction, and then to maintenance and control as well as to eventual demolition or renovation of buildings. Inside this lifespan, essential requirements are generated from considerations of social, environmental, and economic issues for high-efficient energy-saving building systems in compliance with building codes and regulations
	Short < 20 year	
Function	Living	In relation to the built environment, the term 'function' refers to the purpose of a building or structure. It can also relate to the proper operation, process or performance of something and how it works, such as plant, tools, lift, building services. In this case the function of the total building is meant. Buildings may have a range of different functions (for example, a factory may include offices, a restaurant, assembly lines.
	Utility	
	Health, education, recreation, etc.	
Client	Private sector	Clients are always involved in construction projects. There are different types of clients with different interests. The biggest difference can be made between the private client and the public client.
	Public sector	
Ambitions	High ambitions	An ambition is a strong wish to achieve something. For every project there can be a difference in the ambition for circularity. One project team would like to achieve it, while the other experiences that feeling less.
	Low ambitions	
User	Rented	The approach of the building can also depend on the type of user. A building can be put into use by the client itself or a client can rent it out or sell it on. This provides a different view of the building.
	Owned	
Phase	Initiation/definition phase	A construction project consists of four different phases. Dividing a project into phases makes it possible to lead the project in the best possible direction. Through this division into phases, the total workload of a project is divided into smaller components, thus making it easier to manage.
	Design/realisation phase	

APPENDIX J. RESULTS ANALYZE MANAGEMENT ASPECTS

Cost

Parameter		SC Resp. A	Client Resp. B	Architect Resp. C	Contracto Resp. D	PM Resp. E	PM Resp. F	Architect Resp. G	SC Resp. H	Contracto Resp. I	SC Resp. J	Client Resp. K	Client Resp. L	PM Resp. M	Architect Resp. N	Contracto Resp. O	+	/	-	Average
Project size	Bigger >100000m2	+	-	+	+	+	-	+	-/	+/	+/	+	+	+	/	+	9	1	2	+
	Smaller <100000m2	-	-	-	-	x	--	--	+	-	+	/	-	-	/	-	2	2	8	-
Project type	New construction	-	/	/	-	+	/	-	/	-/	-/	-	+	-	+	-	3	4	6	-
	Renovation	/	/	-	/	+	/	+	+	/	-	-	-	-	-	+	4	5	6	-
	Temporary construction	+	/	+	/	+	/	+	+	+/	+	+	-	/	/	-	7	5	2	+
Duration	Longer > 2,5 year	+	-	+	+	-	+	+	/	-	+	+	+	-	-	/	8	2	5	+
	Short < 2,5 year	-	+	-	/	+	-	-	/	+	-	+	-	-	+	-	5	2	8	-
Investment size	Bigger > 10 million	+	+	+	+	x	+	+		-		+	+	/		+	9	1	1	+
	Smaller < 10 million	+	-	-	-	x	-	-		+		-/	-	-		-	2	0	8	-
Complexity	High complexity	+	-	-	-	-	-	-	/	+	/	-	-	-	-	-	2	2	11	-
	Low complexity	+	+	+	/	+	+	+	/	-	/	+	+	+	+	+	11	3	1	+
Number of stakeholders	> 10 stakeholders	-/	+	x	-	-	/	/	-	-	-	-	-	-	-	-	1	2	10	-
	≤ 10 stakeholders	+	-	x	/	/	/	/	+	/	+	+	+	+	+	+	8	5	1	+
Environment	Urban area	+/	/	/	/	+	/	-	-	/	+	-	-	/	-	+	3	6	5	/
	Rural area	/	/	/	/	/	/	+	+	/	-	+	+	/	+	-	5	8	2	/
Series of projects or one fo a kind	Series of projects	+	+	+	+	+	+	+	+/	+-	+	+	+	+	+	+	13	0	0	+
	One of a kind project	-	-	/	/	/	/	-	/	/	-	-	-	-	/	-	0	7	8	-
Level of detail	High level of detail	-	-	-	-	+	-	-	/	-+		-	-	-	-/	-	1	1	10	-
	Low level of detail	+	+	/	/	-	+	+	/		+	+	+	+	+/	+	9	3	1	+
Urgency	High	-	+	X	-	+	+	-	+	+	/	-	-	/	+	+	7	2	5	+
	Low	+	-	X	-	-	/	+	-	-	/	+	+	-	-	-	4	2	8	-
Lifespan	Longer >75 year	+	/	X	/	+	/	-	/	-	-	-	+	/	/	-	3	6	5	/
	Shorter < 20 year	+	/	X	/	/	+	/	+	-	+	+	+-	+	+/	+	7	4	1	+
Function	Living	-			+			-	/	-	/	/	+			-	2	3	4	-
	Utility	+						+	+	+	+					+	6	0	0	+
	health, education, recreation, etc.	/	/	x	-	/	/	-				+	-	/	/		1	6	3	/
Client	Private sector	/	/	x	/	/	-	-	/	+	+/	-	+	/	/	-	2	7	4	/
	Public sector	+	/	x	/	+	/	+	/	--	+	-+	-	/	/	+	5	6	1	/
Ambitions	High ambitions	-	-	+	/	+	+	-	+	+	/	-	-	-	+	+	7	2	6	+
	Low ambitions	/	-	/	/	-	-	-	-	/	-	/	+	-	+	-	2	5	8	-
User	Rentals	+	/	/	/	-	/	/	/	-	+	/	+	-	-	-	3	7	5	/
	Buyers	-	/	/	/	-	+	/	/	+	-	/	+	-	+	-	4	6	5	/
Phase	Initation phase	+	-	++	+	+	+	+	/	+	+	/	+	+	+	+	11	2	1	+
	Definition phase	-	-	+		+	+	+	/						+	+	6	1	2	+
	Design phase	-	-	+		+	+	-	-			-			+	-	4	0	6	-
	Realisation phase	-	/	-	-	-	-	-	/	-	/	-	-	-	-	-	0	3	12	-

Time

Parameter		SC Resp. A	Client Resp. B	Architect Resp. C	Contracto Resp. D	PM Resp. E	PM Resp. F	Architect Resp. G	SC Resp. H	Contracto Resp. I	SC Resp. J	Client Resp. K	Client Resp. L	PM Resp. M	Architect Resp. N	Contracto Resp. O	+	/	-	Average
Project size	Bigger >100000m2	+	-	+	+	+	-/	+	-	-/	+	/	+	-	+/	+	8	1	3	+
	Smaller <100000m2	-	+	-	-	x	-/	--	+	-	-	/	-	-	/	-	2	2	8	-
Project type	New construction	-		/	-	+	/	-	-	-	-	/	+	-	+	/	3	4	7	-
	Renovation	-		-	+	+	/	+/	-/	-	-	-	-	-	-	+	3	1	8	-
	Temporary construction	+	-	+	- +	+	/	+	+	-	+	+	-+	/	/	-	7	3	3	+
Duration	Longer > 2,5 year	+	-	+		-	+	+	+		+	+	+	/	+	+	10	1	2	+
	Short < 2,5 year	-	+	-	/	+	-	-	-		-	-	-	-	-	-	2	1	11	-
Investment size	Bigger > 10 million	+	+	+	+	x	+	+	+	-	/	+	+	/	/	+	10	3	1	+
	Smaller < 10 million	+	-	-	-	x	-	-	-	+	/	-/	-	-	/	-	2	2	9	-
Complexity	High complexity	+	-	-	-	-	-	-	-	+	/	-	-	-	-	-	2	1	12	-
	Low complexity	+	+	+	/	+	+	+	+	-	/	+	+	+	+	+	12	2	1	+
Number of stakeholders	> 10 stakeholders	-/	+	x	-	-	-	/	-	-	-	-	-	-	-	-	1	1	11	-
	≤ 10 stakeholders	+	-	x	/	/	+	/	+	/	+	+	+	+	+	+	9	4	1	+
Environment	Urban area	+/	/	/	/	+	-	-	/	/	+	-	-	/		+	3	6	4	/
	Rural area	/	/	/	/	/	/	+	+	/	-	+	+	/		-	4	8	2	/
Series of projects or one fo a kind	Series of projects	+	+	+	+	+	+	+	/+	+-	+	+	+	+	+	+	13	0	0	+
	One of a kind project	-	-	/	/	/	/	-	-	//	-	-	-	-	/	-	0	5	9	-
Level of detail	High level of detail	-	-	-	-	+	-	-	-	-+		-	-	-	-/	-	1	0	11	-
	Low level of detail	+	+	+	/	-	+	+	+		+	+	+	+	+/	+	11	1	1	+
Urgency	High	-	-	/	-	+	+	-	+	+	/	-	-	-	+	+	6	2	7	-
	Low	+	+	X	-	-	/	+	-	-	/	+	+	-	-	-	5	2	7	-
Lifespan	Longer >75 year	+	/	X	/	+	/	/	/	-	-	-	+	-	/	-	3	6	5	/
	Shorter < 20 year	+	/	X	/	/	+	/	/	-	+	+	/	-	+/	+	5	6	2	/
Function	Living				+			-	/	-	-	/	+			-	2	2	4	-
	Utility							+	+	+	+					+	5	0	0	+
	Education, health, recreation, etc.	+	/	x	-	/	/	-				+	-	/	/		2	5	3	/
Client	Private sector	/	/	x	/	/	/	-	/	+	/+	-	+	/	/	-	2	8	3	/
	Public sector	+	/	x	/	+	/	+	/	-	+	-+	-	/	/	+	5	6	2	/
Ambitions	High ambitions	-	+	+	/	+	-	-	+	+	/	-	-	-	-	+	6	2	7	-
	Low ambitions	/	-	/	/	-	-	-	-	/	-	/	+	-	+	-	2	5	8	-
User	Rentals	+	/	/	/	-	/	/	/	-	+	/	+	-	-	/	3	8	4	/
	Buyers	-	/	/	/	-	+	/	/	+	-	/	+	-	+	/	4	7	4	/
Phase	Initation phase	+	-	+	+	+	+	+	/	+	+	/	+	+	+	+	12	2	1	+
	Definition phase	-	-	+		+	+	+	/						+	+	6	1	2	+
	Design phase	-	-	+		+	+	-	-			-			+	-	4	0	6	-
	Realisation phase	-	/	-	-	-	-	-	-	-	/	-	-	-	-	-	0	2	13	-

Quality

Parameter		SC Resp. A	Client Resp. B	Architect Resp. C	Contracto Resp. D	PM Resp. E	PM Resp. F	Architect Resp. G	SC Resp. H	Contracto Resp. I	SC Resp. J	Client Resp. K	Client Resp. L	PM Resp. M	Architect Resp. N	Contracto Resp. O	+	/	-	Average
Project size	Bigger >100000m2	/	-	+	/	/	/	/	/	-	+	+	/	/	/	/	3	10	2	/
	Smaller <100000m2	+	+	+	/	/	-	/	/	-	-	-	/	/	/	/-	3	7	4	/
Project type	New construction	/		++	/	+	+	/	/	/	/	+	+	/	/	+	5	8	0	/
	Renovation	/		+	/	+	/	/	/	-	/	/	+	/	/	/	3	10	1	/
	Temporary construction	-	/	+	/	+	/	/	+/	-	+	+	-	/	/	-	4	6	4	/
Duration	Longer > 2,5 year	+	+	+		+	+	+	/	-	+	+	+	/	/	+	10	3	1	+
	Short < 2,5 year	-	-	-	/	-	-	-	/	+	-	-	-/	/	/	/	1	5	8	-
Investment size	Bigger > 10 million	+	+	++	/	x	+	+	/	/	+	+	+	+	/	+	9	4	0	+
	Smaller < 10 million	+	-	-	-	x	-	-	/	+	-	/-	-+	-	/	/	2	3	7	-
Complexity	High complexity	+	/	-	-	-	-	-	/	+	/	/	-	/	-	-	2	5	8	-
	Low complexity	+	/	+	/	+	+	+	/	-	/	/	+	/	+	+	8	6	1	+
Number of stakeholders	> 10 stakeholders	/ -	+	x	-	+	-/	/	-	/	-	-	+-	/	-	/-	2	3	5	-
	≤ 10 stakeholders	+	-	x	/	/	+/	/	+	/	+	+	+	/	+	/+	6	5	1	+
Environment	Urban area	/+	/	/	/	+	/	+	/	/	+	/	/	/	+	/	4	9	0	/
	Rural area	/	/	/	/	/	/	/	/	+	-	/	/	/	-/	/	1	11	1	/
Series of projects or one fo a kind	Series of projects	+	+	+	+	+	+	+	/+	+-	/	+	+	+	+	+	12	1	0	+
	One of a kind project	-	+	/	/	/	/	-	/	//	/	/-	/	/	/	-	1	9	3	/
Level of detail	High level of detail		-	+	-	+	-	-	/	/		-	/	/	-/	-	2	4	6	-
	Low level of detail		+	-	/	-	+	+	/		+	+	/	+	+/	+	7	3	2	+
Urgency	High		/	X	/	+	+	/	+	+	+	+	+	/	+	+	9	4	0	+
	Low		/	X	/	-	/	+	-	-	-	-	-	/	-	-	1	4	8	-
Lifespan	Longer >75 year	+	/	X	/	+	/	+	/	/	/	-	+	/	/	-	4	8	2	/
	Shorter < 20 year	+	/	X	/	/	+	/	/	+	+	+	-	/	/	+	6	7	1	/
Function	Living				+			/	/	-	/	+	+			/	3	4	1	/
	Utility							/	+	+	+					+	4	1	0	+
	Education, health, recreation, etc.	+	/	x	-	/	/	/				+	-	/	/		2	6	2	/
Client	Private sector	/	/	x	/	/	-	-	/	+	/+	+	+	/	/	-	3	7	3	/
	Public sector	+	/	/	/	+	/	+	/	/	+	+	+	/	/	+	7	8	0	/
Ambitions	High ambitions	-	+	++	/	+	+/	+	+	+	+	+	/	+	+	+	10	2	1	+
	Low ambitions	/	-	-	/	-	-	-	-	/	-	-	-	/	/	-	0	5	10	-
User	Rentals	+	/	/	/	-	/	+	-	-	-	/	+	-	-	-	3	5	7	-
	Buyers	-	/	/	/	-	+	-	+	+	+	/	+	+	+	/	7	5	3	+
Phase	Initation phase	+	-	++	+	+	+	+	/	+	+	+	+	+	+	+	12	1	1	+
	Definition phase	-	-	+		+	+	+	/						+	+	6	1	2	+
	Design phase	-	-	+		+	+	-	-			-			+	-	4	0	6	-
	Realisation phase	-		-	-	-	-	-	/	-	/	-	-	-	-	-	0	2	12	-

APPENDIX K. OVERVIEW RESULTS MANAGEMENT ASPECTS

Effects + conditions on management aspects

Project parameter		Cost		Time		Quality	
Project size	Big >10000m2	+	When a larger construction volume means a larger construction sum, as a result of which the investment costs for circularity will have a smaller share of the total volume.	+	A larger construction project and more size mean that the extra time has less influence, work is done more efficiently and the working time is often longer.	+	When more attention is paid to quality in a larger project and when circular materials are used.
		/		/		/	
		-	When the exploitation phase is not included and there is no overview of the risks of the project.	-	When products are not available or are available later and there is no room for extra preparation time.	-	When high-quality materials and/or sufficient materials are not available.
	Small <10000m2	+	When no extra time is needed to apply circularity.	+	When no extra time is needed and there is more knowledge that makes the process more effective.	+	When there are fewer risks in smaller projects and they are easier to oversee so that more circularity can be opted for.
		/		/		/	
		-	When a smaller construction volume means a smaller construction sum, which means that circularity has a larger share of the construction costs.	-	When a smaller construction project ensures that the extra time has more influence. Circularity currently requires even more energy, because it is an even more unknown subject that can be seen in the planning.	-	When no energy is invested in circular solutions.
Project type	New construction	+	When circular materials become available in large masses.	+	When circular materials become available in large quantities and the parties have more knowledge.	+	When you start with a clean sheet so that you can manage quality well (and fewer risks are present)
		/		/		/	
		-	Due to the great need for materials, which are not yet available in large quantities in a circular/secondary/renewable manner.	-	When the great need for materials is not yet available in great masses, which allows for more time to collect and through the time spent in the learning aspect.	-	When there is insufficient money and time available.
	Renovation	+	When what can be preserved is preserved. Fewer materials = less costs.	+	If a good quality 3D model of the project is available and there is experience and flexibility from the parties.	+	When there is more time and money.
		/		/		/	
		-	When extra time needs to be spent on scanning and designing. Extra time is reflected in extra costs.	-	When extra time is spent on scanning what comes out of the building and taking the existing situation into account when designing.	-	When there is limited time and money.
	Temporary construction	+	When you take dismantling into account in advance so that at the end of the project not everything has to be written off through demolition.	+	Through standardization of a product, it takes more time in the development phase, but you will benefit later. You can allocate the extra time in the second life.	+	When it can be managed well and more time and money is available.
		/		/		/	
		-	When the building cannot be dismantled.	-	When it is custom made, which means that it takes more preparation time and it is more difficult to reuse at the end of its life.	-	When there is no overview and there is limited time and money.
Duration	Long > 2.5 year	+	When better-balanced choices can be made because more time is available.	+	When there is more room to weigh up, to broaden the scope, and get everyone involved.	+	When this creates scope to steer on quality.
		-	When more time works, costs increase.	-	If the scope is not broadened and people do not connect well or find each other. (Depends on project size in which sizes this has a negative effect)	-	If information is lost by switching parties/persons.
	Short < 2.5 year	+	When the necessary knowledge about circularity is already in the team.	+	When the knowledge about circularity is already in the team.	+	When the knowledge about circularity is already in the team.

		-	When money has to be released to realize the circular ambitions.	-	When innovation for circularity takes even more time due to too little knowledge.	-	When less time is taken to consider all possibilities and people often fall back to standard (traditional) solutions.
Investment size	Wide budget	+	When there are more expectations for circularity, for which more budget is made available.	+	When more budget equals more time. With more time, better considerations can be made and collaborations can be entered into.	+	When better considerations are made and there is room for new techniques.
		-	When there are too many stakeholders to approve.	-	If too many people or people with little knowledge or ambitions for circularity have to give approval on or in the project.	-	If too many people are involved who have to approve the project, this makes decisions more difficult and can lead to less innovation.
	Tight budget	+	When a creative search is made for circular solutions that can be implemented cost-neutrally or cheaper.	+	When looking for simple circular solutions.	+	When the time is available to creatively search for circular solutions that can be implemented cost-neutral or cheaper.
		-	When more budget is needed to apply circularity in the project.	-	When things always have to go faster with a tighter budget, which is not yet feasible for the application of circularity.	-	When more budget is needed to be able to deliver high quality circularly and there is less room to make trade-offs.
Complexity	High complexity	+	When risks can be managed well and when there is an overview of the project.	+	When risks are well managed and there is an overview of the project.	+	When the knowledge about circularity is already in the team.
		-	When in a complex project every decision has multiple consequences, there is more customization in the project and circularity entails more risks.	-	When it is more difficult to control time and keep an overview of a complex project. Every decision you make has multiple consequences.	-	The products/elements have more complicated and unique connections, which makes it more difficult to achieve the right quality with circular products/elements. The products/elements must be available and must be able to provide the guarantee.
	Low complexity	+	When circularity is chosen more often and there are more strategies to choose from. Which ensures that the risks will be lower.	+	When there is more knowledge, which means that less effort has to be made. The project will consist of far fewer aspects so that choices can be made quickly and the consequences can be understood quickly.	+	You can do many different things in the field of circularity with low complexity. There is a choice of many different products to build a simple project.
		-	When the risks become bigger because too little knowledge is available or can be obtained.	-	When there is less knowledge, which means that more time has to be invested.	-	When circularity is added to the project too late.
Number stakeholders	> 10 stakeholders	+	When the stakeholders have sufficient knowledge in the field of circularity.	+	When the stakeholders have sufficient knowledge in the field of circularity.	+	When the stakeholders have sufficient knowledge in the field of circularity.
		-	When more stakeholders have more opinions, principles, and interests. This will cause more confusion and more money to fit circularity in.	-	When more stakeholders mean more opinions, all of which you have to align, which can take a lot of time.	-	When it is more difficult to communicate because there are more opinions and more people have to be convinced to cooperate.
	≤ 10 stakeholders	+	When less time is needed to align, allowing for better team response.	+	When you have to put less energy (time) into it to convince everyone.	+	When there are fewer opinions so that more stakeholders are behind the project and the goals of the project.
		-	When more time is needed to get everyone on the same page, due to different opinions in the team, which is reflected in money.	-	If more time is needed to get everyone on the same page, due to different opinions within the team.	-	When different opinions do not align and there is not a clear goal.
Environment	Urban area	+	When working from the idea that building in the city is often more expensive.	+	If there is a low/no time pressure and the products can be supplied properly.	+	When the client wants to make a statement.
		/		/		/	
		-	When an external storage location costs money, there is less room to experiment and there is a long process to meet the requirements.	-	When there is a high pressure to build and a lot in the environment has to be closed off to supply the products.	-	When the mobility in the environment is insufficient and there is little space to store products and elements.
	Rural area	+	When a spacious construction site is available.	+	When there are fewer requirements that need to be met and there are no extra travel times (for products, personnel, etc.).	+	When there is more space on the construction site, which will cause less damage and there is more room to try out circularity.
		/		/		/	
		-	When there is little space on the construction site or when there are many requirements.	-	When there is a longer travel time (for products, personnel, etc.).	-	When the project is difficult to reach and there is little space on the construction site.

Series of projects or one of a kind	Series of projects	+	When the investment to be taken upfront can be written off over the entire series and beginners' mistakes will disappear throughout the series.	+	When the extra time that has to be taken at the front can be written off over the entire series, more experience is gained throughout the series, and knows how to find the right people.	+	When you can keep improving throughout the series, create a developed standard. The appearance can be different per building, while the system is the same.
		-	When not developed and improved throughout the series.	-	When innovations are not included throughout the series and more time has to be invested in advance.	-	When it is not developed and improved throughout the series and innovations are not included.
	One of a kind project	+	When the knowledge is already there and the design process no longer needs to take place.	+	When the knowledge is already there and the process no longer needs to take.	+	When sufficient attention is paid to circularity and to the latest developments in the field of circularity.
		/		/		/	
		-	Due to a longer design process, more budget is needed and because it is a one-off, it is difficult to reuse it later, so that it will yield less.	-	When it takes more time to develop a circular project and get the right parties involved.	-	When there is a loss of quality due to too little knowledge about circularity.
Level of detail	High level of detail	+	When high-quality products can be used so that higher quality can be delivered and the end-life value is higher.	+	If you do not fasten too much in advance and can still adjust the detail based on the available materials.	+	When the detail is carefully thought through, creating a pleasant environment and reducing the need to replace products and materials.
		-	When it gets more complicated requiring more attention and knowledge to develop the detail.	-	When it gets more complicated requiring more attention to develop the detail and find the right materials to go with it.	-	When it is complex, specific, and complicated, which makes the reuse of materials often more difficult and often requires a proven solution.
	Low level of detail	+	When less attention has to be put into the design process and everyone knows how the detail works, no mistakes are made.	+	When there are fewer challenges and less stringent requirements to meet, which means less time figuring everything out.	+	When a simple detail makes it easier to disassemble and deliver good quality. By having a few different details as possible, the error rate will remain low.
		-	When there are many different details, resulting in less knowledge about it and more errors.	-	When there are many different details, which means that there is less knowledge about it and more time has to be invested in the design process.	-	When a circular ambition is missing in the elaboration of the details so that less circularity is included.
Urgency	High urgency	+	When high urgency provides more room in the project because the extra costs for circularity have already been included in the estimate in advance.	+	If the traditional working methods are reset and a standard circular method can be applied.	+	When you also get more parameters (money and time) so that attention can be paid to quality.
		-	When there is a rush behind the project so that not all materials are available.	-	When there is still too little knowledge to apply properly, which can provide more time to arrive at the right knowledge.	-	When there is a rush behind the project, which ensures that there is no room to pay attention to the (circular) quality.
	Low urgency	+	When more time is created due to low urgency or if the motivation is there, which frees up more money.	+	If the traditional working methods are reset and a standard circular method can be applied.	+	When there is more time to be able to sort everything out properly.
		-	When there is less motivation to apply circularity, which ensures that no extra money is made available.	-	When there is less motivation to apply circularity, which ensures that no extra time is made available.	-	When the choice is made earlier to do the obvious, which can have negative consequences on quality.
Lifespan	Long >75 year	+	Depends mainly on other parameters.	+	Depends mainly on other parameters.	+	When the focus is on materials without loss of quality and on demountable construction.
		/		/		/	
		-	Becomes negative on the investment budget when the costs for the higher quality materials increase to maintain the quality for a longer time.	-	When making the project disassembled in advance saves you more time.	-	When materials are used that have a rapid loss of quality and the construction is not demountable.
	Short <20year	+	When the building or the materials are reused to a high standard after their lifespan so that it yields something at the end of the project.	+	When demountable construction takes no extra time.	+	When suppliers get the materials back at the end of the project, ensuring better quality upfront.
		/		/		/	
		-	When the building or materials are not reused after their useful life.	-	When the building or materials are not reused after their lifespan the extra time is spent for nothing.	-	When construction is not demountable, which results in a lower circular quality.

Function	Living	+	When a construction method is developed that can compete with the linear construction method for housing.	+	When a construction method is developed that can compete with the linear construction method for housing and circular construction can be carried out in series.	+	When circular materials can deliver better quality.
		/		/		/	
		-	When circular construction methods do not yet compete with the well-developed linear construction method for housing.	-	When the circular construction method cannot yet compete with the well-developed linear construction method for housing.	-	If the specified requirements are not met.
	Utility	+	When it quickly changes the function so that the client has more a reason to build adaptable.	+	When the function is changed quickly so that the client has more to spare to build in an adaptable way.	+	When there is already a lot of work with modular systems, which has a positive effect on quality.
		-	When the importance of being flexible is not seen in advance.	-	When the importance of being flexible is not seen in advance.	-	When it gets too big and becomes unmanageable.
	Health, accommodation, education, recreation, etc.	+	When there are high ambitions and a team that wants to make it happen.	+	When the client wants to free up extra money and time.	+	When circular materials can deliver better quality.
		/		/		/	
		-	When it is a complex building.	-	When it is a complex building and additional time and budget are required.	-	When it is still too complex for which the quality requirements cannot be met.
Client	Private sector	+	When the ambition for circularity is high, the clients also want to invest money in it.	+	When the ambition for circularity is high, resources are also made available.	+	When the ambition for circularity is high, resources are also made available, which leads to higher quality.
		/		/		/	
		-	When the ambition for circularity is low and the client does not want to invest money in it. Then the building is developed as cheaply as possible.	-	When the ambition for circularity is low, less time is made available.	-	If the ambition for circularity is low, fewer or not then no resources are made available, which means that the quality will be lower.
	Public sector	+	When more budget can be made available or circular construction can be cheaper.	+	When they feel social pressure and want to lead the way.	+	When high ambitions and demands are set.
		/		/		/	
		-	When the investment budget is too tight to add circularity.	-	When the public sector does not want to make anything extra available for it.	-	When budget and time are not available, which means that the quality will be lower.
Ambitions	High ambitions	+	When more money/time is made available in advance because the priority lies with circularity.	+	When the ambition is expressed early on.	+	When a team is formed that ensures more circularity.
		-	When circularity increases costs because there is still insufficient knowledge.	-	When more time has to be invested in researching what is possible, gathering the right knowledge, and engaging the right parties.	-	When circularity is not applied in the right way.
	Low ambitions	+	When circularity is used from the start.	+	When circularity is used from the start.	+	When more attention is paid to exploring all circular options.
		-	When circularity is added later, when it is added, costs more money.	-	When adding circularity later, it takes more effort and requires a lot more pulling.	-	When ill-considered things are applied more often and the easy way is chosen more quickly.
User	Rentals	+	When circularity can be incorporated into the business model.	+	When the importance of circularity is seen.	+	When the flexibility is taken into account, the user is involved in the project and the wear and tear are included in the project.
		/		/		/	
		-	When the circular applications cannot be earned back with the business model.	-	When the importance of circularity is not seen.	-	When the user is not involved and the wear and tear are not taken into account.
	Buyers	+	When the building remains in ownership for longer, which means that more can be invested.	+	When the building remains in ownership for longer, which means that more can be invested.	+	When the user has a higher ambition, as a result of which he sees the added value of circular quality.
		/		/		/	
		-	When the building is not owned for a longer time.	-	When the building is not owned for a longer time.	-	When the information about the building is not properly transferred to the user.
Phase	Initiation phase/ Definition phase	+	When the decisions for circularity are made as early as possible, it takes less	+	When the process is set up from the start to include circularity, it does not have to cost anything extra and	+	When other design methods can be used, which benefits the quality.

			energy to add circularity. Here is also the person who makes the budget available at the table.		everyone has a mindset to look at it circularly.		
		-	When the decisions for circularity are not made and it will cost more later to add it to the project.	-	When the process is not implemented circularly and the mindset is not for it.	-	Wanneer er niet voor een andere manier van ontwerpen wordt gekozen.
	Design phase / Realisation phase	+	When circularity can still be easily added.	+	When circularity can still be easily added.	+	When circularity can still be easily added.
		-	When you have to take a step back to properly add circularity because you have to adjust things in earlier phases.	-	When it costs you more effort to introduce circularity and you have yet to create it.	-	When there is little ambition to add circularity or the suppliers do not supply circular products, it is added in lesser sizes.

APPENDIX L. RESULTS ANALYZE CIRCULAR DESIGN STRATEGIES

Parameter		SC Resp. A	Client Resp. B	Architect Resp. C	Contractor Resp. D	PM Resp. E	PM Resp. F	Architect Resp. G	SC Resp. H	Contractor Resp. I	SC Resp. J	Client Resp. K	Client Resp. L	PM Resp. M	Architect Resp. N	Contractor Resp. O	Average
Project size	Bigger >100000m2	3, 5, 6, 2, 1	Everything	Everything	1, detachable & flexibility	Everything	1, 2, 3, 4, 5	1,2,3, 6=more difficult	2,3,4,5	Everything, focus 6 en 4	Everything	Everything 4 more difficult	5, 6, 1, 2, 3	3, 2	Everything	3, 2, 1	1, 2, 3, 5, (4, 6 more difficult)
	Smaller <100000m2	4, 5, 6, 2, 1	1,2	Everything		Everything	2, 3, 4, 5, 6	3,4,5,6 chance	1, 6	5, 3, 2	Everything	5, 4, chance 1, 2, 3, 6 always	5, 6, 4, 1, 2, 3, detachable	4, 3	Everything	4, 5, 6, 2, 1	6, 5, 4 is done more 1, 2, 3 always
Project type	New construction	Everything	1, 3, 4, Everything	6, 3, 5 renewable raw materials, detachable, future-proof	Everything	1, 2, 3, 5, 6, more difficult 4	1, 2, 3, more difficult: 4, 5, 6	1,2,3	Everything	1, 2, 3, 5	3, 1, 2, 4, 5, 6	1, 2, 3, 6, (4, 5 more difficult)	Everything (less 1, 4)	1, 2, 3	Everything	1, 2, 3, 5, 6 (secundair, detachable & renewable)	1, 2, 3, 6 more difficult 4, 5
	Renovation	Refuse, reduce, reuse (own building), remanufacture, renewable 1, 2, 3, 5, 6	1, 2, more difficult	1, 4 reuse	1, 2, 3, 5 Secundaire raw materials	4, limited 5, 6,	4, 3, 1	1,4,5,6 re-use	1,2,4,5, (3, 6, more difficult)	2, 3, 4, 5, 6	1, 2, 4, 5, 6	4, 5, Everything	1, 4 Everything	2, 4	Everything	reuse 4, 2,	1, 2, 5, 6, focus on 4, more difficult 3
	Temporary construction	detachable, prevention, reuse, 1, 2, 4, 5, 6	3, detacheble, 4 re-use	Levencyclus impact, renewable		Everything	1, 2, flexibility, adaptable, re-use	1,2,3,4,5,6 future-proof	2, 6, 4, detachable	1, 2, 3, 4	3, 1, 2,4, 5, 6	6, 4, 5	detachable	1, 2, 6	Everything	4, 2	Everything with focus on future-proof
Duration	Longer > 2,5 year	Everything	Everything	Everything	Everything	Everything	1, 2, 3, 4, 5, 6 reuse, secundair	4,5,6	Everything	Everything, focus on 6 and 4	Everything	Everything chance for 4	Everything	2, Everything	Everything	Everything	Everything with chance for 4, 5 and 6
	Short < 2,5 year	more difficult re-use, remanifactory, 5	1,2	Everything	Everything	Everything	1, 2, 3	1,2,3	(detachable, recycling, renewable more difficult) 3,2, milieu-impact	2, 3	5, 1, 6, less 3	3, 1, 2	1, 2, 3, 4, 5	Everything	4 more difficult	1, 3	1, 2, 3 more difficult 4, 5, 6
Investment size	Bigger > 10 million	Everything	Everything	Everything	Everything	1, 2, 3, 5, 6,	Everything	Everything	flexibility, 3, detachable	Everything	Everything	Everything, 6	Everything, future-proof, detachable en renewable	Everything	Everything	Everything	Everything with chance for strategies which cost more
	Smaller < 10 million	4, re-use, renewable raw materials	re-use is dropped, the first 3 remain because it is cheaper	Everything	1, 2, 3	Everything	The less money descends from 6 to 1 (1,2,3)	Everything	1,2	1, 2, 3 (2,3)	4, 1	1, 2, 3, 4	1, 2, 3	3, 2, 1	Everything	1, 2, 3, 4	1, 2, 3, 4 (descends from 6 to 1)
Complexity	High complexity	Everything	1,2, next ones will be complicated	Everything	4, 5, 6, more difficult	more complex: 2, 4, 5	1, 2, 3 descends from 6 to 1	1, 2, 3	(detachable, milieu-impact, re-use more difficult) others are applicable	1, 2, 3, 4	Everything	1, 2, 3	1, 2, 3 (more difficult 4, 5, 6)	6	1, 2, 3, 6 (4, 5 more difficult)	1, 3, (2 if there is time)	1, 2, 3 more difficult 4, 5, 6
	Low complexity	Everything	Everything	1, Prevention, detachable	Everything	Everything	4, 5, 6, 1, 2, 3	Everything	detachable, re-use, further also everything	2, 3	Everything	Everything	Everything	Everything	Everything	Everything	Everything with chance for detachable
Number of stakeholders	> 10 stakeholders	No direction	Everything	Everything	1, 2, 3	Everything	Loopt af van 6 naar 1	Everything	Everything, preventie	Everything (moeilijker)	Everything	Everything, hangt van de kennis af	Everything	2, 3,	Everything	Everything	Everything (hangt van de kennis af of loopt van 6 naar 1 af)
	≤ 10 stakeholders	No direction	Everything	Everything	Everything	Everything	Everything	Everything	Everything	Everything	Everything	Everything	Everything	Everything	Everything	(4, 5, 6) Depending on ambitions	Everything
Environment	Urban area	reuse objects, faster 1, rethink, refuse	Everything	Everything	Everything	4, 5, 6 does not matter: 3	/	4, 5, 6 easier everything	Everything	2, 3 more important	Everything, advantage on 5, 2	1, 2, 3, prefab surounding	Everything	Everything	1, Everything	Everything	Everything
	Rural area	think less about space, less compact	Everything	Everything	Everything	4, 5, 6 does not matter: 1 ,2, 3	/	6 easier Everything	Everything	6 further everything	Everything	Everything	Everything	Everything	Everything	1, 2, 3, 4	Everything, less focus on prevention
Series of projects or one fo a kind	Series of projects	1, 2, 3, 4, 5, 6	1,2,3,5,6	2, 3, 5, 6	6, 5, 4, 3, 2, 1	3, flexibility, adaptable, 5, 6, 1, 2	Everything	Everything	less focus preventie, meer focus detachable	1, 2, 3 geen re-use, less (5, 6)	Everything	6, Everything	1, 2, 5, 6	1,2, 3, 5, 6,	Everything (4 more difficult)	Everything (steeds meer detachableheid)	1, 2, 3, 5, 6, focus detachable, 4 is more difficult
	One of a kind project	1, 2, 3, 4, 5, 6	4, Everything	Everything	1, 2, 3,	4, 5, 6, 1, 2	Everything	Everything	Focus preventie, more difficult detachable, important quality and longevity	Everything	Everything	1, 2, 3, 4, 5, 6 client	Everything	Everything	Everything	4, 1, 3, 5	Everything

Level of detail	High level of detail	more exclusion of strategies	1,2,5,6	Everything	-	Minimalistisch, flexibility, 2, 4, 5, 6	1, 2, 3	1, 2, 3	Everything	Everything	Everything	1, 2, 3 (4,5,6 less)	1, 2, 3	Everything	Everything	4, 5, 6	1, 2, 3, (less 4, 5, 6)
	Low level of detail	detachable	Everything	Everything	-		Everything	4, 5, 6	Everything	1, 2, 3	Everything	Everything	Everything	Everything	Everything	Everything	1, 2, 3	Everything
Urgency	High	Everything	Everything	Everything	Everything overwegen - naar	voornamelijk 4	Everything	1, 2, 3, 6	Everything	Everything	Everything	Everything	Everything	Everything	Everything	1, 2, 3, 4	Everything
	Low	Everything	1,2,3	Everything	To customer request		1, 2, 3	Everything	Prevention	falls of 6, 5, 4, 1, 3, 2	2, 5, 6 less: 1,3,4	2, 3, 1	1, 2, 3	1, 4	1, 2, 3	1, 2, 3	Mainly only 1, 2, 3 but decreasing from 6 to 1
Lifespan	Longer >75 year	flexibility, future-proof	1,2,3,6	Everything	Everything	2, 3, 4, 5, 6	1, 2, 3, 4, 5	3, 2	less detachable, --> technical lifecycle	1, 2, 3,5, 6	Everything	1, 2, 3 (4, 5, 6) risk attached	less detachable, more 3, 5, 6	3, 6, 1, 2	Everything	2, 3, 5, 6	1, 2, 3, 5, 6
	Shorter < 20 year	detachable, Re-use	4,5, the rest is also possible	1, 4, Re-use		2, 4, 5, 6, --> 3	Everything focus on prevention	6	prevention, milieu-impact, detachable	1, 2, 3	2, 3	4, 5, 6, (1, 2, 3)	detachable, Everything	2, 3	Everything	1, 2, 3, 4	Everything focus on prevention, detachable en renewable
Function	Living					5, 6, adaptable		3, 2,1	less secundaire raw materials	1, 2, 3		6, 5, 4				1, 2	1, 2, 3 at the moment less 4, 5, 6
	Utility					3, flexibility		flexibility, 5, 6								3, 5, 6, future-proof	Everything, focus future-proof and already more 5, 6
	health, education, recreation, etc.	flexibility, future-proof	Varying per function	Everything	The less complex the deeper into the strategies	high requirements--> more difficult 4	/	Public --> 3,2	Everything	Everything	Everything	Education: robustness, Everything		Everything	Everything	Everything	Everything but the more complex the less is applied
Client	Private sector	-	Everything	Everything	Everything	Everything	Everything (high ambitie)	Everything	3, lifecycle, flexibility	Everything	Neutral	1, 2, 3	Everything	Everything	Everything	Everything	Everything with more focus on flexibility
	Public sector	-	Everything	Everything	Everything	Everything	Everything (high ambition)	1,2,3	Everything, prevention	Everything	Neutraal	Everything	Everything	Everything	Everything	4, 5, 6, 1, 2, 3	Everything
Ambitions	High ambitions	1, 2, 3, 4, 5, 6, re-use, flexibility, detachable, adaptable	Everything	Everything	Everything	Everything	Everything	Everything 2,3	Everything	Everything	Everything	Everything	Everything	Everything	Everything	4, 5, 6	Everything.
	Low ambitions	5, Recycle	1,2	Choose specific strategy	1, 2, 3	reuse 3, flexibility, demontable	lose weight from 6 to 1	Everything	3, 1,	2, 3	5, 6	1, 2, 3 or less	1, 2, 3	3, 1	1, 2, 3, (4 falls of)	1, 2, 3	1, 2, 3 or less
User	Rentals	For both adaptable and flexibility	Everything	detachable, robustness	Everything	Rent: prevention (wear and tear)	/	Everything	future-proof, flexibility	Nothing	Neutral	4, 5, 6		Everything	Everything	Everything	Everything, with focus on future-proof and robustness
	Buyers	For both adaptable and flexibility	Everything	Everything	Everything	Everything	/	Everything	Everything	Everything	Neutral	Everything		Everything	Everything	Everything	Everything
Phase	Initation phase	1, 3	Everything	Everything		Everything	Everything	Everything with focus on 1,2,3	Everything, preventie		Everything	Everything	Everything	Everything	Everything	4, 5, 6, 1, 3	Everything focus on 1, 2, 3
	Definition phase	2 (VO) --> 4, 5, 6	Everything									Everything			Everything		Everything focus op 1, 2, 3
	Design phase	2 (VO) --> 4, 5, 6	Everything					4,5,6	2, 3, 4, 5, 6	Everything					Everything		Everything focus on 4, 5 and 6
	Realisation phase		3,4,5	re-use, limited choice		raw materials	descends from 6 to 1		life-cycle, flexibility, re-use	Nothing	5, (6 more difficult)	4	more difficult	4, 5, 6	less 4, 5, 6	1, 2, 3	Material niveau, 4, 5, 6

APPENDIX M. OVERVIEW RESULTS CIRCULAR DESIGN STRATEGIES

Best option circular design strategies + reasons

Parameter		Circular Design Strategies	Reason
Project size	Big >10000m2	1, 2, 3, 5, (4, 6 more difficult)	If the project is bigger, you have more options, so you can apply more strategies and explore what you can do. Recycled objects can get trickier because getting a large number of the same objects in today's market is difficult. Also, designing with renewable raw materials is even more difficult, because it is still very new in the construction industry.
	Small <10000m2	6, 5, 4 is done more 1, 2, 3 always	With a smaller project, one does not have to exclude the other. Designs with recycled objects and secondary raw materials are currently more for small-scale projects because there is not yet a lot of supply. Renewable raw materials are used more often in smaller projects because you can use small projects as a pilot.
Project type	New construction	1, 2, 3, 6 (focus on 3) (4, 5 more difficult)	With new construction, you have to do everything. In many cases, it will not cost you anything extra, because that will then become your starting point. Always start with renewables and then move on. Prevention, reduction of life cycle impact, and future-proofing are going well and will be applied more quickly. These three have been living with the parties for some time now. Designing with recycled objects and secondary raw materials becomes more difficult because it depends on which materials are available on the market.
	Renovation	Everything (focus on 1, 4)	Attention to refuse, reduce and re-use. You have to make sure that you use fewer materials, work minimalistic and combine things. Future-proofing is more difficult with renovation projects because it often already has a core and shell, which makes it more difficult to be flexible. When designing with reused objects, the focus is on what you can still use from the reused building itself and how much do you still need to replace.
	Temporary construction	Everything (focus 3, 6)	The most important is future-proofing because it concerns a short period. In this context, future-proofing means that you can adapt it or that you can reuse it in the future. Flexibility, adaptability, and longevity must be weighed up very precisely. With temporary construction, you have to look at life cycle impact, renewable raw materials, and reused objects. In temporary construction, you see renewable raw materials more and more. That they look at biobased raw materials and materials that may not last that long but are simply broken down in a natural process.
Duration	Long > 2.5 year	Everything (chance for 4, 5, 6)	If it has a long duration, there is more time, which means that more research can be done and all strategies can be applied. With a longer duration, there is a greater chance for reuse, secondary raw materials, and renewable raw materials. With a longer duration, you have the time to search for materials or wait for materials to become available.
	Short < 2.5 year	1, 2, 3 (more difficult 4, 5, 6)	The pressure that is placed on the project influences your ability to apply the strategies. The shorter the construction period, then you have less time to investigate whether you can use recycled materials. Secondary and renewable raw materials are also currently requiring even more attention. For more attention is no time in a small project. With shorter projects, more attention is often paid to future-proofing, reduction of life cycle impact, and prevention, because much more is already known about this. If you don't have a lot of time, it's not that easy to think everything out and find out.
Investment size	Wide budget	Everything (more likely for strategies that cost more, 3 and 6)	If you are well within your budget then you have to do everything or do something of everything. The larger the investment, the more relevant the strategies become. Some things are even more expensive at the moment because the material is durable. With a higher investment, you can also look at future-proofing earlier, because flexibility, detachability, etc. can also cost more money, due to other techniques, etc.
	Tight budget	1, 2, 3, 4 (more difficult 5, 6) (decreases from 6 to 1)	With a low investment, you have to think very carefully on the front edge. Among other things, to see how you can use as little material as possible, which generally saves a lot of money. Prevention, reduction of the life cycle, and future-proofing can then be done from smart detailing and by not using unnecessary materials. Although it is often less money, it decreases from 6 (secondary raw materials) to 1 (prevention).

Complexity	High complexity	1, 2, 3 (more difficult 4, 5, 6)	Circularity currently increases the complexity and that, in combination with a complex building, makes it very difficult. The more complex, the more specific, the more difficult it becomes for the real reuse of materials. Then there is also less work with secondary and renewable raw materials because it is more difficult to adapt to a complex project. Detachability, flexibility, and adaptability are the question of whether this is still possible with high complexity. The fact that reused objects, secondary raw materials, and renewable raw materials are used less often also has to do with guarantees. It is more about prevention, reduction, and future-proofing.
	Low complexity	All strategies	With a low complexity, you could consider everything. Then it is easier to adjust something so that an object or material does fit or can be applied. With a low complexity, more attention remains to think about the strategies.
Number of stakeholders	> 10 stakeholders	All strategies (depends on knowledge, otherwise it will go down from 6 to 1)	The more stakeholders, the more opinions you have, the more things are considered. If there are more stakeholders with a lot of influence, this sometimes makes things more complex. But if everyone thinks from a circular point of view, then it shouldn't matter. Then it can even become easier or faster. How easily the strategies can be applied also has to do with network and finding materials.
	≤ 10 stakeholders	All strategies	With fewer stakeholders, everything can be considered more easily. There are fewer opinions which makes it less complex. It may be that there is less knowledge and a smaller network. Furthermore, the type of stakeholders mainly has an influence. It depends on the ambition of the stakeholder.
Environment	Urban area	All strategies	In the urban environment, you think more about space. Here you often have to apply rethink and refuse concerning your environment and you have a limited footprint to work on. In urban areas you are also closer to your resources which makes it easier to use different materials and all strategies can be considered.
	Rural area	Alle (minder focus op preventie) (kans voor 6)	In rural areas, a pitfall is that if you have more space, you are less pushed to think about the use of space. You then build faster with more volume and less compact. If it has to do with where your raw materials come from, renewable raw materials in a rural area are easier, depending on where they are processed and manufactured.
Series of projects or one of a kind	Series of projects	1, 2, 3, 5, 6, (4 is more difficult)	Here you can weigh up all the strategies and see what the best option is. For one project it is a lot of money to think it all out. If you start working in a series, you can spread those costs over the entire series. This creates more space to consider all strategies. But if it all has to look the same, then you have to have all those materials at hand, then the reuse of objects becomes more difficult. Reuse of objects is even more difficult at the moment.
	One of a kind project	All strategies (change for 4)	With a unique project, you often need fewer reused objects and you can still go in all directions at the front. Although there is also the pitfall that if you do it once, it will be discussed less deeply and you will look more at prevention, reduction of the life cycle, and future-proofing. It mainly depends on the ambitions of the client and the available project budget.
Level of detail	High level of detail	1, 2, 3, (more difficult 4, 5, 6)	The more complicated it gets, the more strategies you will exclude. A high level of detail makes it very specific and then things fall off, such as the reuse of objects and secondary resources. But at the moment, everyone is even more likely to stick to designs for prevention, reduction, and future-proofing.
	Low level of detail	All strategies	The strength is in simplicity. The simpler it remains, the better it is detachable and the more strategies you can apply.
Urgency	High urgency	All strategies	If circularity is of importance, then you can consider everything. Then you can also represent certain choices well because that is the starting point. There is also pressure from several sides. It also depends on the motivation of the client and how skilled the consultants are.
	Low urgency	Mainly only 1, 2, 3 but decreasing from 6 to 1	With low urgency you will sooner have someone who finds it hassle and difficult, he will do it less quickly. In the case of low urgency, prevention, reduction, and future-proofing will receive attention and the others will not. It then chooses where the knowledge is already there and no effort is made to investigate the others.
Lifespan	Long >75 year	1, 2, 3, 5, 6 (focus on 3)	With a longer lifespan, the technical lifespan is much more important. You have to look at how the building can last as long as possible, with as little replacement as possible. More focus on flexibility and future-proofing. With a longer lifespan, designing with reused objects and secondary raw materials becomes less. Objects have already had a life and are going for the second, third, or fourth round. Renewable raw materials are also important here, if it has been standing for a long time and you are also going to design with renewable raw materials, then you have a win-win situation. Although it is not used very often at the moment. Many construction projects still want proven technology.
	Short < 20 year	All strategies	With shorter projects you have to focus very much on detachability and that it can all be reused after the life of the project. The materials have much more impact on the environment because it is only for a short time. Prevention is also important in this respect to see how you can use

			fewer materials and renewable raw materials because they are compostable.
Function	Living	All strategies (less detachable) (focus on 4, 5, 6)	If you look at homes, you are not going to make your construction so robust that you can use a production environment in it. You see that for each function you will approach such a project in a completely different way. The difference lies in the flexibility of future-proofing. Homes are used in the longer term, so prevention and reduction are more important there, that they last a long time, are easy to maintain, and are less likely to break. With living, you can also look more at renewable raw materials, secondary raw materials, and adaptability, because it is less complex.
	Utility	All strategies (focus 3) and more 5, 6	The utility should be flexible and ready to transform into another function. At the moment that is already a standard. Designing with secondary raw materials and renewable raw materials is increasingly being considered, but still depends on the client.
	Health, accommodation, education, recreation, etc.	All strategies but the more complex the less is applied	Certain functions have certain conditions. Thinking of hospitals, there it is difficult to design with recycled objects. There are then certain requirements for the materials. This mainly affects recycled and secondary raw materials. For each function, you have to look at which strategy is possible or not. Public buildings are usually built for many years. Then future-proofing and life cycle impact are very important. Schools and industrial buildings must be robust.
Client	Private sector	All strategies	The private sector often does not want to lead the way, but also certainly does not want to lag behind. So they are getting more and more of those sustainability goals. Also, that gives a higher value to their real estate and can use it as PR. But this all comes down to ambition. If the client thinks circularly, he will be able to consider everything. If the client is not involved at all, designs with renewable raw materials will be scrapped. The less important the strategies decrease from 6 to 1.
	Public sector	All strategies	The type of client should not matter. If you choose in advance whether you think circularity is important or not, it does not matter whether it is the private or public sector. For example, as soon as they can invest the same, they can also approach it with the same strategies. The public sector feels more like an exemplary role from the perspective of social responsibility.
Ambitions	High ambitions	All strategies	A high ambition is good to have. Circularity is not the path of least resistance, because you complicate things in every way. If you have a high ambition, you are prepared to invest more in making different choices. You then have to try to approach the whole spectrum and see what we can do everywhere.
	Low ambitions	1, 2, 3 or less	With a low ambition, you should try to choose a direction as clearly as possible. Then you look at the situation, on which strategy can best be focused. With low ambitions, at least future-proofing, reduction and prevention should be important. We always do those three strategies. These three strategies are often still interesting for the client. You need to have more ambition to work circularly, otherwise, it will quickly become too expensive or it will take too much time, etc. The lower the ambition, the more you lose from 6 to 1.
User	Rentals	All (focus 3, 1 (robustness))	If you are a landlord, you like it if it is flexible, because then you can adjust it if the need changes. Parts can also be replaced more easily, making it a bit more robust. With tenants, you have to think much more about prevention and wear and tear. That's not to say you don't have to think about those other things. It would depend on many other factors and not specifically on this parameter.
	Buyers	All strategies	If you are the owner, you like it if it is flexible, because then you can adjust it if the need changes, there is no difference. For the client himself, future-proofing, prevention, and reduction are important. In the long run, this will be better for someone who owns a building. If a client enters into it himself, he can consider everything and make it according to his ambition. Furthermore, it will depend on many other factors and not specifically on this parameter.
Phase	Initation phase/Definition phase	All strategies (focus on 1, 2, 3)	You can apply anything at an early stage. Then you can still change everything in the process. At this stage, you need to write down the odds very well and see which strategy you want to follow. Future-proofing, reduction, and prevention should already be formulated as goals in the initiative/definition phase. The materials themselves often come at a later stage, but you have to be aware at this stage that it has to be detachable, etc.
	Design phase	All strategies (focus 4, 5, 6)	In the design phase, you could still opt for reused objects, renewable or secondary raw materials. Because these three are about materials, they can also be used at a later stage. With the other strategies, you are stuck with your choice. Then it is seen as a plus, then it is argued that it comes at the expense of other qualities. As the process progresses, everything has to be managed, but raw materials become more important.

	Realisation phase	Material level (focus 4, 5, 6)	In the realization phase, you can still look at the strategies that are very specific about the materials. If you enter late, you still have the option to exchange traditional commodities. Then you look at recycled objects, secondary and renewable raw materials. It gets very complicated if you have already thought about how it will look like how you are going to do it.

APPENDIX N. MERGED TABLE WITH RESULTS

	Designing for prevention		Designing for the reduction of life cycle impact		Designing for future-proofing		Designing with reused objects		Designing with secondary raw materials		Designing with renewable raw materials	
Cost	Project size	3 Bigger	Project size	3 Bigger	Project size	3 Bigger	Project size	1 Bigger	Project size	3 Bigger	Project size	1 Bigger
		1 Smaller		1 Smaller		1 Smaller		1 Smaller		1 Smaller		1 Smaller
	Project type	1 New construction	Project type	1 New construction	Project type	1 New construction	Project type	1 New construction	Project type	1 New construction	Project type	1 New construction
		1 Renovation		1 Renovation		1 Renovation		1 Renovation		1 Renovation		1 Renovation
		3 Temporary construction		3 Temporary construction		3 Temporary construction		3 Temporary construction		3 Temporary construction		3 Temporary construction
	Duration	3 Longer	Duration	3 Longer	Duration	3 Longer	Duration	3 Longer	Duration	3 Longer	Duration	3 Longer
		1 Shorter		1 Shorter		1 Shorter		1 Shorter		1 Shorter		1 Shorter
	Investment size	3 More	Investment size	3 More	Investment size	3 More	Investment size	3 More	Investment size	3 More	Investment size	3 More
		1 Less		1 Less		1 Less		1 Less		1 Less		1 Less
	Complexity	1 High complexity	Complexity	1 High complexity	Complexity	1 High complexity	Complexity	1 High complexity	Complexity	1 High complexity	Complexity	1 High complexity
		3 Low complexity		3 Low complexity		3 Low complexity		3 Low complexity		3 Low complexity		3 Low complexity
	Number of stakeholders	1 More	Number of stakeholders	1 More	Number of stakeholders	1 More	Number of stakeholders	1 More	Number of stakeholders	1 More	Number of stakeholders	1 More
		3 Less		3 Less		3 Less		3 Less		3 Less		3 Less
	Environment	1 Urban area	Environment	1 Urban area	Environment	1 Urban area	Environment	1 Urban area	Environment	1 Urban area	Environment	1 Urban area
		2 Rural area		2 Rural area		2 Rural area		2 Rural area		2 Rural area		2 Rural area
	Series of projects or one of a kind	3 Series	Series of projects or one of a kind	3 Series	Series of projects or one of a kind	3 Series	Series of projects or one of a kind	1 Series	Series of projects or one of a kind	3 Series	Series of projects or one of a kind	3 Series
		1 One of a kind		1 One of a kind		1 One of a kind		1 One of a kind		1 One of a kind		1 One of a kind
	Level of detail	1 High	Level of detail	1 High	Level of detail	1 High	Level of detail	1 High	Level of detail	1 High	Level of detail	1 High
		3 Low		3 Low		3 Low		3 Low		3 Low		3 Low
	Urgency	3 High	Urgency	3 High	Urgency	3 High	Urgency	3 High	Urgency	3 High	Urgency	3 High
		1 Low		1 Low		1 Low		1 Low		1 Low		1 Low
	Lifespan	2 Long >75 year	Lifespan	2 Long >75 year	Lifespan	2 Long >75 year	Lifespan	1 Long >75 year	Lifespan	2 Long >75 year	Lifespan	2 Long >75 year
		3 Short < 20 year		3 Short < 20 year		3 Short < 20 year		3 Short < 20 year		3 Short < 20 year		3 Short < 20 year
	Function	1 Living	Function	1 Living	Function	1 Living	Function	1 Living	Function	1 Living	Function	1 Living
		3 Utility		3 Utility		3 Utility		3 Utility		3 Utility		3 Utility
		2 Health, education, recreation, etc.		2 Health, education, recreation, etc.		2 Health, education, recreation, etc.		2 Health, education, recreation, etc.		2 Health, education, recreation, etc.		2 Health, education, recreation, etc.
	Client	2 Private sector	Client	2 Private sector	Client	2 Private sector	Client	2 Private sector	Client	2 Private sector	Client	2 Private sector
		2 Public sector		2 Public sector		2 Public sector		2 Public sector		2 Public sector		2 Public sector
	Ambitions	3 High	Ambitions	3 High	Ambitions	3 High	Ambitions	3 High	Ambitions	3 High	Ambitions	3 High
		1 Low		1 Low		1 Low		1 Low		1 Low		1 Low
	User	2 Rentals	User	2 Rentals	User	2 Rentals	User	2 Rentals	User	2 Rentals	User	2 Rentals
		2 Buyers		2 Buyers		2 Buyers		2 Buyers		2 Buyers		2 Buyers
	Phase	3 Initation/definition phase	Phase	3 Initation/definition phase	Phase	3 Initation/definition phase	Phase	3 Initation/definition phase	Phase	3 Initation/definition phase	Phase	3 Initation/definition phase
		1 Design/realisation phase		1 Design/realisation phase		1 Design/realisation phase		1 Design/realisation phase		1 Design/realisation phase		1 Design/realisation phase

	Designing for prevention			Designing for the reduction of life cycle impact			Designing for future-proofing			Designing with reused objects			Designing with secondary raw materials			Designing with renewable raw materials		
Time	Project size	3	Bigger	Project size	3	Bigger	Project size	3	Bigger	Project size	1	Bigger	Project size	3	Bigger	Project size	1	Bigger
		1	Smaller		1	Smaller		1	Smaller		1	Smaller		1	Smaller		1	Smaller
	Project type	1	New construction	Project type	1	New construction	Project type	1	New construction	Project type	1	New construction	Project type	1	New construction	Project type	1	New construction
		1	Renovation		1	Renovation		1	Renovation		1	Renovation		1	Renovation		1	Renovation
		3	Temporary construction		3	Temporary construction		3	Temporary construction		3	Temporary construction		3	Temporary construction		3	Temporary construction
	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer
		1	Shorter		1	Shorter		1	Shorter		1	Shorter		1	Shorter		1	Shorter
	Investment size	3	More	Investment size	3	More	Investment size	3	More	Investment size	3	More	Investment size	3	More	Investment size	3	More
		1	Less		1	Less		1	Less		1	Less		1	Less		1	Less
	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity
		3	Low complexity		3	Low complexity		3	Low complexity		3	Low complexity		3	Low complexity		3	Low complexity
	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More
		3	Less		3	Less		3	Less		3	Less		3	Less		3	Less
	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area
		2	Rural area		2	Rural area		2	Rural area		2	Rural area		2	Rural area		2	Rural area
	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	1	Series	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	3	Series
		1	One of a kind		1	One of a kind		1	One of a kind		1	One of a kind		1	One of a kind		1	One of a kind
	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High
		3	Low		3	Low		3	Low		3	Low		3	Low		3	Low
	Urgency	1	High	Urgency	1	High	Urgency	1	High	Urgency	1	High	Urgency	1	High	Urgency	1	High
		1	Low		1	Low		1	Low		1	Low		1	Low		1	Low
	Lifespan	2	Long >75 year	Lifespan	2	Long >75 year	Lifespan	2	Long >75 year	Lifespan	1	Long >75 year	Lifespan	2	Long >75 year	Lifespan	2	Long >75 year
		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year
	Function	1	Living	Function	1	Living	Function	1	Living	Function	1	Living	Function	1	Living	Function	1	Living
		3	Utility		3	Utility		3	Utility		3	Utility		3	Utility		3	Utility
		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.
	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector
		2	Public sector		2	Public sector		2	Public sector		2	Public sector		2	Public sector		2	Public sector
	Ambitions	1	High	Ambitions	1	High	Ambitions	1	High	Ambitions	1	High	Ambitions	1	High	Ambitions	1	High
		1	Low		1	Low		1	Low		1	Low		1	Low		1	Low
	User	2	Rentals	User	2	Rentals	User	2	Rentals	User	2	Rentals	User	2	Rentals	User	2	Rentals
		2	Buyers		2	Buyers		2	Buyers		2	Buyers		2	Buyers		2	Buyers
	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase
		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase

	Designing for prevention			Designing for the reduction of life cycle impact			Designing for future-proofing			Designing with reused objects			Designing with secondary raw materials			Designing with renewable raw materials		
Quality	Project size	2	Bigger	Project size	2	Bigger	Project size	2	Bigger	Project size	1	Bigger	Project size	2	Bigger	Project size	1	Bigger
		2	Smaller		2	Smaller		2	Smaller		2	Smaller		2	Smaller		2	Smaller
	Project type	2	New construction	Project type	2	New construction	Project type	2	New construction	Project type	1	New construction	Project type	1	New construction	Project type	2	New construction
		2	Renovation		2	Renovation		1	Renovation		2	Renovation		2	Renovation		2	Renovation
		2	Temporary construction		2	Temporary construction		2	Temporary construction		2	Temporary construction		2	Temporary construction		2	Temporary construction
	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer	Duration	3	Longer
		1	Shorter		1	Shorter		1	Shorter		1	Shorter		1	Shorter		1	Shorter
	Investment size	3	More	Investment size	3	More	Investment size	3	More	Investment size	3	More	Investment size	3	More	Investment size	3	More
		1	Less		1	Less		1	Less		1	Less		1	Less		1	Less
	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity	Complexity	1	High complexity
		3	Low complexity		3	Low complexity		3	Low complexity		3	Low complexity		3	Low complexity		3	Low complexity
	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More	Number of stakeholders	1	More
		3	Less		3	Less		3	Less		3	Less		3	Less		3	Less
	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area	Environment	2	Urban area
		2	Rural area		2	Rural area		2	Rural area		2	Rural area		2	Rural area		2	Rural area
	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	1	Series	Series of projects or one of a kind	3	Series	Series of projects or one of a kind	3	Series
		2	One of a kind		2	One of a kind		2	One of a kind		2	One of a kind		2	One of a kind		2	One of a kind
	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High	Level of detail	1	High
		3	Low		3	Low		3	Low		3	Low		3	Low		3	Low
	Urgency	3	High	Urgency	3	High	Urgency	3	High	Urgency	3	High	Urgency	3	High	Urgency	3	High
		1	Low		1	Low		1	Low		1	Low		1	Low		1	Low
	Lifespan	2	Long >75 year	Lifespan	2	Long >75 year	Lifespan	2	Long >75 year	Lifespan	1	Long >75 year	Lifespan	2	Long >75 year	Lifespan	2	Long >75 year
		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year		2	Short < 20 year
	Function	1	Living	Function	1	Living	Function	1	Living	Function	1	Living	Function	1	Living	Function	1	Living
		3	Utility		3	Utility		3	Utility		3	Utility		3	Utility		3	Utility
		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.		2	Health, education, recreation, etc.
	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector	Client	2	Private sector
		2	Public sector		2	Public sector		2	Public sector		2	Public sector		2	Public sector		2	Public sector
	Ambitions	3	High	Ambitions	3	High	Ambitions	3	High	Ambitions	3	High	Ambitions	3	High	Ambitions	3	High
		1	Low		1	Low		1	Low		1	Low		1	Low		1	Low
	User	2	Rentals	User	2	Rentals	User	2	Rentals	User	2	Rentals	User	2	Rentals	User	2	Rentals
		3	Buyers		3	Buyers		3	Buyers		3	Buyers		3	Buyers		3	Buyers
	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase	Phase	3	Initation/definition phase
		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase		1	Design/realisation phase

APPENDIX O. RESULTS SURVEY VALIDATION SESSION 1

	15-2-2022 10:44
	Participant A
1.	Ja het model is snel duidelijk
2.	De resultaten zijn helder
3.	Dat is duidelijk, wel kan de uitleg nog meer SMART worden omschreven (bijv. wat is 'bigger')
4.	Geen verbeterpunten
5.	Ja die zijn duidelijk
6.	De input kan meer SMART worden uitgevraagd , soms ontbreken mogelijkheden om de juiste input te leveren (bijv. een stap tussen < 15jaar en < 75 jaar)
7.	Ja
8.	Meer keuze mogelijkheden in de input tabel
9.	Ja
10.	Ja redelijk overeenkomstig de verwachting
11.	Wellicht kan dit nog iets duidelijker/ meer toelichting
12.	Geen verbeterpunten
13.	bij nieuwe projecten (nieuwbouw of renovatie) van utiliteitsbouw of woningbouw
14.	Aan huisvestingsadviseurs/ projectmanagers die ambities en eisen ophalen voor een nieuw project
15.	vooral in de definitie-/pve fase
16.	Ja dit kan meer inzicht geven in de mogelijkheden
17.	Wat mij nog niet helemaal helder is hoe de impact op kosten/planning/kwaliteit wordt bepaald naar aanleiding van de input, maar wellicht staat dit wel al bij de explanation

	15-2-2022 10:47
	Participant B
1.	Ja, het geeft op basis van de ingevulde parameters weer in hoeverre circulariteit (verder) kan worden geïntegreerd in het project.
2.	Ja, het dashboard geeft voldoende duidelijkheid
3.	Ja, echter de objectieve waarden (bijv. wanneer is iets een groot of klein project) zou ik nog toevoegen.
4.	Wellicht nog een conclusie of aanbeveling als eerste vervolgstap op basis van de invulling. Al is dit best een klus om automatisch uit een model te laten rollen, voor een vervolgstap zou dat interessant zijn.
5.	Ja, het model spreekt voor zich
6.	Ja
7.	Ja het werkt goed en vloeiend.
8.	Mijns inziens werkt het naar behoren, ik zie daardoor geen verbeterpunten voor het model.
9.	Ja, er staan duidelijke omschrijvingen in het model.
10.	Ja, al is het bij ons deels afhankelijk van de invulling van de laatste parameter en de nuance die daarbij nodig is. Wij zijn in het project in afronding van de definitiefase en opstart van de VO-fase. De invulling van deze parameter heeft nu een grote invloed gehad op de resultaten.
11.	Ja, het geeft een afwegingskader. Zoals eerder aangegeven zou het nog sterker worden als er ook al een eerste aanbeveling uit het model wordt aangedragen, al kan dat natuurlijk in een gesprek n.a.v. de uitkomsten.
12.	Geen specifieke punten, het model is duidelijk.
13.	Het is heel breed in te zetten omdat het in iedere fase als peilstok voor circulariteit kan worden gebruikt. Ik zou dit model voornamelijk gebruiken aan het begin van het opstellen van het Programma van Eisen, zodat het helpt bij het bepalen van de eisen die betrekken hebben op circulariteit.
14.	Projectmanagers en adviseurs
15.	Zoals bij 13 aangegeven, vooral aan de start van de PvE fase. Dus de definitiefase.
16.	Ja het geeft een beeld voor de opdrachtgever.
17.	Zoals eerder aangegeven, een directe aanbeveling die volgt uit de resultaten.

APPENDIX P. MODEL: CHOICE FOR CIRCULAR DESIGN STRATEGIES & EFFECTS ON COST, TIME & QUALITY

APPENDIX P. The model is attached as a Excel file – Excel_24032022-Model

MASTER THESIS

NICOLE DE KWAASTENIET

MARCH 2022

Thank you for reading.