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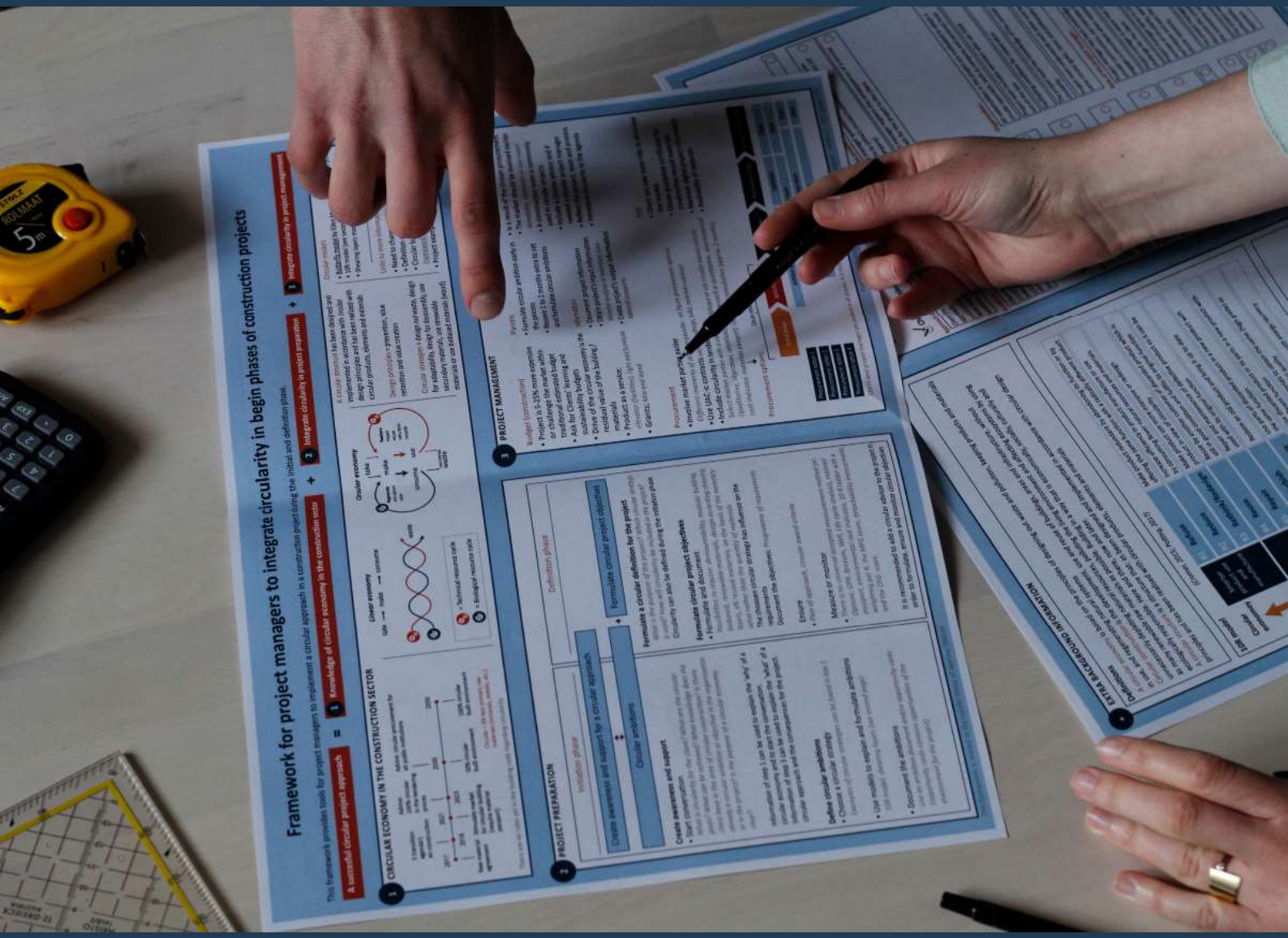

Developing a framework to integrate circularity in construction projects

Creating a framework for project managers to integrate circularity in the initiation and definition phase of construction projects

Master Thesis

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Preface

Dear reader,

This master thesis report provides information on the topic of integrating circularity in construction projects by project managers. It concludes my studies and is written to obtain my master degree in Construction Management and Engineering at Eindhoven University of Technology.

From a young age, I was already interested in organising and optimising processes in combination with solving issues (of others). Linking this to the Built Environment, it might not surprise you that I am interested in construction project management. I am grateful for the opportunity to graduate on project management in combination with circularity. By proving a tool for the project managers to integrate circularity in construction projects, I hope I have contribute to the shift towards a circular economy and to the prospect of more project managers being able to manage circular projects from the initial phases onwards.

Various people have contributed directly or indirectly to this study. I would first like to thank my university supervisors, Qi Han and Raymond Opdenakker, for their expertise, support, valuable guidance and advise. In addition, I would like to thank the company Sweco and my colleagues for their enthusiasm, endless interest and warm welcome, even in a time with only online contact. A special thanks for Christiaan Voorend, for his enthusiasm, helpful feedback and involving me in all interesting activities in the field of circularity. For this research, I had help of many respondents, who helped me gathering data by giving their knowledge and interesting insights on different topics. The framework would not have been reached its current design without their valuable help. Finally, I would like to thank my family, my boyfriend and my friends for their advice, great support, enthusiasm and the necessary fun distractions during my entire study. This has certainly contributed to a very enjoyable time!

I hope you enjoy reading it,

Jeanine Többen
Eindhoven, March 2021

Table of content

Summary

Living in a fast changing world with a highly unsustainable philosophy and way of living contributed to the writing of various policies to stimulate a more sustainable approach. The Dutch government has set the goal of having a hundred percent circular economy by 2050 and to achieve an interim target of a fifty percent reduction in the use of primary raw materials by 2030 (Het ministerie van Infrastructuur en Waterstaat, 2019; Rijksoverheid, 2016). The construction sector has been selected as one of the priority sectors to achieve a circular economy, since it is unavoidably linked to the (over)exploitation of natural resources. The current economy has a radically different philosophy compared to the the circular economy and behavioural adjustments are needed to make the transition happen. A circular building process is assumed to be different from a traditional building process (Versteeg Conlledo, 2019; Venselaar, Heinz, & Lousberg, 2019). The client has a major force in adopting and ensuring circularity at a project level (Adams, Osmani, Thorpe, & Hobbs,2017). However, the project manager, whose main task is to advise the client in order to achieve the client's final goal and to manage the process of a project, does not have the knowledge and capabilities to execute circular construction projects. Furthermore, limited research has been conducted on integrating circularity in the initiation and definition phase, also known as the foundation phases of a project.

To improve the capabilities and knowledge of project managers to execute the initiation and definition phase of construction projects according to the concept of circular economy, a framework has to be designed for project managers. This will provide them with access to general knowledge of the concept and tools to transform their current management into circular management, in order to realise circular projects and contributing to the (fully) circular economy targets set by the government. Following from this, the research question of this thesis is: 'How to design and validate a framework for project managers who are involved in the initiation and definition phase of a construction project, that improves the capabilities and knowledge to realise circular construction projects?'

The Design Cycle belonging to the overall Design Science Research method has been used to divide the research in three steps; problem investigation to collect knowledge, solution design to design the framework and solution validation to validate the framework. Three types of interviews and a case study analysis have been conducted to obtain knowledge for the framework. Interview A has been conducted with seven circular advisors, interview B has been conducted with eight construction project managers, and 12 stakeholders of the cases have been interviewed using interview C to complement the project information of six analysed cases. The six cases have been divided into two traditional projects and four (semi-)circular projects. Furthermore, success factors have been identified in literature and in the performed methods, which subsequently are assessed with a Fuzzy Delphi Method. A fourth interview, which is called interview D, was used to validate the developed framework with four experts.

Within this research the definition of 'circular construction' and 'a circular building' have been explored as well as important circular models such as the 10R model and the shearing layers model. It was found that there are differences in project management in terms of working method, project management and the role of the project manager. A conversation to discuss the goals and create awareness and support needs to be initiated in the initial phases of a project. Furthermore, circular ambitions need to be defined and circular project objectives have to be formulated. Besides that, several consequences have been identified for the management aspects if a circular approach is adopted. The research shows that project managers have limited knowledge of the circular concept, are open to innovate, but need some tools to support the change in their working method. The Fuzzy Delphi Method was used to assess the success factors, which led to 27 identified success factors that should be included in the initiation and definition phase when adopting circularity.

Requirements in the form of four design propositions have been formulated with the CIMO-logic approach of Denyer, Tranfield, & Van Aken (2008). These design propositions include: to help the project manager to integrate circularity in the initiation and definition phase of the project, the circular model designed for the project managers can be used (1) as a basic model to illustrate the process of a circular approach and the consequences of a circular approach for the project, (2) to explain to the client why a circular approach is required, how it can be achieved and what a circular approach means for the project, (3) both by the project manager to consider the approach and interactively with the client to discuss a circular approach for the project or (4) as a checklist to realise projects according to the circular concept.

Additionally, the content for the framework has been determined. The determined content and the design propositions made it possible to create a framework, which consist of two pages in A3 format. The framework consists of three important steps to approach a circular project successfully. These steps are elaborated on the first page of the framework and entails: 'knowledge of circular economy in the construction sector', 'integrate circularity in project preparation' and 'integrate circularity in project management'. The second page contains extra background information of definitions, two important models, and the 27 identified success factors in the format of a checklist.

The framework has been validated with experts in the field of construction project management. The framework is validated as effective, ready to implement and is described as useful for the current challenges, demands and questions of the market. The developed and validated framework answers the research question. Although the framework was validated as effective, it can be concluded that the transition to a circular economy is still in progress. For this reason the framework satisfies the needs at the moment, but has to be updated in the future with new developments and additional information. The framework is developed for project managers but can also be used by other stakeholders involved in the initiation and definition phase of projects to integrate circularity.

Recommendations for future research can be made. First of all, the framework is mainly focussed on the initiation and definition phase. However, it but can be elaborated with knowledge, additional tasks, other consequences for the management aspects and role of the project manager when the excluded phases of a project will be taken into account. Secondly, within this research the analysed cases were focussed on utility projects. Other type of projects would be interesting to investigate such as housing (complexes). Thirdly, the relation between circularity and the other sustainability aspects can be investigated and combined in one model. Fourthly, more research is needed regarding the necessary investment for a circular approach and the remaining value at the end of a building's life time. The amount of residual value is of importance to weigh the additional investment needed for a circular approach. An assessment framework would be desired by the project managers and clients. Finally, the choice of a particular circular strategy appears to be important and future research can focus on this topic in combination with the consequences for the management aspects or in combination with the formulation of project objectives.

Samenvatting

Levend in een snel veranderende wereld met een zeer onduurzame filosofie en manier van leven, zijn er verschillende beleidsmaatregelen in opkomst om een duurzamere aanpak te stimuleren. De Nederlandse overheid heeft zich ten doel gesteld om in 2050 een honderd procent circulaire economie te hebben met als tussendoel een vijftig procent reductie van het gebruik van primaire grondstoffen in 2030 (Het ministerie van Infrastructuur en Waterstaat, 2019; Rijksoverheid, 2016). De bouwsector is geselecteerd als een van de prioriteitssectoren, omdat het onvermijdelijk verbonden is met de (over)exploitatie van natuurlijke grondstoffen. De filosofie van de huidige economie is radicaal anders ten opzichte van de circulaire economie en gedragsaanpassingen zullen nodig zijn om de transitie te realiseren. Een circulair bouwproces wordt dan ook verondersteld als een ander proces ten opzichte van een traditioneel bouwproces (Versteeg Conlledo, 2019; Venselaar, Heinz, & Lousberg, 2019). Daarnaast heeft de opdrachtgever een grote rol in het integreren en borgen van circulariteit op projectniveau (Adams, Osmani, Thorpe, & Hobbs,2017). De projectmanager, die als belangrijkste taken heeft om de opdrachtgever te adviseren om projectdoelen te bereiken en het projectproces beheerst, beschikt echter niet over de kennis en capaciteiten om circulaire bouwprojecten uit te voeren. Daarnaast is er beperkt onderzoek gedaan naar het integreren van circulariteit in de initiatief- en definitiefase, ook wel de fundamentele fases van een project.

Ten behoeve van het verbeteren van de capaciteiten en kennis van projectmanagers om de initiatief- en definitiefase van bouwprojecten uit te voeren volgens het concept van de circulaire economie, is er een raamwerk ontworpen voor projectmanagers, zodanig dat zij toegang hebben tot algemene kennis van het concept en tools om hun huidige management om te vormen naar circulair management, om zo circulaire projecten te realiseren en bij te dragen aan de doelstellingen van de overheid. Dit onderzoek formuleert een antwoord op de vraag: 'Hoe kan een raamwerk worden ontworpen en gevalideerd voor projectmanagers, die betrokken zijn bij de initiatief- en definitiefase van een bouwproject, dat de capaciteiten en kennis verbetert om circulaire bouwprojecten te realiseren?'

De Design Cycle die behoort bij de Design Science Research methode is gebruikt om het onderzoek op te delen in drie stappen; probleemonderzoek om kennis te verzamelen, oplossingsontwerp om het raamwerk te ontwerpen en oplossingsvalidatie om het raamwerk te valideren. Drie type interviews en een case studie analyse zijn uitgevoerd om kennis te vergaren voor het raamwerk. Interview A is gehouden met zeven circulaire adviseurs en interview B heeft acht bouwprojectmanagers geïnterviewd. Daarnaast zijn 12 betrokkenen van de cases geïnterviewd met interview C om de projectinformatie van de zes geanalyseerde cases aan te vullen. De zes cases zijn onderverdeeld in twee traditionele projecten en vier (semi-)circulaire projecten. Verder zijn succesfactoren geïdentificeerd in de literatuur en in de resultaten, die vervolgens zijn beoordeeld met de Fuzzy Delphi Methode. Een vierde type interview, dat interview D wordt genoemd, wordt gebruikt om het ontwikkelde raamwerk te valideren met vier experts.

Binnen dit onderzoek zijn de definitie van circulair bouwen en een circulair gebouw onderzocht, evenals belangrijke circulaire modellen zoals het 10R model en het bouwlagen model. Gebleken is dat er verschillen zijn in projectmanagement op het gebied van werkwijze, managementaspecten en de rol van de projectmanager. Een gesprek om de doelen te bespreken en bewustwording en draagvlak te creëren moet in de beginfasen van een project worden geïnitieerd. Dit gesprek kan leiden tot circulaire ambities die moeten worden omgezet naar circulaire projectdoelstellingen. Het kiezen voor een circulaire aanpak brengt verschillende consequenties met zich mee voor de managementaspecten van een project. Daarnaast is uit het onderzoek gebleken dat de projectmanagers al beperkte kennis hebben van het circulaire concept, open staan voor innovatie, maar enkele handvatten nog nodig hebben om de verandering in hun werkwijze te kunnen doorvoeren. De Fuzzy Delphi Methode is

gebruikt om de succesfactoren, die geïdentificeerd zijn in dit onderzoek, te beoordelen, wat heeft geresulteerd in 27 succesfactoren die moeten worden meegenomen in de initiatief- en definitiefase bij het toepassen van circulariteit.

Eisen voor het raamwerk zijn geformuleerd in vier ontwerpvoorstellen met de zogenaamde CIMO-logic benadering van Denyer, Tranfield, & Van Aken (2008). De ontwerpvoorstellen omvatten: ter ondersteuning van de projectmanager bij het integreren van circulariteit in de initiatie- en definitiefase van het project kan het raamwerk worden gebruikt; (1) als basismodel om het proces van een circulaire aanpak en de consequenties van een circulaire aanpak voor het project te illustreren, (2) om aan de opdrachtgever uit te leggen waarom een circulaire aanpak nodig is, hoe deze bereikt kan worden en wat een circulaire aanpak betekent voor het project, (3) zowel door de projectmanager om de aanpak te overwegen als interactief met de opdrachtgever om een circulaire aanpak voor het project te bespreken of (4) als checklist voor de benodigde elementen per fase met aandachtspunten voor een circulaire aanpak om projecten volgens het circulaire concept te realiseren.

Vervolgens is de inhoud voor het raamwerk bepaald, die samen met de ontwerpvoorstellen resulteerden in een raamwerk van 2 pagina's op A3 formaat. Het raamwerk bevat 3 belangrijke stappen die doorlopen moeten worden om een circulair project succesvol aan te pakken. Deze stappen zijn uitgewerkt op de eerste pagina van het raamwerk en betreffen: 'kennis van circulaire economie in de bouwsector', 'circulariteit integreren in projectvoorbereiding' en 'circulariteit integreren in projectmanagement'. De tweede pagina bevat extra achtergrondinformatie met definities alsmede twee belangrijke modellen en vervolgens de 27 geïdentificeerde succesfactoren in de vorm van een checklist.

Het raamwerk is gevalideerd met bouwprojectmanagers, die het raamwerk valideerden als effectief, klaar voor implementatie en beschreven het als bruikbaar voor de huidige uitdagingen, eisen en vragen van de markt. Het ontwikkelde en gevalideerde raamwerk beantwoordt de onderzoeksvraag. Hoewel het raamwerk als effectief is gevalideerd, kan worden geconcludeerd dat de transitie naar een circulaire economie nog in volle gang is. Om deze reden voldoet het raamwerk aan de behoeften van dit moment, maar zal het in de toekomst geactualiseerd moeten worden met nieuwe ontwikkelingen en aanvullende informatie. Het raamwerk is ontwikkeld voor projectmanagers, maar kan ook worden gebruikt door andere belanghebbenden die betrokken zijn bij de initiatief- en definitiefase van projecten om circulariteit te integreren.

Het onderzoek leidt tot een aantal aanbevelingen voor toekomstig onderzoek. Ten eerste is het raamwerk gericht op de initiatie- en definitiefase, het kan echter worden uitgewerkt met kennis, aanvullende taken, andere consequenties voor de managementaspecten en rol van de projectmanager wanneer de uitgesloten fasen van een project in het onderzoek worden meegenomen. Ten tweede hebben de geanalyseerde projecten zich binnen dit onderzoek toegespitst op utiliteitsprojecten maar andere type projecten zullen ook onderzocht moeten worden. Daarnaast is er onderzoek nodig naar de relatie tussen circulariteit en andere duurzaamheidsconcepten en deze toe te voegen aan het raamwerk. Verder is er meer onderzoek nodig naar de benodigde investering voor een circulaire aanpak en de restwaarde aan het einde van de levensduur van gebouwen. De hoogte van de restwaarde is van belang om de benodigde extra investering voor een circulaire aanpak af te wegen. Een afwegingskader zou gewenst zijn door de projectmanagers en opdrachtgevers. Tot slot blijkt de keuze voor een bepaalde circulaire strategie van belang en kan toekomstig onderzoek zich richten op dit onderwerp in combinatie met de consequenties voor de beheeraspecten of in combinatie met het formuleren van projectdoelstellingen.

Abstract

This study provides a first approach to integrate circularity in the early stages of a construction project by the project manager. The circular ambition of the Dutch government stimulates a different approach in project management compared to traditional projects. To manage circular projects, project managers need to have knowledge about how to integrate circularity in the initiation and definition phase of a construction project. This research tries to design a solution by creating a framework for the project managers to integrate circularity in the initial phases of construction projects. The solution is designed by using the Design Science Research (DSR), which divided the research in three steps: (1) investigate the problem by literature, interviews and case study analysis, (2) design solutions by a Fuzzy Delphi method, interviews and design propositions and (3) validate the design by expert interviews.

The study identified the differences between circular construction and a circular building, important circular models and the differences in project management in terms of working method, management aspects and the role of the project manager. In addition, project managers have limited knowledge of the circular concept, are open to innovate, but need some tools to support them in adopting new working methods. The Fuzzy Delphi Method assessed success factors, which resulted in 27 factors that should be included in the initiation and definition phase when adopting circularity.

A framework has been designed with the help of design propositions and this has resulted in two pages of A3 format. To approach a circular project successfully, knowledge of circular economy in the construction sector is needed, circularity has to be integrated in the project preparation and circularity has to be integrated in project management. Furthermore, the framework incorporates extra background information and the 27 identified success factors in the format of a checklist. The framework reflects the identified circular approach, could be used interactively by both client and project manager, is validated by expert opinions as effective, is ready to be implemented and is described as useful for the current challenges, demands and questions of the market.

Key words: Framework; Circular building; Project manager; Construction sector; Initiation and Definition phase

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Glossary

Client	is the initiator of a project, the owner and most of the time the one who pays.
CE advisor	is the circular advisor or consultant in a project. The circular advisor is temporarily present to share or apply substantive knowledge on circularity and are up to date with the latest developments.
Construction team	A construction team is a project-related partnership between a client and one or more specialists who work together in a coordinated manner towards an execution-oriented design that can be realised for a project.
CPM	is the construction project manager who advise the client about the client's project, facilitate and give support during the process. Their expertise is to manage projects with the management aspects.
Definition phase	is the second phase of a project.
Framework	is the artefact of this study and refers to organizing (new) ideas in an overall picture such that the (new) concept is easy to remember and apply.
GROTIK aspects	Management aspects: money, risks, organisation, time, information, communication and quality.
Initial phases	includes the first phases of a project: initiation and definition phases.
Initiation phase	is the first phase of a project.
Management aspects	aspects used by a project manager to manage a project. Traditionally consisting of cost, quality and time.
Market parties	are the parties that advise, design or implement and join a project in order to complete its objective.
Material passport	is a document consisting of all the materials that are included in a product or construction.
Project management	is the application of knowledge, skills, tools and techniques to meet the project requirements.
Project manager	see CPM. A project manager can be hired for the construction aspects or for all aspects involved in the project.
Project preparation	is used in this research to describe the process of the initial phases. In the project preparation, the projects are formed and prepared for the for the phases succeeding the definition phase.
Success factors	affects the success of adopting circularity in a project. They include key elements, drivers and other factors.

List of Abbreviations

BIM	Building Information Modelling
BREEAM	Building Research Establishment Environmental Assessment Method
C2C	Cradle to Cradle
CE	Circular economy
CE advisor	Circular advisor
CIMO	Context, Intervention, Mechanism, Outcome
CPG score	Circular performance of building (in Dutch: circulairprestatie gebouwen)
CPM	Construction Project Manager
Design, Build, Maintain contract	form of UAC-ic contract
DSR	Design Science Research
EMF	Ellen Macarthur Foundation
FDM	Fuzzy Delphi Method
LEED certificate	Leaderschip in Energy and Environmental Design certification system
Mia grant	Environmental investment deduction (in Dutch: Milieu-investeringsaftrek)
MPG score	Environmental Performance of Buildings (in Dutch: MilieuPrestatie Gebouwen score)
PDF	Portable Document Format
PMBOK	Project Management Body of Knowledge
RQ	Research Question
SF	Success Factors
SQ	Sub-Question
UAC	Uniform Administrative Conditions for the Execution of Works 2012 (in Dutch: UAV 2012 = Uniforme Algemene Voorwaarden)
UAC-ic	Uniform Administrative Conditions for integrated contracts (in Dutch: UAV-gc 2005 = Uniforme Administratieve Voorwaarde voor geïntegreerde contracten 2005)
Vamil grant	Arbitrary depreciation of environmental investments (in Dutch: Willekeurige afschrijving milieu-investeringen)
WELL certificate	Well certificate form SGS Search

List of Figures

List of Tables

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1. Research introduction

This chapter presents the topic of this research, the aim of the research and how the research will be conducted. Therefore, this chapter describes the research context in *chapter 1.1*, the problem definition in *chapter 1.2* and the research questions in *chapter 1.3*. The research design will be elaborated in *chapter 1.4*, the research boundaries in *chapter 1.5* and the practical and scientific relevance of this research in *chapter 1.6*. Finally, a reading guide will provided in *chapter 1.7*.

1.1 Research context

The need for a change

Living in a fast changing world with a highly unsustainable philosophy and way of living, humans of today have a lot of serious challenges to deal with. These serious problems include global warming, resource scarcity, exhaustion of natural resources, environmental pollution and disruption of ecosystems. These are some of the consequences of our current behaviour as humans, which was established more than 200 years ago during the industrial revolution (Kubbinga et al., 2018; Tsolis, 2017). Since then, the enormous global economic growth, which has propelled human welfare, has been on a steep growth trajectory initiated by a series of industrial and technological developments (Kok, Wurpel & Ten Wolde, 2013; Verberne, 2016). The research of Adams, Osmani, Thorpe & Thornback (2017) supports this by stating that the human population continues to use more material resources as the population grows and income increases. This will probably lead to a scarcity in many material resources, which will result in more expensive resources and in the worst case a loss for future use (Adams et al., 2017). The degradation of the ecosystem is a real threat to next generations since oil, natural gas, water, food, and minerals are critical to ensure our well-being and are crucial to the way we live, produce and consume nowadays (EMF & McKinsey & Company, 2014). The threat of the ecosystem can be supported by several studies but one of the first and leading was the report 'Limits to Growth', which was published by the Club of Rome in 1972 and spread the alarming message that with business as usual – at that point – the human population was headed for global overshoot and collapse (Clark & Fulmer, 1973). In an update and review of this report the concerning conclusion was made that in the last 30 years the changes in policies had been insufficient to shift to a more sustainable track (Meadows, Randers, & Meadows, 2004).

Sustainable policies – a circular economy

Defining a sustainable track is still a big issue nowadays. However, various policies have been written to stimulate a more sustainable approach. With the 'Netherlands circular in 2050' programme, the Dutch government set the goal of having a hundred percent circular economy by 2050. The government's ambition, together with social partners, is to achieve an interim target of a fifty percent reduction in the use of primary raw materials by 2030 (Het ministerie van Infrastructuur en Waterstaat, 2019; Rijksoverheid, 2016). Some advices and ambitions have been included in Figure 1.1.

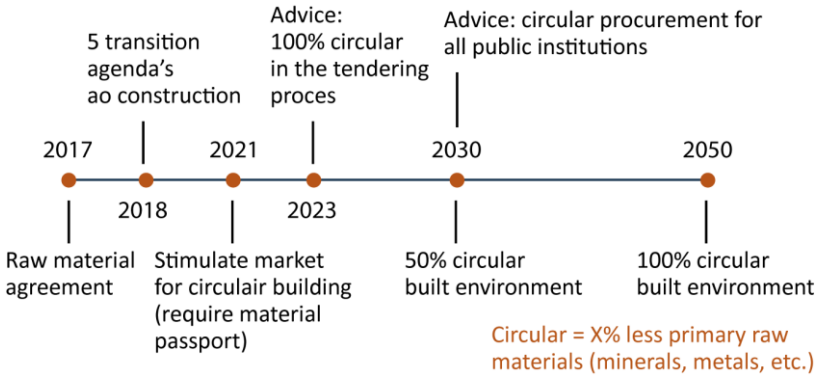

Figure 1. 1 - Timeline with advices and ambitions of the Dutch government (Author (2021) based on Rijksoverheid (2016)).

In order to achieve the 'one hundred percent circular economy by 2050' ambition, several sectors have been selected as priority sectors, the construction sector is one of them (Rijksoverheid, 2016). The construction industry is an important sector for the global economy, but unfortunately it is unavoidably linked to the (over)exploitation of natural resources (Prins, Mohammadi, & Slob, 2015; Rijksoverheid, 2016). It is not surprising that the construction industry is marked as a priority industry, as the (Dutch) construction industry has a heavy burden on the equilibrium in terms of consumption of raw materials and production of waste (Kubbinga et al., 2017; Schoolderman et al., 2014). The study of Eberhardt, Birgisdottir & Birkveld (2019) states that the manufacturing of most building materials requires large amounts of material and energy resources. These materials are either down-cycled or end up as waste after demolition. The building industry roughly consumes 40% of all materials globally, while also generating 35% of the worlds waste of which most is being landfilled or incinerated (Eberhardt et al., 2019; Kubbinga et al., 2018; Rijksoverheid, 2016).

A transition is needed to achieve circular ambitions

In respect of the Dutch government's ambition, all industries, including the construction industry, will have to focus on achieving a circular economy. Several individuals and corporate entities have become increasingly aware of the greater role they need to play in preserving natural resources which leads to an overall growing interest in the concept of a circular economy (Green Deals, 2018; Nasir, Genovese, Acquaye, Koh, & Yamoah, 2017). The current economy is called the 'take-make-dispose' economy and has been sustained by cheap and available resources to create conditions for growth and stability (EMF & McKinsey & Company, 2014). Conversely, the circular economy (CE) is an economic system aimed at eliminating waste, pollution and emission and employ reuse, remanufacturing and recycling to create a closed system (Okorie et al., 2018). The circular economy aims to keep products, equipment and infrastructure in use for a longer period, thus improving the productivity of resources in order to decrease waste generation to the largest possible extent (Ghisellini, Ripa & Ulgati, 2018; Okorie et al., 2018). It should be noted that the approach and philosophy of a circular economy is radically different when compared to the linear economy. The differences between the two economies will be further explained in *chapter 2 - Theoretical Background*.

The transition to a circular economy will not happen automatically since it asks for behavioural adjustments, another way of thinking, and working of all parties involved (Drijvers, 2019). The research of Venselaar, Heinz & Lousberg (2019) noticed that a transition to a circular economy will require dramatic changes in the current system of production, especially for the architecture, engineering and construction sector. Most importantly it is not only unclear what these changes are, it is also unclear how to implement them in building projects. Furthermore, there must be an initiator who understands the importance of a circular process and wants to get started with it (Drijvers, 2019). Leising, Quist, & Bocken (2017) state that the building industry implements innovations, such as a circular economy, relatively slowly. The research of Eberhardt et al. (2019) complements the slow transition to a circular economy by stating that the circular economy has already been applied in many other sectors using frameworks, but few frameworks have yet been developed for the complex problem of the construction industry. The term framework refers to organizing (new) ideas in an overall picture so that it is easy to remember and apply the (new) concept.

Besides, the research of Eberhardt et al. (2019) describes that the building industry is characterised by a strong project-based, institutionalized practice as well as market mechanisms that in many aspects do not fit the facilitation of CE principles since building projects require input from a great number of stakeholders (Eberhardt et al., 2019; Winkler, 2011).

1.2 Problem definition

A circular building process is assumed to be a different process compared to a traditional building process (Venselaar et al., 2019; Versteeg Conlledo, 2019). This is supported with the arguments of involving other supply chain partners such as demolition companies in a different stage of the process, the arisal of new structures for ownership of materials and products, which involve new needed contractual and regulatory arrangements, and the emergence of new income flows. The study of Venselaar et al. (2019) implies that the management of circular building processes will not be effective or lead to truly circular results unless it is based on the concept of circular economy. This means that projects managed from a non-circular world view are unlikely to deliver the performance and benefits of the circular economy. According to the study of Adams et al. (2017), the client has a major force in ensuring circular economy outcomes at a project level. The study claims that the client's vision and the strategy with long-term thinking are critical success factors to adopt circularity on the project level. However, the same study concludes that most clients does not recognize this as a major factor or does not have the knowledge to implement it. The study of Versteeg Conlledo (2019) recommends to observe the involvement of project managers in a circular project and investigates their tasks and their addition in the transition to a circular project. The main task of the project managers at Sweco, which is an engineering and consultancy firm connected to this graduation project, is to advise the client about their project, facilitate and give support during the process and provide advisers and specialists in order to achieve the final goal of the client. When this is linked to the literature described above, it is very important that project managers know how to convert their traditional 'linear' management into circular management in order to be able to realise circular projects for the client. The report of the Ministry of infrastructure and water management (2019) set a priority to have knowledge, experience and the right instruments at the right place to transit our economy to a circular economy. With the above arguments it can be concluded that (Sweco's) project managers, can be identified as crucial people in the construction chain to transit the management of construction projects according to the principles of circular economy.

The problem context for this master thesis research is the lack of capabilities and knowledge of project managers, who are involved in construction projects during the initiation and definition phase, to execute circular construction projects according to the concept of circular economy. To reduce the lack of capabilities of project managers, this research attempts to design an instrument in the form of a framework to integrate circularity in the initial phases of a construction project. This research can be described as a design problem according to the theory of Wieringa (2014), since the solution of the problem is a design in the form of a framework, also called an artefact of this study. This theory of a design problem belongs to the overarching concept of Design Science Research, which will be further elaborated in the *chapter 3.1*.

A design proposition has been created to offer a general template for the creation of a solution within a particular field problem. The research of Denyer et al. (2008) creates a design proposition called the CIMO-logic, which is constructed as follows: in this class of problematic **C**ontexts, use this **I**ntervention type to invoke these generative **M**echanism(s), to deliver these **O**utcome(s). The design proposition of this graduation research is expressed as follows:
To improve the capabilities and knowledge of project managers to execute the initiation and definition phase of construction projects according to the concept of circular economy **(C)**, a framework will be designed for project managers **(I)**, so that the project managers have access to general knowledge of the concept and tools to transform their current management into circular management **(M)**, in order to realise circular projects and contribute to the (fully) circular economy targets set by the government **(O)**.

Concluding, this graduation research strives to provide a solution to the design problem by achieving the following objective:

Design a framework, which is developed for project managers who are involved in the initiation and definition phase of a construction project, that improves the capabilities and knowledge of project managers and helps to transform the current performed management of project managers into circular management in order to realise circular construction projects.

1.3 Research questions

In order to be able to achieve the research objective, this research strives to answer the main research question:

'How to design and validate a framework for project managers who are involved in the initiation and definition phase of a construction project, that improves the capabilities and knowledge to realise circular construction projects?'

For answering the main research question several sub-questions have been formulated and need to be answered. These sub-questions are categorized into topics of the design cycle, which are discussed in the book of Wieringa (2014), and consists of the components; '(real world) problem investigation', 'treatment design' and 'treatment validation'. In this research, the term treatment is replaced by 'solution'. This method will be further elaborated within *chapter 3.1.*

(Real world) Problem investigation:

SQ1. What does the concept circular economy mean in the construction sector?

SQ2. What are the differences between traditional and (semi-)circular project management regarding the initiation and definition phase in terms of the process, the project management, the involved stakeholders, the role of the project managers and the working method?

SQ3. What is the knowledge of project managers in the field of circular economy, which knowledge would they still like to have and what is their approach to integrate circularity (or a new concept) in the construction process during the initiation and definition phase?

SQ4. Which success factors can be identified in literature and should be integrated during the initiation and definition phase of a circular project to realise a circular building?

SQ5. Which success factors can be identified within the results of the used methods of this research and should be included during the initiation and definition phase of a circular project to realise a circular building?

Solution design:

SQ6. Which success factors have to be included in the initiation and definition phase of a circular project to realise a circular building?

SQ7. Which frameworks do already exist for the construction sector to integrate circularity and how should the new framework look like?

SQ8. Which 'general' knowledge and essential tools should be available for all project managers to convert their management and realise circular construction projects?

SQ9. How to design a framework for project managers to apply circularity in the initiation and definition phase of a construction project?

Solution validation:

SQ10. Would the framework be able to support and provide the project managers with knowledge in order to transform their current project management into circular project management during the initiation and definition phase?

1.4 Research design

The sub-questions of this research have been divided into the topics of the design cycle. The design cycle can be extended by including implementation of the artefact and validation of the implementation, which is called the engineering cycle. In this study, the focus is exclusively on the design cycle. The sub-questions, the proposed methods, the involved data and the theory of the design cycle are presented in a graphical research design (see *Figure 1. 2*).
Every separate component of the design cycle will give input to an upcoming component. Every component consists of sub-questions, that will be answered by research methods and the involved data. The chosen research methods and the overall method of the Design Science Research will be explained in more detail in *chapter 3.1*.

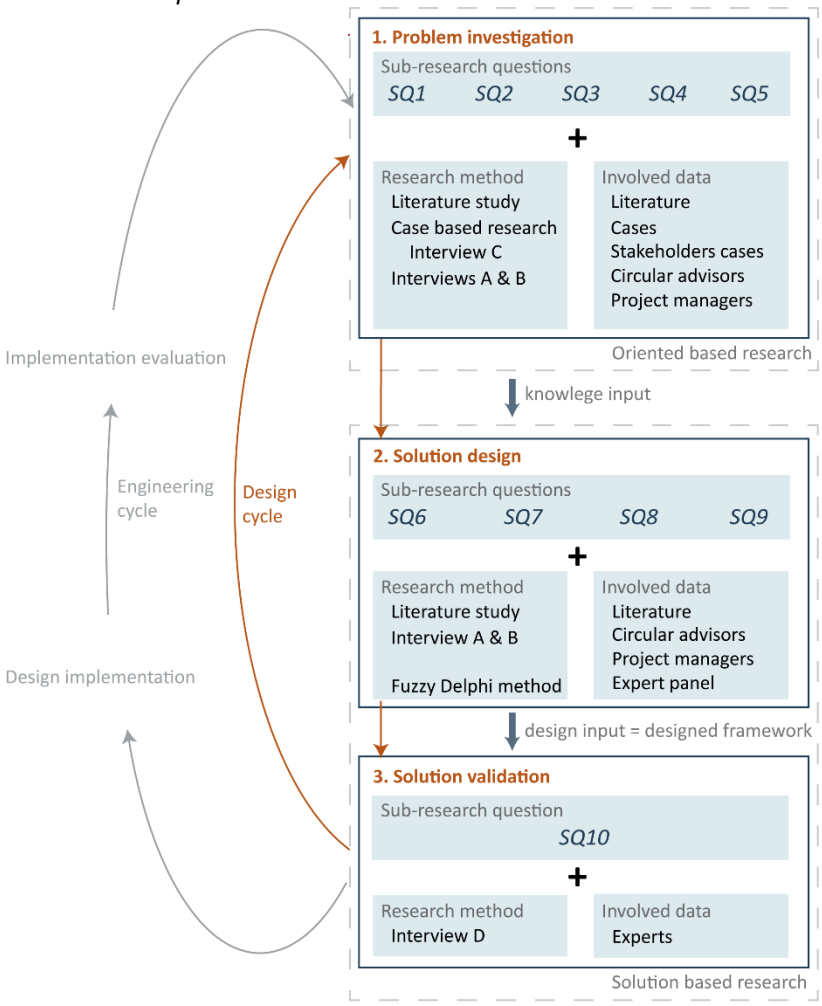

Figure 1. 2 - Graphical research design (Author, 2021).

1.5 Research Boundaries

The objective of this graduation research is to 'design a framework, which is developed for project managers who are involved in the initiation and definition phase of a construction project […]'.
As the objective suggested this research will focus on the initial phases of a construction project. These phases are the initiation and definition phase and provide the foundation for the follow up phases. Furthermore the framework will be created for construction project managers that are involved in the initial phases of a project.

The research design make use of the design cycle and contains the three aforementioned phases. These phases can be completed several times in a Design Science Research but will be completed once in this study due to time constraints.

1.6 Scientifical and practical importance

Scientifical importance

Already some researches exist that have been focussed on managing circular projects (Berg, 2019; Venselaar et al., 2019; Versteeg Conlledo, 2019). However, these studies focus on the entire building process and no study specifically focuses on the initial phases of a project, namely the initiation and definition phase. The studies mentioned do provide some factors that should be applied in the early stages of a project, but this knowledge is still very limited. In addition, according to the study of Adams et al. (2017), the client has a major force in ensuring circular economy outcomes at a project level, but the same study concludes that the client does not recognize this as a major factor or does not have the knowledge to implement it. The client has a lot of influence in the initial stages of a project. Besides, the research of Venselaar et al. (2019) states that it is necessary to manage according to the circular concept in all stages, otherwise there will be no fully circular building in the end that performs and contains the benefits of a circular economy. These scientifical insights show a lack of understanding of how to address circularity in the initial phases of a construction project and will be called the first research gap.

Furthermore, the research of Eberhardt et al. (2019) states that not many frameworks have been developed yet for the construction industry that address the complex issue and promote the transition to circularity. This is also in line with the report of the Ministry of Infrastructure and Water Management (2019) which set a priority to have knowledge, experience and the right instruments at the right place to transit to a circular economy. The second research gap is the lack of a framework which addresses circularity and can be used as an instrument for the transition to a circular economy

Practical importance

The project managers at Sweco advise the client about their project, facilitate and give support during the process and provide advisers and specialists in order to achieve the final goal of the client. The construction project managers of Sweco still have no knowledge on how to switch their traditional management into circular management. The transition to a circular economy has only just begun, but the government's ambitions to become fully circular in 2050 encourage market parties to include circularity in their construction projects. This leads to the demand from clients for project managers to assist in addressing circularity in the client's projects. This practical insight leads to the demand to provide the project manager with tools and knowledge to address circularity in projects and to help the project manager to switch to circular management.

1.7 Reading guide

This report includes six chapters (excluding *chapter 1 – introduction*) in order to answer the main research question. *Chapter 2* provides a theoretical background of the differences between a linear and a circular economy and gives insight in the project management of construction projects. *Chapter 3* will elaborate on the research methods used and will therefore elaborate on the Design Science Research, the interviews methods, the case based research and the Fuzzy Delphi Method. The three different phases are covered in separate chapters. *Chapter 4* focusses on the problem investigation and will therefore answer sub-question 1 till 5. It will elaborate on circular economy in the construction sector, the differences between a traditional project and a (semi-)circular project, the role of the project manager and the success factors identified. *Chapter 5* discusses the solution design, the assessment of the success factors, the necessary information for the framework and the designed framework. The last phase, solution validation, will be discussed in *chapter 6*, which entails the validation of the developed framework. The final chapter, *chapter 7* elaborates upon the conclusion, discussion and recommendations of this research.

2. Theoretical Background

This chapter will elaborate on the current economy in *chapter 2.1* and the circular economy in *chapter 2.2*. Furthermore, the term project management will be explained in *chapter 2.3* and the different project phases in *chapter 2.4*.

2.1 The current economy

The current economy has the consumption of products and goods together with the supply and demand as important central drivers in the system, which is called the linear economy (Rau & Oberhuber, 2016). This linear economy is also called the 'take-make-dispose' economy since goods are manufactured from raw materials, sold, used for a certain time-period and then thrown away or incinerated as waste. This economy has been sustained by cheap and available resources to create conditions for growth and stability (EMF & McKinsey & Company, 2014).

In linear economics, the biological and technical resource cycles are intertwined which results in a product that is difficult to recycle (Arup, 2016; Rau & Oberhuber, 2016). The biological resource cycle represents materials which can safely return to the biosphere and can function as biological nutrients for the next cycle. The technical cycle aims to minimize the use of raw materials by extending the lifetime of products, thus needing less materials through smart design or by reutilizing the materials through different ways (EMF, 2015). *Figure 2. 1* shows a graphical representation of the technical and biological resource cycles in the linear economy.

Over the years, various eco-friendly concepts have been developed in order to address the alarming issues of unsustainable production (Tsolis, 2017). These concepts, which are called as the reuse or recycle economy, focus on recycling the products to their original raw materials or to even recycle the entire product. An example is the cradle to cradle concept explained in the book '*The Upcycle'* by Braungart & Mcdonough (2013). The reuse or recycle economy is also represented with the biological and technical recourse cycles in *Figure 2. 1* (Braungart & Mcdonough, 2013; Rijksoverheid, 2016).

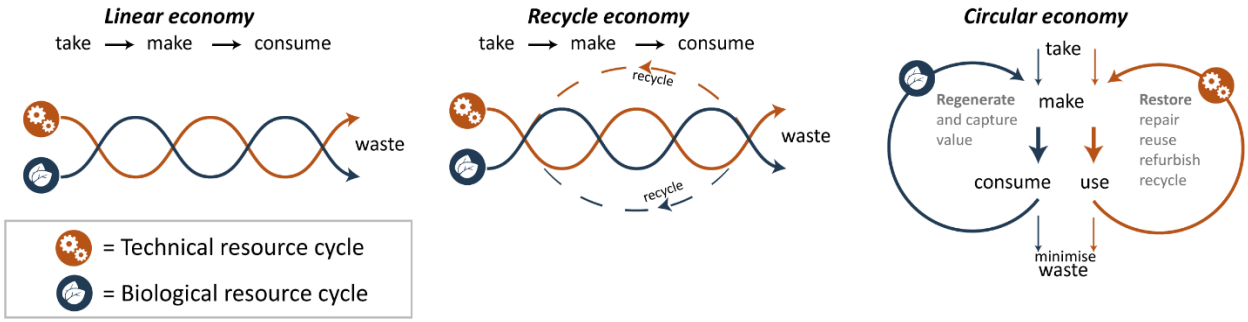

Figure 2. 1 - illustration of the resource cycles represented with the biological and technical cycles per economy (Author (2021) based on Arup (2016) and Rijksoverheid (2016)).

2.2 The circular economy

The concept of a circular economy has arisen in response to the negative impacts of the current economy and is a principle that synthesizes multiple schools of thought from sustainability and industrial engineering principles (EMF, 2015). The Ellen MacArthur Foundation (EMF) is a global leader in circular economy thinking and gives the following definition of a circular economy:

"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." (EMF & McKinsey & Company, 2014, p.15)

The research of Okorie et al. (2018) formulates the circular economy as an economic system aimed at eliminating waste, pollution and emission and employ reuse, remanufacturing and recycling to create

a closed system. The circular economy aims to keep products, equipment and infrastructure in use for a longer period, thus improving the productivity of resources in order to decrease waste generation to the largest possible extent (Ghisellini, Ripa & Ulgati, 2018; Okorie et al., 2018). The research of Van Leeuwen et al. (2018) additionally states that both raw material extraction and end-of-life processing take place within regional or, at the most, national borders. In this regard, the research of Leising et al. (2017) does not restrict the extraction and processing of the materials to national borders but states that it is important to close loops and slow down material flows. In the theory of Leising et al. (2017), it is essential to include the supply chain as a whole, and to involve all parties from design and raw material suppliers to end users, service providers and recyclers, including the associated information flow. Different definitions are used in researches describing the circular economy. However, the definition (and the extensions) defined by the Ellen MacArthur Foundation is used the most (Kirchherr, Reike, & Hekkert, 2017). The principle of a circular economy defined by EMF is adopted in this research, since, as has been investigated by Kirchherr et al. (2017), it forms a fundamental principle in many studies on which this research wants to focus. An illustration of the concept of circular economy is represented in *Figure 2. 1* and based on the Butterfly model (Arup, 2016; EMF & McKinsey & Company, 2014). This model represent an economy in the middle and two resource cycles on both sides that does not intertwine.

2.3 Project management

A project is a temporary effort undertaken to create a unique product, service or result (Project Management Institute, 2021). It is temporary since it has a defined beginning and end, with therefore a defined time, scope and resources. Furthermore, a project has a specific set of operations to accomplish a singular goal, which is not as routine operation. Project management is the application of knowledge, skills, tools and techniques to meet the project requirements (Project Management Institute, 2021).

The definition of project management is in line with the book of Walker (2015) that describes construction project management as:
'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 projects outcome.'
Construction projects require the integration of multiple engineering disciplines, such as structural, civil, geochemical, electrical, fire-safety and mechanical (Versteeg Conlledo, 2019).

Traditionally, the success of project management is related to the ability to deliver scope, cost, quality and time, which is called the iron triangle (Caccamese & Bragantini, 2012). A project managers task is to manage the project and to trade-off the different constraints (Caccamese & Bragantini, 2012). The book of Walker (2015) supplements this with stating that the project manager's goal is to resolve conflicts during the process in the interest of the client.

2.4 Project phases

A project can be divided in phases, in which different set-ups can be identified. The book of Nozeman (2010) divide a project in four phases; initiation phase, developing phase, realisation phase and maintenance phase. In contrast, the website of projectmanagement-training (2021) divides a project in six phases; initiation phase, definition phase, design phase, development phase, implementation phase and follow-up phase . The RIBA plan of work organises a project into eight stages with three phases of design (RIBA, 2020). Within the company Sweco, five stages are used: initiation phase, definition phase, design phase, realisation phase and maintenance phase. The project phases defined at Sweco will be used in this research and are visualised in *Figure 2.2*.

Figure 2. 2 - Project phases used in this research (Author, 2021)

This research focusses on the initiation and definition phases. These phases will be further explained. **The initiation phase** is the first phase of the project. In this phase, the idea for the project is explored and elaborated. Furthermore, the feasibility of the project is examined. These goals will be translated to a proposal or a project plan. Furthermore, project budgets and risks will be reviewed and a business case will be formulated (RIBA, 2020). This phase ends if the project plan is approved.

The definition phase is the second phase, in which the requirements of the project will be specified as clearly as possible. Besides, some feasibility studies can be performed, the budget and the programme of the project will be defined and procurement strategies will be investigated (RIBA, 2020).

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3. Methods

This chapter explains the research method. At the moment there is a lack of available knowledge on how to approach the initial phases of a project with a circular approach. For that reason, this study aims to contribute to that field of knowledge with the development of a framework. Several methods have been used to accomplish in developing the framework. First of all, the overall method of this research is the Design Science Research, which will be explained in *chapter 3.1*. In order to obtain data, the interview method and a case analysis have been conducted. A case study analysis have been conducted to obtain data of managing projects in the initial phases. The case study method will be explained in *chapter 0*. Furthermore, Interviews have been conducted with circular advisors (Interview A) and construction project managers (Interview B) to gain knowledge of the working method, the role of the project manager and to collect desires and advise for the framework. In addition, the interview method has been used to interview stakeholders of the cases to analyse (Interview C) and to validate the framework (Interview D). The used method and the setup of the interviews will be elaborated within *chapter 3.3*. Finally, success factors have been identified within the conducted interviews and analysed cases and these factors have been validated with the Fuzzy Delphi Method, which will be explained in *chapter 3.4*.

3.1 Design Science Research

This research can be described as a design problem according to the theory of Wieringa (2014), since the solution of the problem is a design in the form of a framework. Designing the framework can also be described as the artefact of this graduation project. This theory of a design problem belongs to the overarching concept of Design Science Research. According to Wieringa (2014) is design science the process of design and research for an object in context. The context is given and cannot be designed by the researcher. The problem context of this research is elaborated in *chapter 1.2*. The interaction between artefact and the context could solve the problem and not just the artefact itself (Wieringa, 2014). The mission of using the design science methodology is a quest for improving the human condition by developing knowledge to solve field problems (Denyer et al., 2008). A design proposition can be seen as offering a general template for the creation of solutions for a particular field problem. The goal of this research is to design a framework for project managers to be able to integrate circularity in the initial phases of a construction project. Hence, Design Science Research is a suitable research method.

Several Design Science Research cycles have been developed (van Aken & Romme, 2009; Wieringa, 2014). This research will use the cycle developed by Wieringa (2014), who mentioned two cycles: the engineering cycle and the design cycle. The design cycle consists of the components: (real world) problem investigation, treatment design and treatment validation. The engineering cycle elaborates on the design cycle by implementing the treatment implementation and the implementation evaluation (Wieringa, 2014). These two cycles have also been mentioned in *Figure 1. 2*. This graduation research focuses on the design cycle. The sub-questions defined in *chapter 1.3*, are also divided within the components of the design cycle. In this research, the term treatment is replaced for solution, since, in an engineering environment, it is more common to use the term solutions. However, it is important to be careful, this is why in the theory of Wieringa (2014) the term treatment is used, since the artefact may solve a problem only partially or maybe not at all (Wieringa, 2014). The (real world) problem investigation will consist of knowledge question, which implies asking for knowledge about the world as it is, containing descriptive and explanatory questions (Wieringa, 2014). Answering these questions will contribute to (re)design the artefact. The three different components of the design cycle reflect the three phases of this research and will be discussed below.

3.1.1 Phase 1 – Problem investigation

The sub-questions belonging to the topic (real world) problem investigation need input from literature, project managers, circular advisors and executed projects. The first method to be chosen for this research is a literature study in order to answer questions regarding the definition of circularity in the building sector and to find success factors investigated in other studies.
The information that needs to be generated from project managers and circular advisors can be answered by using surveys or interviews. A survey has great opportunities to question a lot of people due to the online possibilities and can generate precise results with the answers that are given (Sincero, 2012). However, within this method it is not possible to intervene the respondent when he or she is giving an interesting answer and the researcher want to know more about that specific topic. It is possible to intervene within the interview method, but the researcher should be aware of the fact that he or she can influence the answers (Dekker, 2019). As the transition to a circular approach has just started, any additional information available from the respondents is welcome and useful, which is why the interview method was chosen. This interview method will be further explained in *chapter 3.3*. In order to investigate differences between executed projects, two types of research are possible according to the theory of Wieringa (2014); the case based or the sample based research. Since the projects to be investigated do not look at averages and variations, it can be concluded that the case based research is chosen. The case study research will be further elaborated in *chapter 0*.

3.1.2 Phase 2 – Solution design

In order to design the framework, four sub-questions needs to be answered. First of all, the success factors identified in sub-questions 4 & 5 needs to be assessed to determine which factors should be included in the framework. The validation of the factors will be done with the Fuzzy Delphi Method (FDM) and is explained in *chapter 3.4.* This methodology is mainly used to gather information in a structured way to find consensus about a certain subject within a panel of experts (Gupta & Clarke, 1996). Another option to verify the success factors would have been to conduct an expert interview, but with this method it is harder to make an impartial judgement about the factors since the researcher has to compare the factors and interpret the data. For this reasoning, the Fuzzy Delphi Method is chosen, since this make use of a ranking system.
Furthermore, information needs to be gathered about the layout and format of the framework. This information will be obtained by literature and the interviews with the circular advisors and construction project managers. Besides, the content has to be defined for the framework for which no specific method will be used, since the content is a result of all the gathered information of phase 1. Finally, once all needed information has been collected, the framework can be created.

3.1.3 Phase 3 – Solution Validation

The last phase of this research should validate the framework. The research Venable, Pries-Heje & Baskerville (2016) agrees with the theory of Wieringa (2014) that a validation of the artefact is crucial to Design Science Research (DSR) and requires researches to rigorously demonstrate the utility, quality and efficacy of a design artefact using well-executed evaluation methods.
In addition, the validation will also examine whether the knowledge of the artefact contributes to the knowledge base. In this way the artefact will also be validated on the quality of its knowledge outcomes (Venable et al., 2016). The validation procedure will be further developed in *chapter 6.1*.

3.2 Case study research

This chapter will discuss the case based research that will be performed in order to obtain knowledge for answering sub-questions 2 and 5. It should therefore provide information between the differences of project management with and without a circular approach in the initial phases of a construction project. Besides, it should give insight in success factors for realising circular projects.

The first paragraph explains the setup of the case based research, the second paragraph elaborates on the selection of cases and the last paragraph describes the collection of data.

3.2.1 Set up of case based research

In order to investigate the differences between executed projects, two types of research are possible according to the theory of Wieringa (2014); the case based or the sample based research. Since the projects to be investigated do not examinate averages and variations, which is examined in sample based research, it can be concluded that the case based research is chosen. In this study, the case research will use project documents to analyse the project and will be complemented by interviews to complete the information obtained from the cases.

Initially, three various terms of project management have been defined and are given below:

- The term **traditional project (management)** implies that a project is realised according to the current / old way of management. Traditional projects are executed according to the take-make-dispose plan, also known as the linear economy. Within traditional project, circularity does not occur in the questioning (belonging to the initiation and definition phase), nor in the realisation or execution of the project.
- The term **circular project (management)** implies that a project is realised according to principles of a circular economy, in which the project is restorative or regenerative by intention and design. Within circular projects, circularity has been implemented into the DNA of the project and is totally embedded in the project.
- The term **semi-circular project (management)** indicates that the managed project consists of (a few) components according to the circular economy concept but cannot be named as a fully circular project. By this is meant that the projects has restorative of regenerative elements in the intention period or in the design but cannot be called fully circular, because parts of the concept are used or circularity is implemented in parts of the building.

During the case study research, the researcher discovered that there is no difference between a semi-circular and a circular project since every project tries to achieve the highest attainable level of circularity. This results in a change in the various types of project management. From now on the terms circular project and semi-circular project are combined in the term (semi-)circular projects.
The projects with traditional project management and (semi-)circular project management are investigated with the same methods.
In this research a minimum requirement is set to have at least 2 cases per project management type. This is based on the theory of Yin (2003) stating that analytic conclusions arising from more than one case study will be more powerful than coming from one single case. Moreover, having only one case study may cause doubt about the uniqueness or artefactual conditions around the case (Yin, 2003).

3.2.2 Selection of cases

In order to be able to select the cases to analyse, requirements have been set up. Based on these requirements cases are selected.
First of all, the cases must be classified under the correct denomination, i.e. it must comply with the definition of the terms traditional or (semi-)circular projects. Secondly, the researcher should be able to get access to project information and stakeholders involved in the initiation and definition phase. This access can be given by documents or by interviews. Thirdly, the researcher should be able to

contact the project manager and being allowed to investigate the project. The fourth criterion is that the project manager is willing to participate in the study by means of an interview. The fifth criteria is that the initiation and definition phase are already finished or the project should already be completed. The project should have been completed recently and not before 2014 as since this year publication on the concept of circularity has started. Furthermore, the project must include a utility building as this is a process where usually more interests or stakeholders are involved. For example, a utility project could have several users, which could lead to several clients. Furthermore, utility projects can be financed by investors or public stakeholders such as a municipality. All these stakeholders will need to be at the table when initiating a project. The number of stakeholders is usually smaller in a residential project due to the lesser separation of facilities, although the amount of owners can be larger at housing complexes. Nevertheless, within this study it is focussed on utility projects. Finally, the project should be executed within The Netherlands because of the Dutch regulations and the possibilities to compare the cases.

Potential cases have been analysed on the above mentioned requirements and coded with a name to ensure the privacy of those involved, to reduce reader bias and to make the best comparison possible. If the project does not meet one of the requirements, it is categorised as unsuitable. The projects that are available for this research have been renamed. The selection of cases can be found in *Table 3. 1*.

Table 3. 1 - Selection of cases for the case based research (Author, 2021).

Code of project	Type of project	Current phase	Suitable
Project I	Traditional project	Completed	No
Project II	Traditional project	Completed	No
Project III	Traditional project	Completed	No
Project IV	Traditional project	Realisation phase	Yes, will be called Project A
Project V	Traditional project	Realisation phase	Yes, will be called project B
Project VI	Traditional project	Design phase	Yes, has been seen as a backup project
Project VII	(Semi-)Circular project	Design phase	No
Project VIII	(Semi-)Circular project	Realisation phase	Yes, will be called project D
Project IX	(Semi-)Circular project	Realisation phase	Yes, will be called project C
Project X	(Semi-)Circular project	Completed	Yes, will be called project E
Project XI	(Semi-)Circular project	Completed	No
Project XII	(Semi-)Circular project	Realisation phase	No
Project XIII	(Semi-)Circular project	Completed	No
Project XIV	(Semi-)Circular project	Design phase	Yes, will be called project F

Table 3. 1 shows that 2 traditional projects are analysed and 4 (semi-) circular projects. This doubling in the (semi-)circular projects is due to the fact that the research started with 3 different types of projects in which 2 cases were analysed per type, after which the semi-circular projects and the circular projects were merged. This resulted in 4 projects for the (semi-)circular projects.

3.2.3 Collection of case data

According to the theory of Yin (2018), it is important to use multiple sources of data within the research. At least two methods are used; the project documents and two interviews per case. By conducting two interviews per case and by taking the project document into account, triangulation of data has been reached.
Another important aspect according to the theory of Yin (2018) is that an external observer could follow the derivation of evidence from research question to conclusion. This can be interpreted as the reliability of the study. To ensure the reliability of the research, every case will be analysed according to several topics, which will be explained in the next section. Furthermore, the interviews with two stakeholders, which is labelled with interview C and will be discussed in *paragraph 3.3.4*, are transcribed and included in *Appendix I – Transcripts interview C*. The project document of the cases are not included in this research as this is not in line with the privacy policy of this research. No permission has been requested to the owner of the project to analyse the projects as the name of the project is not published.

In order to answer sub-question 2, information in terms of the progress of the initiation and definition phase, the involvement of stakeholders within the initiation and definition phase, the used project management, the circular ambition and the role of the involved project manager should be obtained by conducting a case analysis. In order to obtain this target, several topics have been investigated and are listed in *Table 3. 2*.

Table 3. 2 - Topics to be covered within the case analysis (Author, 2021).

Topic	Questions to be answered
General project information	What is the aim of the project?
	What type of client is involved?
	What is the scope of the project?
Initiation and definition phase	Which activities have been performed during the initiation and definition phase (regarding circular and sustainable aspects)?
	What was the progress of the initiation and definition phase?
	Which documents are important and provided information for the follow-up phases after the initiation and definition phases?
	What has been the progress of the project after the initiation and definition phase?
Project management	How was the project managed?
	In which form did the invitation to tender take place?
	What was the budget and how is it defined and announced?
	What form of contract was used?
	How does the phases within the project looks like?
	What was the duration of the initiation and definition phase?
Role of the project manager	What has been the question of the client to the Project manager?
	Which knowledge does the project manager deliver to the project?
Involved Stakeholders	Which stakeholders have been involved within the initiation and definition phase?
	How does the organisation chart of the initial phases of the project looks like?
Circular ambitions	Was there a circularity aspect involved within the project? And how was it defined?
	Which documents ensured the circularity aspects?
	Was there a change in management due to including a circular approach?

If the elements cannot be extracted from the project documents, it will be asked during an interview with the stakeholders as illustrated in Interview C (see *paragraph 3.3.4*).

To be able to analyse and compare the different projects, each project has been analysed separately by means of collecting project documents and conducting interviews. From the analysis, results are obtained and subsequently discussed in *paragraph 4.2.2*. The results of the cases will be compared with a cross case approach. This cross case analysis will eventually lead to a conclusion on the differences between a traditional project and a semi-circular project. The approach of analysing the projects is shown in *Figure 3. 1*.

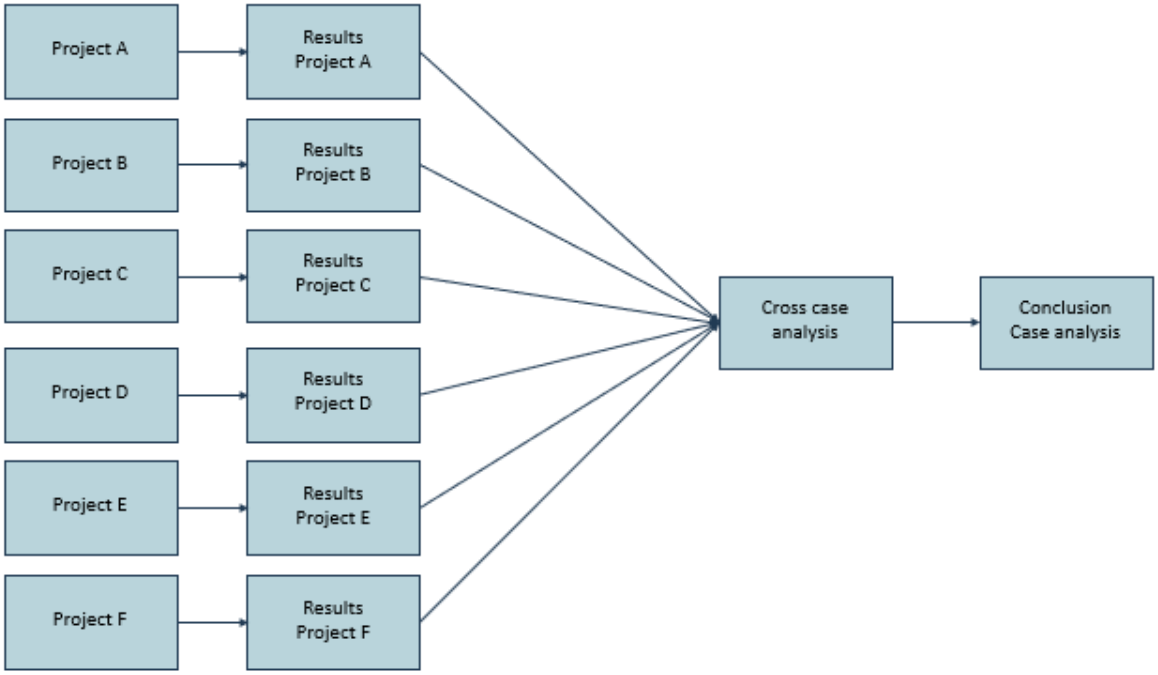

Figure 3. 1 - Approach of the case based research to analyse projects (Author, 2021).

3.3 Interviews

This chapter will discuss the interview methodology including four different type of interviews have been conducted. First of all, the interview method will be explained. Subsequently, the four different types of interviews will be elaborated. Interviews have been conducted with circular advisors (Interview A) and construction project managers (Interview B) to gain knowledge in order to answer sub-questions 1, 2, 3, 5 and 7. Interview C has been used to collect additional information from stakeholders of the analysed cases in order to answer sub-question 2 and Interview D is used to validate the framework with experts affiliated with sub-question 10. All type of interviews are covered in a separate paragraph.

3.3.1 Interview method

The purposes of the interviews is to gain more knowledge in order to be able to answer several sub-questions. The objective of the interviews is to understand the opinion and experience of the interviewees, which means that all interviews for this research are qualitative. Different kind of interview structures can be used for qualitative research. The different interview structures will be elaborated in *Table 3. 3*.

Table 3. 3 - The different kind of interview structures (Author, 2021).

Interview type	Description
Unstructured	Due to the absence of structured questions, a free-flowing and open conversation is created. The researcher relies on the interaction with the respondent to guide the interview process (Creswell, Hanson, Clark Plano, & Morales, 2007). Unstructured interviews are not useful when the researcher already has a basic understanding of a phenomenon and pursues for particular aspects of it (Wildemuth, 2016).
Semi-structured	A set of predetermined open-ended questions are created. Additional questions may emerge from the dialogue during the interview process (DiCicco-Bloom & Crabtree, 2006). This interview type is broadly used for qualitative research and combines the best features of the unstructured and structured types. This type ensures that the area of focus is covered due to the set of predetermined questions, while the possibility of developing the interview towards other directions of interests remains present (DiCicco-Bloom & Crabtree, 2006).
Structured	This interview type make use of predetermined questions and a structured approach. All interviews uses the same question (Turner, 2010). The structured interview type could be best applied in situations in which complete knowledge about a topic is available (Turner, 2010).

Within this research, a basic understanding is present of integrating a circular approach in project management, which makes the unstructured interview type unsuitable. Furthermore, there is no complete knowledge about the subject, since the transition to a circular approach is still ongoing, which eliminates the structured interview type. The semi-structured interview is considered to be the most suitable for this research and will therefore be selected for all four different interviews.
Within the four semi-structured interviews the open ended questions are predetermined, however, deviation of the interview is possible. The interview will be guided into other directions when the dialogue leads to this. However, it is important that all the questions are asked.

Recommendations for constructing an effective interview have been taken in consideration during developing the semi-structured interviews. These recommendations are (Mcnamara, 2009; Sande, 2019):

1. Wording should be open-ended.
2. Questions should be as neutral as possible.
3. Questions should be asked once at a time.
4. Questions should be worded clearly.
5. Be careful asking 'Why' questions.

Besides the above recommendations it is also important that the interviewer makes use of an introduction to lay the basis for the conversation. The interviewer has to ensure that the participant knows the purpose of the interview. Furthermore, it is important to start with a question that could be answered easily by the interviewee to create a nice atmosphere, to give the interviewee a warming up and to make the interview flow more smoothly.
Abovementioned recommendations have been used to compose the interview questions of all four different kind of interviews. The established questions will be discussed in the paragraph that elaborates on the specific interview.

Every interviewee has received an informed sheet, which contains information about collecting and processing the data obtained from the interviewees. This information sheet is added to *Appendix A – Informed consent sheet* and created in both languages; English and Dutch. As is mentioned in this informed sheet, all interviewees will be coded to reduce reader bias and to ensure the interviewees privacy.
During every interview the researcher has briefly introduced the research, described the aim of the specific interview and explained briefly the content of the interview.

Due to covid restrictions, the interviews could not be conducted face to face, but had to take place via Microsoft teams.

All interviews are recorded with the approval of the respondents. Summary transcripts have been made of the recorded interviews. A summative approach is a time efficient method to only note essential information. The transcripts will not be approved or signed for validation because no sensitive information is given and this will save time for both the researcher and the interviewee. Transcribing the interviews took 3 to 4 times the duration of each interview.
The transcripts of interview A and B have been open and axial coded with the software programme Atlasti 9. A student licence has been obtained for this software programme.

3.3.2 Interview A

The purpose of interview A is to gain more insight into circularity in the construction sector and how circularity should be integrated by the construction project managers according to the circular advisors.
The circular advisors are consultants in a project and thus temporarily present to share or apply substantive knowledge on circularity. The circular advisers are the people involved who know the content of circularity, can apply it and are up to date with the latest developments. The circular advisers mainly have an advising and inspiring role in the transition to circularity.
The circular advisors of interview A are selected based on several criteria. First of all, participants should be working for companies that are active in realising Dutch construction projects. Secondly, the respondents should be familiar with the concept of circular economy or integrating new sustainability aspects. Thirdly, there are no restrictions to employer companies, but most of the respondents are employees of the company Sweco since they facilitate this research. An overview of the participants of interview A is shown in *Table 3. 4.*

Table 3. 4 - Overview participants interview A (Author, 2021).

Interview number	Name Code	Area of expertise	Interview Date
A1	CE advisor 1	Civil engineering	September 29, 2020
A2	CE advisor 2	Urban development	October 13, 2020
A3	CE advisor 3	Measurability of Circularity and sustainable buildings	October 22, 2020
A4	CE advisor 4	Construction sector	October 13, 2020
A5	CE advisor 5	Construction sector	October 16, 2020
A6	CE advisor 6	Energy transition	October 12, 2020
A7	CE advisor 7	Construction sector	October 2, 2020

The interview questions of interview A have been formulated based on the recommendations as was suggested in *paragraph 3.3.1*. Furthermore, Interview A is used to collect data to be able to answer sub-question 1, 2, 3, 5 and 7. The sub-questions have been taken into account to create the open-ended questions of the semi-structured interview A. The questions of interview A can be found in *Appendix B – Questions interview A*.

Interview A1 was a test interview and CE advisor 1 was informed about this. The interview is still useful since it provides the researcher of relevant information. However, some questions have been modified after this test interview.

All interviews of interview A have been conducted online and had a duration of 45 to 60 minutes.

Interview A has been transcribed, coded and analysed. The interviews were conducted in Dutch, transcribed in Dutch and coded with open and axial coding. The transcripts of interview A1 till A7 can be found in *Appendix C – Transcripts interview A*. The transcripts have been coded and the open coding technique has been applied to three of the seven transcripts. The interviews A1, A2 and A4 were coded using the open coding technique. Transcript A4 was chosen instead of A3 since the interview of A4 was conducted earlier and the transcript was also earlier available for coding. An example of the used coding techniques can be found in *Appendix D – Example used coding techniques*. The open codes were subsequently viewed, renamed, divided into categories and some codes were deleted. This is also called the axial coding technique. Hereafter, the other interviews are coded with the axial codes. During the axial coding phase every transcript is read and coded two times on different days to make sure every useful information is coded and to try to eliminate imprecision.

The results of interview A can be found in the result chapters of the relevant sub-questions. An overview of the subjects that resulted from the interview is shown in *Appendix E – Overview results interview A*, which also provides insight into the relationships between the subjects discussed.

3.3.3 Interview B

The purpose of interview B is to gain more insight into project managers' knowledge of circularity, which knowledge they need in order to be able to integrate the concept in their projects and what requirements they consider for the framework in order to be able to integrate and apply circularity in construction projects.
The construction project managers advise the client about the client's project, facilitate and give support during the process and provide advisers and specialists in order to achieve the final goal of the client. Their expertise is to manage projects with the management aspects. The hypothesis is that the contribution of project managers is important in the transition to a circular economy, but the

results will have to show whether this is actually the case. The construction project managers could also be defined as the stakeholders of the artefact of this study.
The construction project managers of interview B are selected based on several criteria. Firstly, participants should be working for companies that are active in realising Dutch construction projects. Secondly, the respondents should be project managers in the construction sector and familiar with the initiation and definition phase of a project. Thirdly, there are no restrictions to employer companies but most of the respondents are employees of the company Sweco since they facilitate this research. An overview of the participants of interview B is shown in *Table 3. 5*.

Table 3. 5 - Overview participants interview B (Author, 2021).

Interview number	Name Code	Area of expertise	Interview Date
B1	CPM 1	Construction project manager	October 6, 2020
B2	CPM 2	Construction project manager	October 13, 2020
B3	CPM 3	Construction project manager	October 8, 2020
B4	CPM 4	Construction project manager	October 6, 2020
B5	CPM 5	Construction project manager	October 9, 2020
B6	CPM 6	Construction project manager	October 8, 2020
B7	CPM 7	Construction project manager	October 2, 2020
B8	CPM 8	Construction project manager	October 16, 2020

Two additional construction project managers have been asked to participate in interview B, but cancelled due to a lack of time. No replacements have been requested because according to the researcher, 8 opinions would also be sufficient.

Interview B is used to collect data to be able to answer sub-question 2, 3, 5 and 7. The sub-questions and the suggested recommendations in paragraph 3.3.1 have been taken into account to create the open-ended questions of the semi-structured interview B. The questions of interview B can be found in *Appendix F – Questions interview B*.

Interview B8 was a test interview and CPM 8 was informed about this. The interview is still useful since it provides the researcher of relevant information. However, some questions have been modified after this test interview.

Interview B3 and B6 have been conducted in real life. The other interviews have been conducted online by Microsoft Teams. The duration of interview B was 30 - 60 minutes. During interview B1, the internet did not work properly for the interviewee, so there was a short break of 2 minutes during the interview in which CPM 1 switched internet facilities.

Interview B has been transcribed, coded and analysed. The interviews were conducted in Dutch, transcribed in Dutch and coded with open and axial coding. The transcripts of interview B1 till B8 can be found in *Appendix G – Transcripts interview B*. The transcripts have been coded and the open coding technique have been applied to the interviews B1, B2 and B3. An example of the used coding techniques can be found in *Appendix D – Example used coding techniques*. The open codes were then viewed, renamed, divided into categories and some codes were deleted. This is also called the axial coding technique. Hereafter, the other interviews are coded with the axial codes. During the axial coding phase every transcript is read and coded two times on different days to make sure every useful information is coded and to try to eliminate imprecision.

The results of interview B can be found in the result chapters of the relevant sub-questions. An overview of the subjects that resulted from the interview is shown in *Appendix H – Overview results interview B*, which also provides insight into the relationships between the subjects discussed.

3.3.4 Interview C

Interview C is part of the case analysis discussed in *chapter 0*. Within this paragraph an overview will be given of the respondents in interview C. As was discussed in *chapter 0,* six cases have been analysed and for every case, two stakeholders were interviewed. The target was to interview at least the project manager of every project and a second involved person of the project which could be the client. *Table 3. 6* presents the interviewed stakeholders with their function, type of project and interview date.

Table 3. 6 - Overview participants interview C (Author,2021).

Interview code	Coded name of the interviewee	Code of project	Type of project	Date interview
C1	Project manager 2A	Project A	Traditional project	September 30, 2020
C1	Project manager 3A	Project A	Traditional project	September 30, 2020
C2	Project manager client A	Project A	Traditional project	October 20, 2020
C3	Project manager construction 2B	Project B	Traditional project	October 19, 2020
C4	Client B: Educational institution 1	Project B	Traditional project	October 28,2020
C5	Project manager client C	Project C	(Semi-)Circular project	October 26,2020
C6	Project manager construction team C	Project C	(Semi-)Circular project	October 27, 2020
C7	Project manager construction 1D	Project D	(Semi-)Circular project	October 29, 2020
C7	Project manager construction 2D	Project D	(Semi-)Circular project	October 29, 2020
C8	Project manager client D	Project D	(Semi-)Circular project	November 3, 2020
C9	Circular project manager 1E	Project E	(Semi-)Circular project	October 1, 2020
C10	Client E	Project E	(Semi-)Circular project	November2 , 2020
C11	Project manager construction F	Project F	(Semi-)Circular project	October 8, 2020
C12	Project manager client 2F	Project F	(Semi-)Circular project	November 10, 2020

As can be seen in *Table 3. 6*, interview C1 and C7 have been conducted with two stakeholders involved. Interview C supports the case analysis with collecting data of the cases to be analysed. There is no universal questionnaire for interview C, since different project information was available for each case. The topics to be covert have been discussed in *paragraph 3.2.3*.

There has been no test interview within interview type C and interview C10 and C11 have been conducted in real life. The other interviews have been executed online by Microsoft teams. The average duration of interview C was 30 - 90 minutes. During interview C2, the internet did not work properly for the interviewee, so the interview have had several breaks to be able to switch internet facilities.

All interviews were conducted in Dutch and transcribed in Dutch. The transcripts of interview C1 till C12 can be found in *Appendix I – Transcripts interview C*. The results of interview C can be found in *paragraph 4.2.2*.

3.3.5 Interview D

Interview D has been used to validate the developed framework for the project managers with experts. All used experts are construction project managers. *Table 3. 7* presents an overview of the participants of interview D.

Table 3. 7 - Overview participants interview D (Author,2021).

Interview number	Name Code	Area of expertise	Interview Date
D1	Expert 1	Construction project manager	February 16, 2021
D2	Expert 2	Construction project manager	February 16, 2021
D3	Expert 3	Construction project manager	February 16, 2021
D4	Expert 4	Construction project manager	February 17, 2021

Interview D is used to collect the opinions of experts to be able to answer sub-question 10. Open-ended questions with a semi-structured approach have been created for interview D. The questions of interview D can be found in *Appendix J – Questions Interview D*.

There has been no test interview conducted and all interviews have been executed online by Microsoft teams. The average duration of interview D was 45 - 60 minutes. The transcripts of interview D1 till D4 can be found in *Appendix K – Transcripts interview D*. The results of interview D have been used to answer sub-question 10 in *chapter 6.1*.

3.4 Fuzzy Delphi Method

The problem investigation phase will identify several success factors by conducting a literature study, interviews (A and B) and a case study analysis. To obtain an overview of the most important success factors within the initiation and definition phase to enhance realising circular projects, a Fuzzy Delphi Method (FDM) has been conducted to assess the identified success factors.
In this chapter the Fuzzy Delphi methodology and the setup of the FDM for this research will be explained.

The Fuzzy Delphi Method

The Fuzzy Delphi Method is a combination of the Delphi method and the fuzzy set theory (Glumac, Han, Smeets, & Schaefer, 2011; Ishikawa et al., 1993).
The traditional Delphi method is a systematic method of collecting data in a structured way and to find consensus about a certain subject within a group of experts by using a questionnaire (Damigos & Anyfantis, 2011; Gupta & Clarke, 1996). Three important features of the Delphi method are anonymous response, iteration and controlled feedback and statistical group response (Hsu, Lee, & Kreng, 2010). The Delphi method is a valid method for forecasting and it facilitates collective decision-making. However, there are some limitations to the Delphi method, such as the fact that the questions and the answers of the survey may be unclear, that differences in meanings and interpretations of the experts' opinions occur, and that there is a remarkable problem in resolving the fuzziness of the experts' consensus within the decision-making process (Glumac et al., 2011). The uncertainties in the Delphi method are mainly caused by the human element, who validate the factors by means of a questionnaire. The fuzzy set theory is suitable to tackle the uncertainties by embracing the fuzziness (Damigos & Anyfantis, 2011; Glumac et al., 2011). By adding the Fuzzy set theory to the Delphi method the use of fuzzy numbers ensures that the fuzziness of the experts answers will be taken into account. Furthermore, by combining those two methods the quality of questioning and the questionnaire will improve and this will result in a more efficiency and reliable study outcomes (Glumac et al., 2011; Ishikawa et al., 1993).

The Fuzzy Delphi method consists of the following five steps, which will be explained in more detail in the upcoming sections (Glumac et al., 2011; Hsu et al., 2010).

1. *Validate predefined list of factors;*
2. *Collect opinions of expert group;*
3. *Set up overall triangular fuzzy number;*
4. *Defuzzification;*
5. *Screen evaluation indexes.*

Validate predefined list of factors

The first step of the Fuzzy Delphi method is obtaining and selecting the input data. Several success factors will be identified by a literature study, the interviews A and B with the circular advisors and the construction project managers and a case study research. The success factors will be identified to answer sub-questions 4 and 5, which will be elaborated in *chapter 4.4*. These success factors will be validated to predefine the list of factors and being able to execute the Fuzzy Delphi method.

Collect opinions of expert group

In order to collect opinions of the expert panel, three steps had to be taken. First of all the formation of the expert panel, secondly determining the Likert scale and the corresponding triangular fuzzy numbers and thirdly setting up the survey.

In order to form the expert panel, experts have to be approached who have knowledge of the concept of a circular economy, of project management in the initial phases of a construction project or both.

The researcher has contacted 30 potential respondents. The contacted potential respondents are either circular advisors of Sweco, employees of Sweco that participate within in a research programme to integrate circular economy within the company, construction project managers of Sweco and construction project managers who participated within the case study analysis of this research. Some potential respondents have knowledge about both fields: circular economy and construction project management.
The outcome of an FDM questionnaire might be reliable with a homogeneous group of 10-15 respondents (Delbecq, Van de Ven, & Gustafson, 1975). Within this research two homogeneous groups can be identified: the experts in field of circularity and the experts in the field of construction project management. The target response was at least 10 responses per homogeneous group.

For all potential respondents a time reservation of half an hour was made to validate the success factors and this was made two weeks prior to the possibility to validate (before the survey was online). Making a time reservation ensures the researcher to have enough responses since the validation took place in the busy month of December.

The five-point Likert scale is used in this research to validate the success factors. *Table 3. 8* and *Figure 3. 2* shows the Likert scale and the corresponding triangular fuzzy numbers. To ensure the scale is understandable for the expert panel the 5 different scores are supported with a description.
The five point scale has been used since this scale can very well function to reflect the opinion of the panel. Besides, the possibility of answers are fewer which makes it easier for the respondent to choose an answer instead of using a seven or nine point scale.
In this research the Min Max method, which implies asking respondents to give a range for each success factor, has not been used due to the size of the questionnaire and the corresponding risk that respondents are not finishing the survey (Ishikawa et al., 1993).

Table 3. 8 - The five point Likert scale with description and corresponding triangular fuzzy numbers (Author, 2021).

Description questionnaire	**Very unsuccessful**	**Unsuccessful**	**Neutral**	**Successful**	**Very successful**
Value questionnaire	1	2	3	4	5
Fuzzy numbers (a_{ij}, b_{ij}, c_{ij})	(0, 0, 0.25)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1.0)	(0.75, 1, 1)

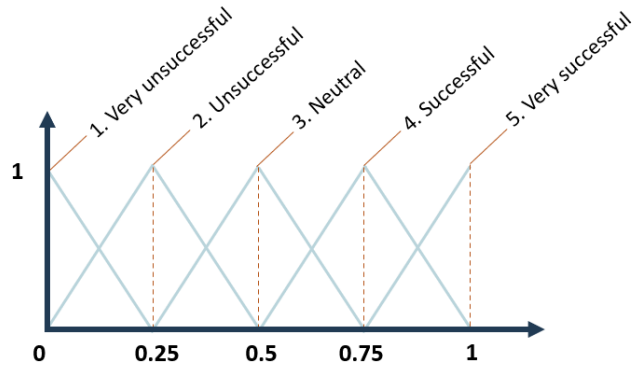

Figure 3. 2 – Scale of Fuzzy numbers (Author, 2021).

Set up overall triangular fuzzy number

The outcome of the questionnaire will result in a matrix that shows the rated values per success factor for all the different respondents and will be as follows:

	R_1	R_2	...	R_n
SF_1	L_{11}	L_{12}	...	L_{1n}
SF_2	L_{21}	L_{22}	...	L_{2n}
...	...	...	...	...
SF_m	L_{m1}	L_{m2}	...	L_{mn}

Where:

R_i = The i^{th} respondent, i = 1, 2, …, n

SF_j = The j^{th} success factor, j = 1, 2, …, m

L_{ij} = The linguistic evaluation of success factor j by respondent i

In order to understand the group decision for each success factor, the general mean model will be used proposed by Klir & Yuan (1995). By using the mean model, the evaluation value of one of the success factors by a single respondent is expressed as a triangular fuzzy number (see third row of *Table 3. 8*):

$$\widetilde{w}_{ij} = (a_{ij}, b_{ij}, c_{ij})$$

Where factor j, success factor, given by factor i, respondent, of n respondents where i = 1, 2, …n, j = 1, 2, …m. Then the fuzzy weighting w_{ij} of j is:

$$\widetilde{w}_j = a_j + b_j + c_j \text{ , where } j = 1,2, \ldots . m \text{ and,}$$

$$a_j = \underset{i}{Min}\{a_{ij}\}, \qquad b_j = \frac{1}{n}\sum_{i=1}^{n} b_{ij}, \quad c_j = \underset{i}{Max}\{c_{ij}\}$$

Defuzzification

The next step in the Fuzzy Delphi method is converting the triangular fuzzy numbers into single real numbers. This step is called defuzzification. In this research the simple centre of gravity method by Klir & Yuan (1995) will be used to convert the fuzzy weight w_j of each single success factor to single derived numbers s_j where j = 1, 2, …, m:

$$S_j = \frac{(a_j + b_j + c_j)}{3}$$

Screen evaluation indexes.

To select the success factors that are most successful for the project manager to realise circular projects and which should be included in the framework, the single derived numbers are tested against a threshold (α). If the single derived number is lower than this threshold the success factor is not selected, if the value of the single derived number is equal or higher than the threshold the success factor is selected.

If $s_j \geq \alpha$ Success factor j is more successful and will be included in the framework

If $s_j < \alpha$ Success factor j is less successful and will not be included in the framework

The literature describes no standard for setting a threshold. The threshold therefore has to be set on the needs of the study and is mostly based on the researchers opinion (Habibi, Jahantigh, & Sarafrazi, 2015; Hsu & Chen, 1996). Three different methods have been identified in literature to determine a threshold. Firstly, the typically used threshold in scientific research is 0,7. Secondly, it is possible to calculate the mean of the single derived numbers and set this as a threshold. Finally, it is also possible to search for a significant margin between the single derived numbers and set the threshold at the upper bound of the margin.

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4. Phase 1 – Problem investigation

The first phase of the design cycle, also called phase 1 - the problem investigation, will explore circularity in the construction industry, the differences between a traditional project and (semi-) circular projects and the role of the project manager and their knowledge in circular building. In addition, success factors will be gathered from literature and from the results of the methods used in this research. This phase will answer the first five sub-questions of this research.

4.1 Circular economy in the Dutch construction sector

As discussed in the introduction, the Dutch government has the government-wide program "The Netherlands Circular by 2050" which sets the goal of having a one hundred percent circular economy by 2050. In this government-wide program, the construction sector has been appointed as one of the five priority sectors. The need for this transition to a circular economy was also explained in the introduction. In order to realize this ambition of the Dutch government, three strategic goals have been designated; (1) raw materials and materials in existing loops must be preserved, (2) new raw materials and materials are filled by circular products and materials and (3) new production methods are deployed (Rijksoverheid, 2016). However, these strategic goals do not yet give specific meaning to what circular building means and how it should be achieved. In order to understand the meaning of circular building, this chapter focuses on answering sub-question 1: *What does the concept circular economy mean in the construction sector?* To answer this sub-question input from the literature and results of interview A are used.

4.1.1 Definition of (a) circular building

Circularity has become a popular concept in the built environment. A circular approach prefers a more circular way of perceiving the building process by closing 'material cycles'. This approach aims at a more conscious use of resources and materials and idialiter to see materials released during demolition as a resource instead of waste (Braungart & Mcdonough, 2013; Rau & Oberhuber, 2016). Both the interviewed CE advisor 3 and 4 *(Appendix C)* follow this definition of a circular approach by Michael Braungart who focuses on the concept of cradle to cradle(C2C). According to the C2C principle is waste equivalent to food and should every material be fully reused (Braungart & Mcdonough, 2013).

The term circular building is used in the construction sector. Tsolis (2017, p. 36) mentioned the difference between circular building, in which the word 'building' is a verb and refers to a series of actions and circular building(s) in which the word 'building' is used as a noun and therefore refers to a physical entity.
Platform Circulair Bouwen 2023 (2019), which strives to draw up national construction sector-wide agreements with regard to circular construction in the Netherlands, and is also national advisor, has also made a distinction between circular construction and a circular building and has given definitions to both names. Platform CB'23 (2019) has defined circular building, as a verb, as follows:
'Circular building means developing, using and reusing buildings, areas and infrastructure without unnecessarily depleting natural resources, polluting the living environment and damaging ecosystems. Building in a way that is economically and ecologically responsible and contributes to the well-being of people and animals. Here and there, now and later'.
This definition is in line with the general definition drawn up and used by the Ellen macArthur Foundation (EMF & ARUP, 2019).

In addition, the following description for a transition to a circular economy in the construction sector is given as 'it will lead to more and higher-quality reuse of materials, products and elements and to a different approach to production, tendering, design and execution of construction projects' (Platform CB'23, 2019).

CE advisor 1 (*Appendix C*) indicates that circular construction in the construction sector means considering all the phases in which the building is involved: from the initiation phase to the dismantling phase.
According to CE advisor 2 and 3 (*Appendix C*) makes a circular economy use of materials with the lowest possible environmental impact, efficiently application of materials and reused or dismantled materials. CE advisor 7 (*Appendix C*) agrees with this and indicates that the disassembling of materials in buildings is important according to a circular approach, which makes modular construction interesting. Building with Lego blocks is mentioned as an example. If we build and represent construction with the cubes, we might ask ourselves whether we go back to the plastic raw material of the cube or whether we retain the shape, sell it and build with the same cube again (CE advisor 7, *appendix C*). CE advisor 3, 4, 6 and 7 (*Appendix C*) indicate that using renewable materials, building in wood and using biobased materials are considerations for a circular approach.
CE advisor 6 (*Appendix C*) indicates that the idea behind circularity is that zero materials are extracted from the planet, nothing is thrown away or destroyed, preferably renewable materials are used, materials released from a building are used and that less is built. The focus should be more on what already is and what is already used instead of creating new. CE advisor 6 (*Appendix C*) also stresses that new buildings are constructed and the significant vacancy rate, reflecting a mismatch between supply and demand. Both CE advisor 3 and 4 (*Appendix C*) mention closing material flows and loops during a circular construction approach, which in addition to materials also include the energy and water loops.

The second interpretation of circular building, as a noun, was also defined by Platform CB'23 (2019) and described as:
'A circular building (i) is designed and executed according to circular design principles and (ii) is realised with circular products, elements and materials'.
The circular design principles, which are mentioned in the definition of a circular building, are based on three themes: prevention, value preservation and value creation. For the first step - prevention - it is important to think differently, to reduce the project to a minimum and to take adaptive capacity as a starting point. In the second step - value preservation - it is important that if no prevention of construction can take place, as many reused materials as possible are used, followed by renewable and/or reusable materials. In the final step - value creation - the functional lifetime of a building should be taken as the basis for the use of materials, consideration should be given to remountable or demountable construction and the environmental impact should be taken into account in the use and choice of products and materials.
CE advisor 1 (*Appendix C*) uses the design principles mentioned above in projects. CE advisor 2 (*Appendix C*) states that a circular product does not exist, since the concept of circularity means closing loops and a product is only one phase in the loop of the material.

4.1.2 Circular models, concepts and strategies

In recent years, various concepts, models, strategies and assessment frameworks have been developed to give shape to circular construction.

Circular models
In the theoretical background, the circular model of the Ellen Macarthur Foundation, the Butterfly model, was explained. This model makes use of a biological and a technical cycle. Regarding the butterfly model, the building sector mainly affects the technical cycle as raw materials are extracted and converted into building materials. In this butterfly model different levels and options are given to circularity, also called as circular design approaches. These circular design approaches are extended in different R models, a model in which all circular design approaches start with an R and the approaches are prioritised (Cramer, 2014; Planbureau voor de Leefomgeving, 2019; Platform CB’23, 2019; Potting et al., 2018; van Buren, Demmers, Van der Heijden, & Witlox, 2016). Some differences

can be observed between the various R-models. The biggest differences are the inclusion of the rethink approach and the position of this circular approach as it is sometimes reversed with the Reduce approach. For this study, the 10R model of Cramer (2014) is added to the model of (Platform CB'23, 2019). This means that both circular approaches rethink and redesign are mentioned in the model. The 10R model can be found in *Figure 4. 1.*

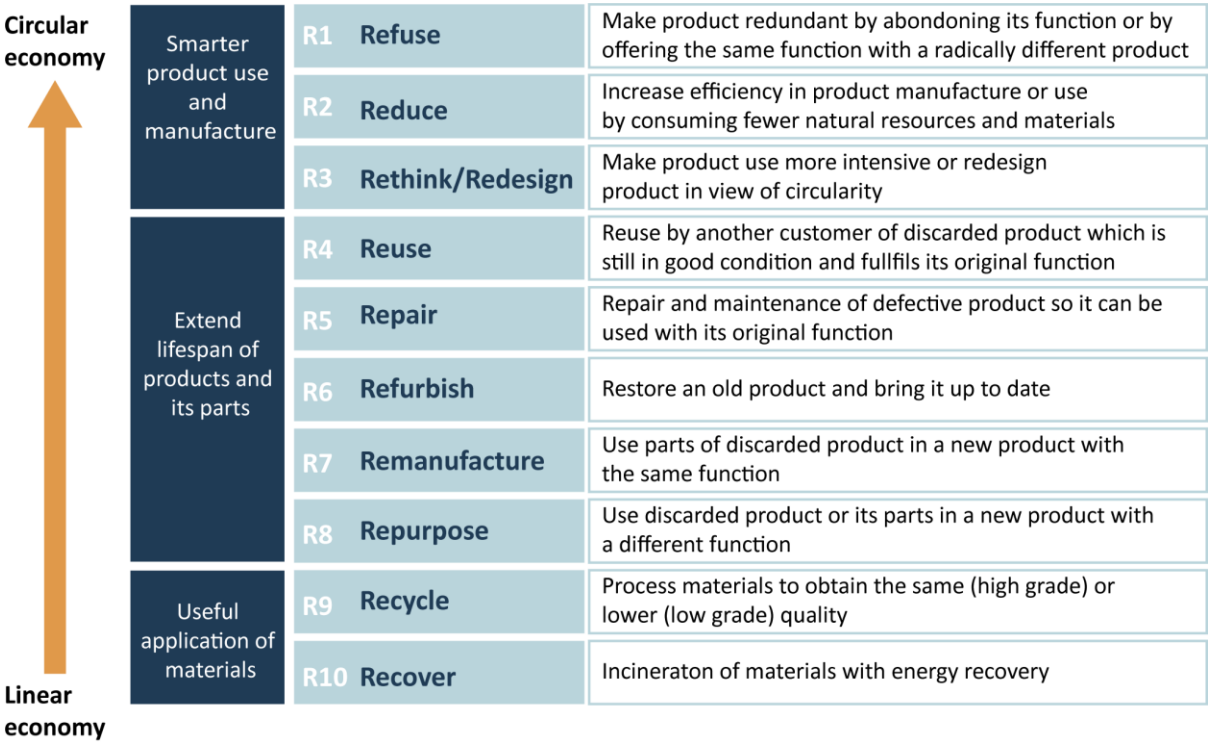

Figure 4. 1 - The 10 R model (Author (2021) based on Cramer, 2014; Potting et al., 2017).

The 10 R model can be seen as a ladder where the highest possible approach has to be applied. The highest possible approach corresponds to the lowest number behind the R. The 10R model consists of R1 Refuse, R2 Reduce, R3 Rethink/Redesign, R4 Reuse, R5 Repair, R6 Refurbish, R7 Remanufacture, R8 Repurpose, R9 Recycle and R10 Recover. As can be seen in *Figure 4. 1*, strategies R1 - R3 belong to 'using and making the product smarter'. Strategies R4 - R8 belong to 'extending the life span of a product and its components' and the last two strategies, R9 and R10 belongs to 'useful application of materials'. The lower the R number, the more circular, the more innovation in product design and the more innovation in the business model. The 10R model and the butterfly model are suggested to explain the meaning of a circular economy and the 10R model is well applicable in construction projects (CE advisor 2 and 5, *Appendix C*)

Another often-discussed ladder is Lansink's ladder, which originated in waste management (Lansink, 1979; Platform CB'23, 2019). This ladder is still often used in the assessment of the degree of circularity, especially at the end of an object's life cycle. The ladder, which can be found in *Figure 4. 2*, consists of six steps, namely prevention, reuse, recycling, energy, incineration and dumping. The lower levels, energy, incineration and dumping, are no longer desirable in a circular economy (platform CB'23).

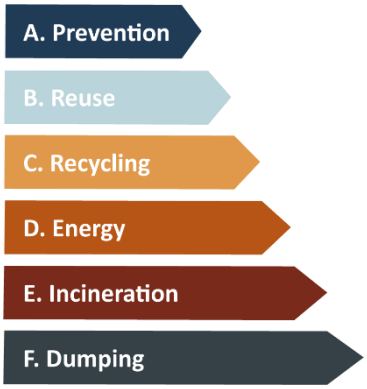

Figure 4. 2 - Lansink's Ladder (Author (2021) based on Platform CB'23, 2019).

Circular concepts

Beurskens & Bakx (2015) state that considering the building as a complete object is still the prevalent way of thinking about buildings. Buildings are designed, realised and used as a total entity. However, over time, buildings will constantly change due to the changes in user demands and in the environmental conditions. Therefore, buildings should be seen as dynamic structures that constantly adapt to current needs.

Although a building is still often seen as a complete object, there are various models that divide buildings into different levels. Pomponi & Moncaster (2017) indicate a systematic point of view, whereby the largest level is the natural environment in which the built environment is present. Within this built environment, cities are identified, which also represent the macro level. The next layer corresponds to the buildings that represents the meso level and the last layer is the manufactured components that represent the micro level. In the same study of Pomponi & Moncaster (2017) it is also indicated that from a circular economy perspective, the built environment research is mainly focused on macro-level and micro-level. CE advisor 3 and 4 (*Appendix C*) confirm that the project of a building should be considered in a broader context than just the building and that a project should try to connect to the environment of the project, as this is also part of a circular idea.

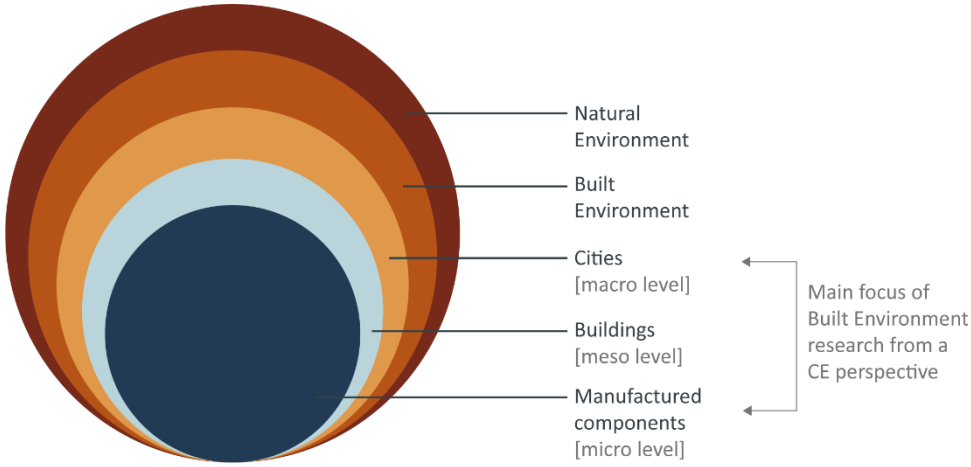

Figure 4. 3 – Dividing the built environment in layers (Author (2021) based on Pomponi & Moncaster (2017))

Whereas Pomponi & Moncaster (2017) approach the building as a whole, Brand (1994) the building in several components and systems. The layer model of Brand (1994) consists in total of 6 layers where a distinction is made between the components of a building and different timescales. This model is an extension of the 4 layer model of Duffy (1990). The shearing layers of Brand include:

- Site - the geographical setting
- Structure - the foundation and load bearing elements
- Skin - the exterior surface
- Services - the internal systems running through a building
- Space plan - the interior layout, walls, doors, floors, etc
- Stuff - the interior

Each layer, mentioned in the model of Brand (1994), encloses materials or parts with the same speed regarding maintenance and life time duration. As described in the research by Brand, recognising different layers in a building will make it easier to adapt if these layers are also taken into account in the design and construction of a building. This life time duration approach results in a hierarchy of layers based on time. This time frame, investigated by Brand (1994) is added to the different layers and are both visualised in *Figure 4. 4*.

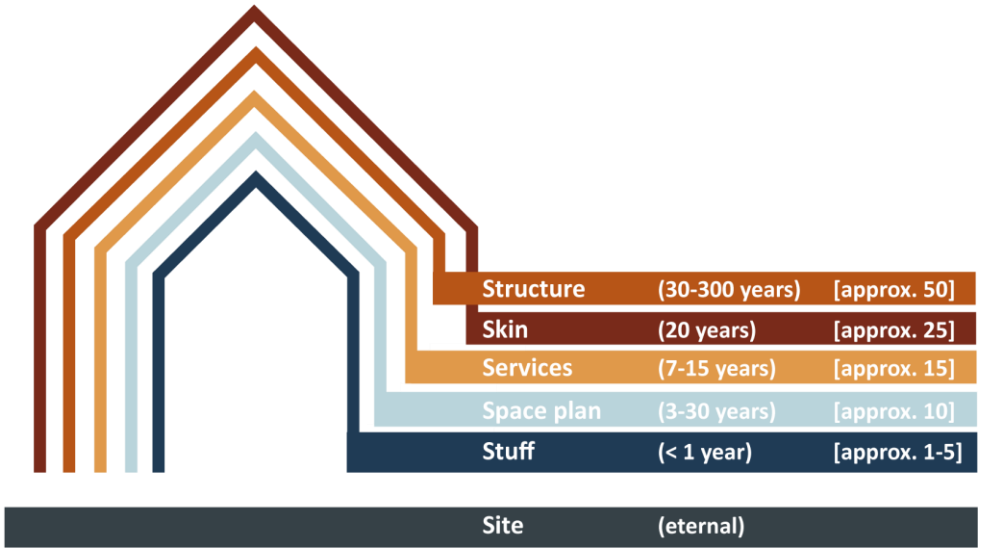

Figure 4. 4 - Shearing layers and their expected and average lifespan (Author (2021) based on Brand, 1994; Crowther, 2001).

Crowther (2001) investigated the different average lifetime durations for every shearing layer, see *Table 4. 1*. The average lifetime are also included in *Figure 4. 4*.

Table 4. 1 - Average lifetime duration shearing layers (Crowther, 2001).

Layer	Average life time (years)
Site	eternal
Structure	50
Skin	25
Services	15
Space plan	10
Stuff	1-5

However, Adams et al (2017) stated that applying the layers to a building, especially its long-lived layers, is still questionable to some extent. This is a result of the limited applied projects wherein circularity in relation to the longer life time layers, such as the structure and skin, has been dealt with recently. The short lived layers and circularity have been adopted in projects, but applying circularity to the long-lived layers is also questionable according to Pomponi & Moncaster (2017).

Circular strategies

Several authors have defined circular strategies, which relate to the way of doing business, or relate to how circularity could be implemented. Some strategies are aimed at dealing with waste at the end of the life cycle, others are aimed at preventing waste in advance, whereby the strategies can thus be applied at the beginning or at the end of the project (Addis, 2006). The graduation thesis of Gerding (2018) mentioned the studies of Ritala, Huotari, Bocken, Albareda, & Puumalainen (2018) and Kraaijenhagen, van Oppen, Bocken, & Bernaso (2016) which categorise circular strategies in narrowing, slowing down and closing. The narrowing strategies reduces the amount of materials and slowing down will reuse materials. Contrary, the closing strategy concerns the recycling of materials. The study of Gerding (2018) compared and framed several strategies with design strategies to implement a circular approach.

Another perspective of circular strategies is given by the book of Cheshire (2016), in which a model is addressed that visualised the principles of the circular economy in relation to the built environment. The model consist of cycles that represent the technical and biological cycles and corresponding design principles, which could be used to achieve the levels of material reutilization. The levels of

material reutilization correspond with the R's of the R model and the loops of the butterfly model, which are both mentioned above. Cheshire (2016) defines five design principles consisting of building in layers, designing out waste, design for adaptability, design for disassembly and selecting materials. Dividing building in layers has been visualised in *Figure 4.3* and *Figure 4.4*. The design out waste principle aimed to reduce waste during the entire building process and is mainly focussed on the engineering side. Design out waste can be divided in: Design for reuse and recovery, design for off-site construction, Design for materials optimization, Design for waste efficient procurement, and design for deconstruction and flexibility (Drijvers, 2019). The design out waste principle correspond to the narrowing strategy mentioned by Gerding (2018). The principles design for adaptability and design for disassembly corresponds to the slowing down strategy described in the master thesis of Gerding (2018). Design for disassembly means designing buildings to facilitate future change and eventual (partial or complete) dismantling in order to recover systems, components and materials (Chiodo, 2005; Guy & Ciarimboli, 2008; Verberne, 2016). In contrast, design for adaptability aims to extend the life of a product by adapting it to changing circumstances and thereby maximising its value over its lifetime (Schmidt, Eguchi, Austin, & Alistair, 2010; Schmidt, Deamer, & Austin, 2011; Verberne, 2016). The last mentioned principle, selecting materials, in Cheshire's (2016) model assumes that materials are an important factor when building with a circular approach whereby different properties should be taken into account when selecting materials. Selecting materials correspond with the closing strategy mentioned by Gerding (2018).

4.1.3 Discussion and conclusion - SQ 1

The first sub-question is: *What does the concept circular economy mean in the construction sector?*
The Dutch government's ambition is to become 100% circular by 2050, whereby the construction sector has been designated as one of the priority sectors, partly due to the high number of materials used, future scarcity of materials and the waste that is currently being produced in the sector.

In the construction sector, a definition is given to circular building as well as to a circular construction. Both definitions are supported by the government advisor on circular construction. The following definition is given for a circular building: *'Circular building means developing, using and reusing buildings, areas and infrastructure without unnecessarily depleting natural resources, polluting the living environment and damaging ecosystems. Building in a way that is economically and ecologically responsible and contributes to the well-being of people and animals. Here and there, now and later'*.
In addition, a circular construction is defined in a twofold manner: *'a circular building (i) is designed and executed according to circular design principles and (ii) is realised with circular products, elements and materials'*. This definition of circular building is in line with the given and widely accepted definition of the Ellen MacArthur foundation. The definition of circular building is more focused on the built environment but is broad in the sense that buildings, areas and infrastructure are all mentioned. This is in accordance with the idea that a building is part of an environment and the circular idea should also be included in this. A building does not only have a function but must also seek connection with the context as indicated by Pomponi & Moncaster (2017) and CE advisor 3 and 4 (*Appendix C*). However, the definition of circular building is still vague regarding where to start and how a building can be built with a circular approach. The definition of a circular construction gives more guidance by referring to circular design principles and that there should be a focus on products, elements and materials. The circular design principles, mentioned in the definition of a circular construction, are prevention, value preservation of materials and value creation of materials. In this respect, the definition of a circular building focuses more on the different layers of a building as it deals with products, elements and materials. This definition is therefore more in line with the identified layers by Brand. In conclusion, both definitions can be used according to user preference to explain circularity but a difference can be made in a broad view where the context is included or exclusively on the building itself.

The CE advisors and the literature mentioned some circular strategies. The CE advisors mentioned detachability, modular construction, the use of renewable materials, biobased and building in wood. In the literature, a distinction can be made between circular strategies and design principles. These design principles are different from the design principles mentioned in the circular construction definition. The circular strategies consist of narrowing, slowing down and closing and the design principles consist of building in layers, designing out waste, design for adaptability, design for disassembly and selecting materials. In order to clarify the term design principle, the design principles that can be categorised into circular strategies will be labeled as circular strategies. This means that the following strategies have been identified: building in layers, designing out waste, design for adaptability, design for disassembly and selecting materials, detachability of materials, modular construction, the use of renewable materials, biobased and building in wood

Various tools can be used to explain and apply the circular economy to the construction project. The 10R model, which elaborates on the butterfly model, the ladder of Lansink and the shearing layers model are tools that could be applied when adopting a circular approach.

4.2 Traditional project management vs. (semi-)circular project management

This chapter will focus on the difference between traditional project management and (semi-)circular project management. In order to get a better understanding of these differences, a case analysis was used in which 2 traditional and 4 (semi-)circular projects were analysed. In addition, use has been made of both interviews A and B. Sub-question 2 is: *What are the differences between traditional and (semi-)circular project management regarding the initiation and definition phase in terms of the process, the project management, the involved stakeholders, the role of the project managers and the working method?* Firstly, the input from the interviews will be discussed and then the six projects will be analysed by means of a case analysis.

4.2.1 Input circular advisors and construction project managers

Various topics are covered in the interviews with the circular advisors (interview A) and construction project managers (interview B). These topics are: working method, project management and the role of the project manager. The topics will be individually discussed with the input from both interviews. The individually results of interview A and B can be found in *Appendix E – Overview results interview A* and *Appendix H – Overview results interview B*. The transcripts of interview A and B can be found in *Appendix C – Transcripts interview A* and *Appendix G – Transcripts interview B*

4.2.1.1 Working method

Analysing the results of the interviews, the topic of working methods can be divided into client's awareness, circular objectives and new working methods.

Client's awareness

A project manager must have the courage to start a dialogue with the client in order to raise awareness of the circular economy and circular construction (CE advisor 1, *Appendix C*). CE advisor 3 (*Appendix C*) responds by arguing that awareness of circular ambitions is necessary for a client to integrate the concept of circularity into projects. CE advisor 2 (*Appendix C*) adds that a success factor for integrating the concept of circularity is to succeed in convincing the client to adopt a circular approach, whereby a clear ambition and vision on the part of the client are important. CE advisor 1, 3 and 4 (*Appendix C*) state that the project manager has an important role in stimulating the demand for circularity among clients and in creating awareness and support for a circular approach. In particular, project managers are in positions where they can integrate new processes. CE advisor 1, 2 and 4 (*Appendix C*) indicate that it is very important that the client and project manager understand each other about the concept of circularity. It is important to start the conversation with the questions: "What is circularity to you?" and "What are your goals?" and to see what can be achieved in the project. At the start of the project, the project managers will have to examine the preconditions of a project and should try to establish a link with circularity or sustainability. Circularity can be a goal, but it is always related to energy transition and climate adaptation (CE advisor 1 and 6, *Appendix C*). CE advisor 4 (*Appendix C*) adds that it is important to ask: what the client want and what objective do they have in mind, which can be clarified with examples to show possibilities within a circular approach. Asking the client about sustainability ambitions at an early stage prevents the ambition or objective from emerging halfway through the project, with the result that the integration of the ambition is then much more difficult with major consequences for the management aspects time and money (CPM 6, *Appendix G*). CE advisor 4 (*Appendix C*) indicates that the initiative for a discussion does not always have to originate from the project manager, but that it can also occur that the client is already aware of the concept and that the client can take the initiative for a circular approach. CE advisor 5 (*Appendix C*) describes the very first step of a circular project as making the client aware of its circular ambitions, followed by the formulation of those ambitions. CE advisor 3 and 5 (*Appendix C*) point out that a construction project manager needs basic knowledge and enough information to be able to start a conversation

and to challenge the client to be more sustainable than they are at the moment. CE advisor 6 (*Appendix C*) adds that project managers also need to understand and to be able to explain the idea behind circularity. For this knowledge, it is important to know the 'why question' of circularity. The story has to motivate, be right and be connected to the story of the client in order to generate support and awareness among the client. CPM 3 (*Appendix G*) also indicates that the construction project managers needs to be able to answer the why, how and what questions asked by the client. CPM 1 and 6 (*Appendix G*) extend this statement with the idea that a project manager does not need to know everything, but does need to know what the concept entails, what it means for the project and what the consequences are when circularity is integrated. CE Advisor 7 (*Appendix C*) adds that the need for a transition is often recognised, but that certain processes in companies are set up in such a way that they do not know how to make the transition. A project manager can help to implement the transition in the project.

Circular objectives

The circular objectives section can be divided into defining, ensuring and measuring the objectives.

Defining circular objectives

During the conversation with the client, which is intended to raise awareness, the project manager should address the circular objectives of the client and check whether the highest achievable objective will be achieved. The (circular) ambitions should be discussed as well in this conversation to understand the goals of the project and to define the collective scope of the project (CE advisor 1, *Appendix C*). CPM 4 (*Appendix G*) indicates that a construction project manager should at least draw the client's attention to sustainability or new concepts such as circularity. However, the client often formulates its own objectives (CPM4, *Appendix G*). CE advisor 2 (*Appendix C*) indicates that defining the objectives should be as specific and complete as possible since it is better to realise that it has been too specific rather than the objectives remained too general and did not lead to a circular approach. Furthermore, CE advisor 2 (*Appendix C*) indicates that there should be a clear circular objective in a circular project. The circular ambitions have to be formulated in project objectives and well documented. A circular ambition must be a precondition of the project, otherwise circularity is the first thing to be eliminated when budget cuts are made (CE advisor 2 and 5, *Appendix C*). These project objectives are often formulated in the definition phase. When formulating (circular) objectives it is important to have a point of reference (CE advisor 2, *Appendix C*). Furthermore, CE advisor 4 (*Appendix C*) indicates that a proper formulation of objectives has a tremendous impact on the design. For example, a client may require certain parts of the building to be dismantlable, require parts to be designed in a modular form, require bio-based and renewable materials to be used, require the building to be designed according to the Stewart Brand layers model or require the building to consist of x% recycled materials. CE advisor 5 (*Appendix C*) agrees with the previous mentioned and states that including circularity in the specifications for tenders has many positive consequences for the integration of circularity in the project. CE advisor 7 (*Appendix C*) says that circularity is a very broad concept, and that the client's opinion of circularity has to be defined in the objectives.

Ensuring circular objectives

A project manager has various options for ensuring circular objectives in his project. The current used options for ensuring objectives can also be used to ensure circular objectives (CE advisor 1, *Appendix C*). It is possible to include various aspects in a tender, even if a client does not ask for them. In addition, formulated objectives can be included in a plan of approach for the project or circular award criteria can be included in a tender which can be divided into quantitative and qualitative award criteria. Quantitative award criteria include making an Environmental Cost Indicator calculation or including a materials passport, etc. Qualitative award criteria, also referred to soft award criteria, include: objectives, ambitions, the organisation of a process, what is the plan of approach, etc. When using qualitative award criteria it is important to discuss in detail how the market will be consulted

(CE advisor 1, *Appendix C*). CE advisor 5 (*Appendix C*) adds that there are a number of moments when circularity can be ensured: what to include in the invitation to tender, which parties will be chosen, which materials will be chosen and how the materials are attached. CE advisor 2 and 5, *Appendix C*) indicate that securing objectives starts with making circularity part of the project objectives. Both CE advisor 3 and 6 (*Appendix C*) indicate that as long as there are no rules in the building regulations and from the government regarding measuring and guaranteeing circularity, everyone will do their own thing and there will be no unity in comparing projects. As soon as legislation and regulations are introduced, there will be unity and the major transition to a circular economy can be started. CE advisor 3 and 4 (*Appendix C*) provided methods to help ensure and monitor the objectives: The GPR score for dwellings and residential buildings, the BREEAM certificate which focuses mainly on utility and sustainability in general, the WELL label which assesses health and comfort and a Life cycle analysis. In addition, advisor 3 (*Appendix C*) indicates that a materials passport may be required in a project. CE advisor 6 (*Appendix C*) indicates that it is important to be able to quantify the objectives in order to monitor progress and ensure that the wanted results are achieved. In addition, CE advisor 1 and 7 (*Appendix C*) indicate that it is also useful to ensure substantive circular knowledge. This knowledge can be ensured by the projectteam, with the help of a sustainability manager or a circular advisor, who can also collect and asses the circular opinions or advice of the team members.

Measuring circular objectives
Besides formulating and ensuring the circular objectives, the objectives should be made measurable by determining which indicators are monitored and measured (CE advisor 2 and 6, *Appendix C*). The examples of an environmental cost indicator, the 10 R ladder with a weighting per R, BREEAM scores, life cycle analysis, the MPG score and GPR score can be considered as circular indicators. Currently, there is no universal measuring method for circularity, but most sustainability measuring tools, such as MPG, BREEAM and GPR do include components of circularity (CE advisor 3, *Appendix C*). For example, it is possible to ask for a lower MPG value in the tender for the project than the government prescribes or to introduce the Circular Performance Building (CPG) score in the project. This CPG measuring method was developed by the same party as the GPR score, but the user does not have to be certified, so the reliability could be questionable (CE advisor 3, *Appendix C*). However, the method does give an indication of the building's circularity rate (CE advisor 3, *Appendix C*). Furthermore, the measurement methods to calculate the detachability of materials or to measure the amount of the kilos of raw materials brought into and released from a building per year could be used to measure the circular objectives as well (CE advisor 3, 4 and 6, *Appendix C*).

New working method
Currently, the approach to projects is linear; there is a question, it is answered with a project, the project is delivered and the hired party leaves. The question arises whether a circular approach should also include a circular service; developing a solution at the beginning, delivering the solution and remaining involved during the lifespan to ensure that solutions remain as optimal as possible (CE advisor 1, *Appendix C*). A circular approach will not result in different work activities, but in different starting points whereby circularity is an addition to the current work (CE advisor 1 and 2, *Appendix C*). It is important to have a circular ambition for the project as early as possible since it avoids the need for adjustments in a later stage (CE advisor 1, 2 and 6, *Appendix C*; CPM 6, *Appendix G*).

Proper documentation of project information is important for designing in a sustainable and circular way, making circular processes transparent and having information about the output of the project (CE advisor 2, *Appendix C*)). It is also important to list the possibilities in the field of circularity at the beginning of the project and to make a longlist of these, after which the possibilities can be selected that suits most. Besides, it is possible to include an inventory scan at the start of the project, which will have consequences for money and time (CE advisor 2, *Appendix C*). CE advisor 1 (*Appendix C*) adds that detailed information about the current state of the project, which could be a material analysis,

should be available at the preliminary stage of a project. A material analysis provides an insight into the materials available, the materials which are released, those which can be reused and could be linked to the circular objectives of a project (CE advisor 1, *Appendix C*).

The subject of circularity has to be added to the agendas of meetings as a reminder for the project manager (CE advisor 5, *Appendix C*). It is extremely important to move from project's circular ambitions to a personal drive for the clients or team members (CE advisor 1 and 4, *Appendix C*). In addition, the project team should be aware of the definition of circularity and the different strategies for circularity such as design in separate systems, building adaptability and building future proof by including flexibility (CE advisor 4 and 6, *Appendix C*). In addition to the scope of the building, project members should also attempt to connect to the context of the building, since this is in line with the definition of circularity (CE advisor 4, *Appendix C*)

In a project, a method should be incorporated that reflects considerations in the design process, which questions: "is the project necessary?", "has every effort exerted to reuse the newly released materials?" and "are all the components in the design necessary or is a reduction in material still possible?" (CE advisor 1, *Appendix C*). Including circular ambitions in the call for tenders during the procurement often leads to positive results in projects with circular components (CE advisor 3, *Appendix C*). Asset management and maintenance should be included in the early stages of the demand for a new building. At the beginning of a project, an analysis can be made of the amount of materials that will be used for construction and the needed materials for maintenance which may show that it is profitable to use extra materials during construction in order to save maintenance material (CE advisor 6, *Appendix C*). A new working method may also involve increasing the standardisation of building (component) dimensions in order to improve the applicability of products in other projects (CE advisor 7, *Appendix C*).

The project managers indicate a cooperation with a circular advisor to incorporate substantive circular knowledge in the project since project managers do not have the knowledge of current developments in the market in the area of circularity (CPM 1, 3, 5 and 7, *Appendix G*). In addition, CPM 1, 7 and 8 (*Appendix G*) also indicate that new collaborations with companies and/or market parties will take place earlier in the process, such as a demolisher or a cost expert to convince the client of the added value of a circular approach. CPM 8 (*Appendix G*) indicates that a project manager cannot integrate circularity in a project on its own.

4.2.1.2 Project management

Analysing the results of the interviews, the topic project management can be divided into current project management and project management with a circular approach.

Current project management

A construction project has a start and an end, which needs to be managed in between (CPM 1 and 8, *Appendix G*). The definition of project management is: a client has a challenge with certain objectives and ambitions and wants to realise them by consulting a project manager to make it a feasible project (CPM 7, *Appendix G*). Generally, a client has a number of objectives for a project, such as time, budget and quality standards that must be met and monitored (CPM 3, *Appendix G*). The project can be divided and executed in phases, in which certain document will be produced per phase (CPM 4, *Appendix G*). The progress of a project will be discussed in a steering committee of the organisation and in the project team (CPM 3, *Appendix G*). The project can be managed with management aspects (CPM 7, *Appendix G*). The standard and most visible management aspects are time, money and quality, to which risk, organisation and information are sometimes added (CPM 1, *Appendix G*). Certain management aspect are more important than others for the client, so each project should determine the focus of the aspects (CPM 7, *Appendix G*).

The process of project management barely differs between the various construction projects, but the project differs in terms of objectives and the focus on the management aspects (CPM 8, *Appendix G*).

Project management with a circular approach

CE advisor 2 (*Appendix C*) stated that the project management process remains the same, but that more in-depth layers will be added, such as the integration of data in order to accelerate the circular economy. CE advisor 6 (*Appendix C*) concurs with this view and explains that the technical content of the project will change. In addition, CE advisor 5 (*Appendix C*) indicates that the process will change since the circular choices have to be considered, which costs more time and money but does result in a more future-proof end product. Managing projects based on time, money and quality is old-fashioned and belongs to linear thinking, but indicates that money is considered as important. Furthermore, this shows that money is an objective rather than a means in projects, whereas preservation of raw materials or the value of raw materials should be more important (CE advisor 1, *Appendix C*).

The construction project managers are also divided in their opinion about the position of circularity in relation to the management aspects. Circularity is a modern theme, which is relevant present day and may be taken for granted in the future, while management is a recurring aspect (CPM 1, *Appendix G*). CPM 3 (*Appendix G*) supplements this by stating that circularity is a theme and not a management tool. CPM 1, 3 and 4 (*Appendix G*) would like to classify circularity as a quality management aspect. According to CPM 8 (*Appendix G*), circularity is a design component with consequences for time and money. CE Advisor 1 (*Appendix C*) states that categorising circularity as a quality aspect is not proportional to the quality, time and money aspects but that it will be an addition to the current activities. In addition, CPM 6 and 7 (*Appendix G*) add that circularity could not be classified as one management aspect as it affects all aspects. At the end, each project manager is free to decide how to include circularity in the management aspects. According to CPM 5 and 8 (*Appendix G*) should circularity be managed and added to the agenda of meetings. CE advisor 2, 3, 5 and 6 (*Appendix C*) stated that a project manager should manage and pursue circularity to become a formal part of the contract and a precondition in the project. There is no consensus on the organisation of circularity in the project. However, CPM 1, 4 and 6 (*Appendix G*) indicate that the project manager should draw the client's attention to new concepts such as circularity. In addition, a client should not have to be concerned about achieving its circularity targets, which should be the task of the project manager (CPM 1 and 6, *Appendix G*). In this respect, a position of trust should be available between the project manager and the client (CPM 8, *Appendix G*). Since every project is unique, it will be necessary to examine with the client which aspects are possible in the field of circularity (CE advisor 1 and 2, *Appendix C*; CPM 7, *Appendix G*).

The results of interview A raised a number of other issues that belong to project management with a circular approach. Therefore, finances, ownership, risks, collaborations and procurement are addressed below.

Finances

Currently, experience in dealing with budgets within circular projects is still limited. The driving force behind a circular economy is the residual value (of materials) at the end of a project's life. The key to a circular approach will be assigning value to materials and the possibility of reusing them (CE advisor 2, *Appendix C*). A remaining value is attractive but only relevant at the end of the project's life. A residual value is therefore only interesting at the start of the project if the client can include it as a deduction from the investment (CE advisor 2 and 4, *Appendix C*). In addition, CE advisor 3 (*Appendix C*) indicates that mapping the residual value is very difficult and only some companies are able to do this. In the future there will probably be a new tax system with taxes on materials, in which materials gaining value (CE advisor 3 and 6, *Appendix C*). As soon as circularity can be made financially attractive,

more demand will arise (CE advisor 7, *Appendix C*). Project managers should be able to inform the client with the consequences for the costs of the project when circular objectives are included, since circular ambitions costs more (CE advisor 5, *Appendix C*). The project manager should also know when it is financially interesting to make use of product as a service or other ownership models (CE advisor 7, *Appendix C*). The MIA-VAMIL grant can be applied when using a materials passport, a low MPG score and some other criteria. A subsidy can also be requested for the GPR-score and BREEAM-score, but a high score is mandatory to have a chance receiving the subsidy (CE advisor 3, *Appendix C*). It can be concluded that there is a paradox in the construction industry at the moment; the business model is to build while circular economy strives to preserve existing components as long as possible. In addition, new construction is usually cheaper than reusing materials because of labour costs and storage costs (CE advisor 6 and 7, *Appendix C*). CE advisor 7 (*Appendix C*) argues that man-hours and machine-hours always recur whether you build new or reuse. The more you return your materials to their original state, the more operations you perform and the more money you spend. If you can limit the reduction of materials to a suitable building material that already has a certain shape, for example Lego blocks, that will saves a lot of money. Ultimately, everything is now dominated by money (CE advisor 7, *Appendix C*).

Ownership

Product as a service is a circular concept in which the ownership of that particular service is transferred to another party. CE advisor 3 (*Appendix C*) states that the building industry is not yet ready for product as a service, but it can be considered for elevator (facilities), lighting and furniture. In addition, it becomes very complex when having several owners for one building, which, in combination to new risks, also involves legal aspects (CE advisor 3 and 6, *Appendix C*). CE advisor 2, 4 and 6 (*Appendix C*) indicate that product as a service entails many risks such as: does the service company exist for the entire life cycle of the building, the fragmentation of ownership and the amount of work involved in maintaining administrative contracts.

Risks

A project manager needs to understand the risks involved in a circular approach and should also mention them during a discussing with the client (CE advisor 1 and 2, *Appendix C*). A circular approach will give rise to new risks, for example gaining guarantees by the reuse of materials (CE advisor 3, *Appendix C*). There are also risks associated with sharing ownership (CE advisor 2, 3, 4 and 6, *Appendix C*).

Collaborations

Collaborations are important within a circular approach. The most common approach to realise circular projects is to form a construction team, which is formed in the definition phase and involving the demolisher or contractor earlier in the process (CE advisor 1, 2 and 5, (*Appendix C*)). Projects with a circular approach have an increasing trend towards a collaborative approach rather than focussing on specifications or other forms of contracts. In addition, procurement awarding is mostly based on a competition-oriented dialogue. It is therefore noticeable that a cooperation with the market is preferable but needs faith in the market (parties) (CE advisor 2, *Appendix C*). Involving parties early in the process will result in more detailed and specific solutions to the project (CE advisor 1, *Appendix C*). Collaborations are necessary in order to have an overview of the supplying chains of materials, to tackle the complexity of projects and due to the increasing multidisciplinary and international focus of projects (CE advisor 2 and 7, *Appendix C*). Cooperation with a sustainability manager or a circularity advisor could help to gather the opinions or advice of the team members, to assess the accuracy of these opinions and to provide technical aspects of the project. A project manager has to verify which parties are needed in the project with regard to circularity (CE advisor 1, *Appendix C*). CPM 1, 3, 5 and 7 (*Appendix G*) also indicate that an expert or consultant on circularity is needed in the project. However, a project team should always support the choices made to include a circular approach (CE

advisor 3, *Appendix C*). In the Netherlands, the working method is rigid and the same cooperation partners are often used in order to control and limit risks. In contrast, small companies are more open to innovation (CE advisor 7, *Appendix C*).

Procurement
Within a tender, a materials passport can be requested to guarantee information on the materials used in a project (CE advisor 3 and 5, *Appendix C*). However, CE advisor 6 (*Appendix C*) does not yet recognise the value of a materials passport, given that the lifespan of a building is approximately 50 years, resulting in a long period before the materials are released again. Furthermore, a materials passport must be stored and adjustments need to be added in the maintenance phase (CE advisor 6, *Appendix C*). It is also possible to request for an Environmental Performance of Buildings value (in Dutch MPG-score), a GPR or BREEAM score in the tender. These values barely mentions circularity, but this will be extended in the future (CE advisor 3, *Appendix C*).

4.2.1.3 Role of the project manager

Analysing the results of the interviews, the topic of the role of the project manager can be divided into the current role of the project manager and the change in the role of the project manager to integrate a circular approach.

Current role of the project manager
The interviewed project managers indicated that the roles they currently fulfilled as project managers varied from project to project. For example, the project manager sometimes works for an executing party such as a consortium that has to build, for a client that has a project or as a consultant for a financier (CPM 1, *Appendix G*). In addition, distinction can be made between working as a delegated client and as a consultant for a client (CPM 4, *Appendix G*). The types of clients of the interviewed project managers therefore differ from governments, municipalities, school boards, companies, housing corporations, pension fund and private parties. These different types of clients also result in different types of projects. However, the similarity between the types of projects is that each project is special or complex for which a project manager is hired. This complexity may consist of a special type of contract or a complex administrative or organisational structure (CPM 1, *Appendix G*). In general, a project manager has tasks that are difficult, tasks where others do not know the procedures and the task of bringing different parties together (CE advisor 7, *Appendix C*). For each type of project, the project manager will have to convince the client of the capability to run the project successfully within the set constraints (CPM 1, 2, 4, 7 and 8, *Appendix G*). When convincing the customer, a business case is usually presented by the project manager in which the customer is informed about the management aspects time, money and quality and the offer of the project manager to the client (CPM 1, *Appendix G*). The project manager manages the process of a project from idea to realisation (CPM 2, 4 and 6, *Appendix G*). A project is divided into phases and certain products are delivered in each phase (CPM 4, *Appendix G*). The project manager is the link between the various parties involved and responsible for the interaction between them (CPM 3 and 6, *Appendix G*; CE advisor 7, *Appendix C*). In addition, a project manager has to arrange the project for the client and thereby relieve the client of his/her concerns. This is essentially working with people, whereby it is ensured that everything is properly managed. It is the task of the project manager to assess the feasibility of the ambitions and objectives of the client (CPM 7, *Appendix G*). In addition, a project manager is given a number of objectives, such as budget, time and quality standards, which must be met and monitored (CPM 3, *Appendix G*). Furthermore, a project manager must be able to translate the client's wishes into design questions and the entire preparation into contract documents. In order to be able to do this, a project manager needs to be an all-rounder; he or she needs to be able to deal with people, have technical affinity, process affinity and financial insights (CPM 4, *Appendix G*). The project managers can convince the client of matters that are part of legislation and regulations, and can advise the client on optional matters (CPM 4, *Appendix G*).

A difference can be made between a project leader and a project manager. A project leader is responsible for one project and a project manager is often responsible for several projects at the same time (CPM 5 and 8, *Appendix G*). In addition, a project manager is less involved in the content than a project leader and is therefore able to maintain overview and a vision for the future (CPM 1, *Appendix G*). A project manager will be positioned between a project leader, who is technical, and an organisation that has little understanding of technology and construction. The task is to look after the interests of both parties (CPM 2, *Appendix C*).

Change in the role of the project manager

A project manager is the advisor of a project and thus the knowledge holder in most cases for the client. The project manager's task is to encourage circularity to become a formal part of the project (CE advisor 1, *Appendix C)*. In this context, project managers will have to be able to transfer knowledge about a circular economy to their own projects (CE advisor 1, *Appendix C*). CPM 1 and 6 (*Appendix G*) indicate that a project manager does not have to know everything, but that they should know what the concept entails so that they can make the right decisions. A project manager should not only be concerned with the processes of a project, but should also have substantive knowledge of the concept of circularity, or should ensure that someone else performs this function within the project team. A circular advisor could add substantive knowledge and ensure the knowledge in a project(team) (CE advisor 5, *Appendix C*). A project manager is responsible for informing the client about opportunities in the field of circularity (CPM 5, *Appendix G*). CE advisor 7 (*Appendix C*) adds that a project manager should provide the client with an impression of building with a circular approach. In addition, the role of the project manager is to ensure that a demand arises with circular ambitions for the project (CE advisor 1 and 3, *Appendix C*). To stimulate this demand, awareness of the concept of circularity and support on the client's side must be created (CE advisor 2, *Appendix C*). In order to generate this demand with circular ambitions, a dialogue will usually have to take place between the project manager and the client which have been discussed in *chapter 4.2.1.1* and can be initiated by the project manager (CE advisor 1, 2 and 3, *Appendix C*). CPM 1 and 7 (*Appendix G*) indicate that the project managers often have the conversation with the client at the beginning of a project, that they should introduce the circular concept to the client and that they have to consult someone when the customer is convinced and it becomes technically specific. CPM 8 (*Appendix G*) adds that the project manager has to propose a circular approach, which will result in the development of processes. A project manager and a consultant will always be needed in projects. A project manager may also function as an estate agent for standard systems in the future, when building with modular components is more desired (CE advisor 7, *Appendix C*).

4.2.2 Input case analysis

Six cases have been analysed by means of a case analysis. The information for the case analysis was obtained from project documents and from the interviews of interview C. Within the upcoming paragraphs, project A will be fully explained. Subsequently, projects B to F will be explained by means of a summary and illustrations. The complete analysis of project B to F can be found in *Appendix L – Case analysis projects B - F*. The interviewees of the project are underlined in the organisation charts. The transcripts of interview C can be found in *Appendix I – Transcripts interview C*.

4.2.2.1 Project A

Project Generic

A hospital location that no longer met safety requirements had to be accommodated at a new location. The new location was merged with the main location of the healthcare institution. The client is a healthcare organisation and the project is a traditional project.

Project Specific

Initiation and definition phase

The initiation and definition phase were an enormous spatial puzzle. The main building was already there, spaces were moved and functions were added to existing spaces.

Initiation phase

The programme manager, from the hospital's real estate team, operated in a functional manner and had discussions with all departments located at the old location. Each department had to indicate the amount of space required for the new location, which resulted in a maximum space for each department. Firstly, a new location was considered, but this was rejected by the board at the beginning of 2018. Subsequently, one project objectives was to fit within the surface area of the main site. Subsequently, different spatial designs were created for each department. The spatial designs were combined into various sub-projects. The initiation phase was mainly a feasibility study executed by project management organisation 1 and the hospital's real estate team. In addition, work resulted in the development plan, the business case in terms of planning, budget and a space analysis with spatial stain drawings.

Definition phase

There was still no technical feasibility study and no programme of requirements. A switch occurred within project management consultant companies, which result in project managers 2A and 3A. They divided the project into smaller fragments. In the definition phase, 12 sub-projects of the various sub-projects defined in the initiation phase have been developed. The spatial stain drawings of the sub-projects have been further elaborated with spot drawings. The ambitions of the client have been discussed and translated into the programme of requirements. This programme of requirements was converted into agreement drawings on which parties could be contracted.

Progress of the project

The agreement drawings were further elaborated in the design phase. The technical side of the project, which is normally also included in the initiation and definition phase, is now incorporated in the design phase. The technical specifications of a sub-project have been determined by the technical specifications of the space around it. The starting documents for the design phase were the plan of requirements, the functional puzzle, the sketch design and a business case. There has been no tender procurement for the design phase. The in-house architect received the order, who also did the plan development in the initiation phase. Most of the necessary parties were already connected to the client's connections and their knowledge have been used during the entire project. The absent market parties which were desired, have been chosen on the basis of their knowledge of hospitals and in accordance with budget. Exploitation was the main focus of this project.

Project management
A project management plan has been written according to the Dutch 'Grotik' management aspects; money, risks, organisation, time, information, communication and quality. This project management plan contains an ambition for sustainability, but this ambition is not managed or used for procurement. Each sub-project has a responsible person, a planning and a budget. Project Manager 2A has final responsibility for all 12 sub-projects, needs to monitor everything and updates the entire steering committee on a global level. Project manager client A ensures that information is exchanged between project A and the client.

Planning
The initiation phase has had a duration of two years. The definition phase took six months.

Budget
Project A had a budget of 18 million. The emphasis in this project was exploitation-oriented budgeting and designing. This implies less margin for the management aspect time and money. Furthermore, within the construction phase choices have been made to save costs in the exploitation phases. A multi-year maintenance budget is included in this project.

Procurement
Since the healthcare organisation is not a government institution, there was no need for European tendering. In this project, the in-house architect and contractor were involved and there was no need for a tender procurement.

Form of contract
From the design phase, a construction team was formed with parties that were already present. A traditional UAC contract have been used.

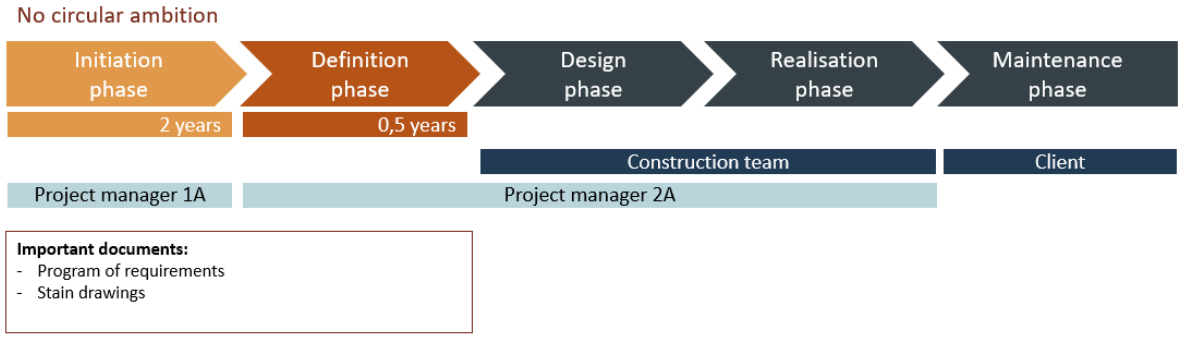

Figure 4. 5 - Process Project A (Author, 2021).

Role of the project manager
The hired external project managers were expected to bring in their own knowledge in addition to the standard management knowledge.

Involved stakeholders
Connections for the consultants were provided by the organisation's network or previous experiences with parties in other projects. Project Manager 1A worked at a strategic level and was replaced by Project Manager 2A and 3A during the definition phase.

Organisation chart

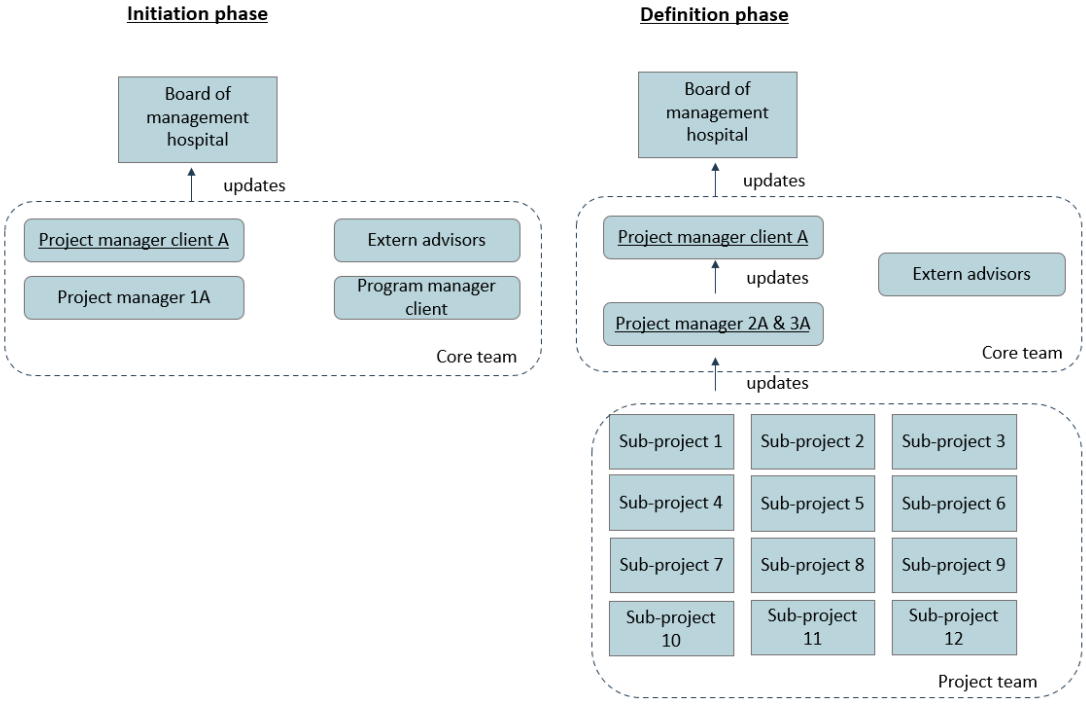

Figure 4. 6 - Organisation chart project A (Author, 2021).

Circular ambition

Circularity was not discussed during the initiation and definition phases and emerged during the design and realisation phases. The project managers 2A and 3A considered translating a circular ambition in a practical form, including time and money, as difficult (*Appendix I*). In addition, Project manager client A indicated that the added value of circularity should be recognised and this was not the case in this project (*Appendix I*). There are sustainability ambitions within the organisation. However, sustainability was not a goal for this project. The main objective was to solve the puzzle of relocating all functions and to realise this as quickly as possible. In the realisation phase, walls and office facilities were reused. However, this has not been named and has been done automatically. It is practical and no administration is involved. In addition, in the realisation phase, there were also some barriers such as the dismantling, storage and assembly of materials. It was seen as more work to reuse old materials of the organisation than to use new ones. The organisation of project A is willing to discuss circularity. Project manager client A (*Appendix I*) suggests to include circular knowledge in an future project at an early stage in order to prepare for the design phase. In smaller projects, circularity could have developed more specifically.

Summary of project A

The project concerns a relocation of a hospital. This is a traditional project without circular ambitions. The aim was to relocate the functions as quickly as possible. In this project, the added value of circularity was not seen. At the transition from initiation to definition phase, there was a change of project manager. The project phases were followed up by each other and executed with stakeholders who were known to the client. Project A is divided into 12 sub-projects and is management with the 'Grotik'-aspects.

4.2.2.2 Summary of project B

The project includes the realisation of a new school involving three types of clients. The project is divided into building south and building north. Building north is following building south. The construction project manager has been replaced between the initiation and definition phases. In the definition phase, a third project manager was appointed for the education and facilities aspects. The project does not have circular ambitions but does have sustainability ambitions in the form of energy neutrality. Even though circularity is not expressed in the construction, it is present in the vision and education of the users. The project is managed according to the 'Grotik'-aspects and the programme of requirements is an important document for the project.

Project management

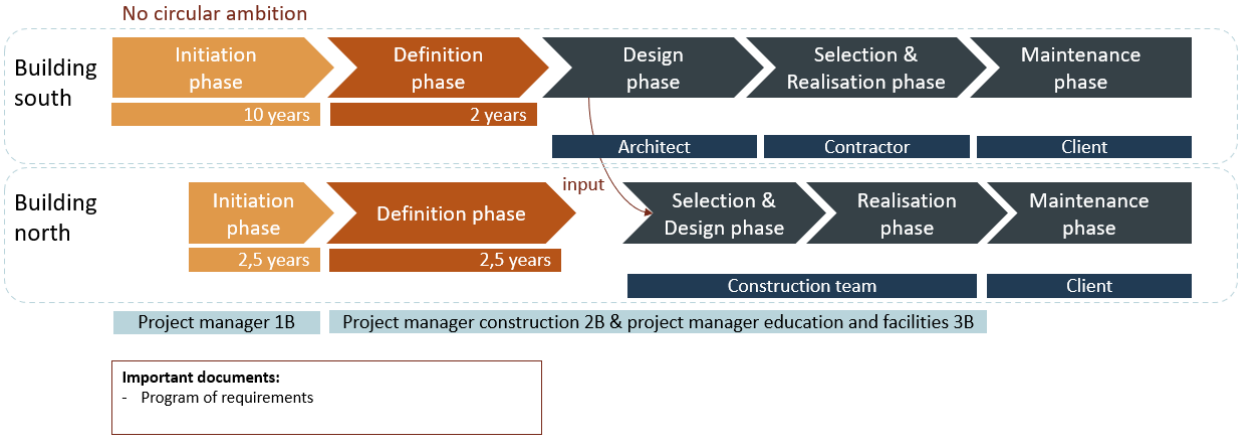

Figure 4. 7 - Process project B (Author, 2021).

Involved stakeholders

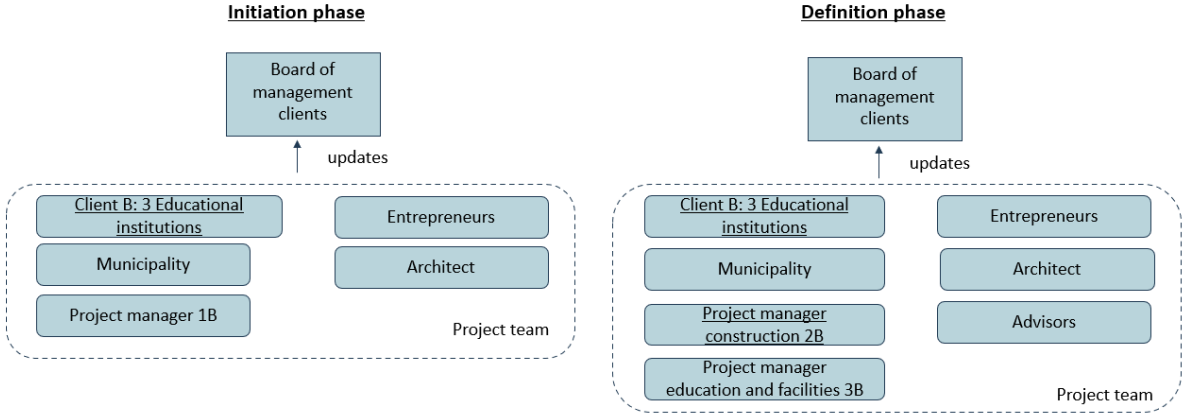

Figure 4. 8 - Organisation chart project B (Author, 2021).

4.2.2.3 Summary of project C

The project concerns a new building to be constructed whereby circularity is an ambition from the start and the entire organisation support the approach. An external party helped to define the ambition and draw up the most important documents. A construction team selection took place in the definition phase based on soft selection criteria. Together with the construction team, the highest achievable programme of requirements was established. In this project 5-10% extra money was needed for circular building and 1 to 2 extra months for formulating the circular ambitions.

Project management

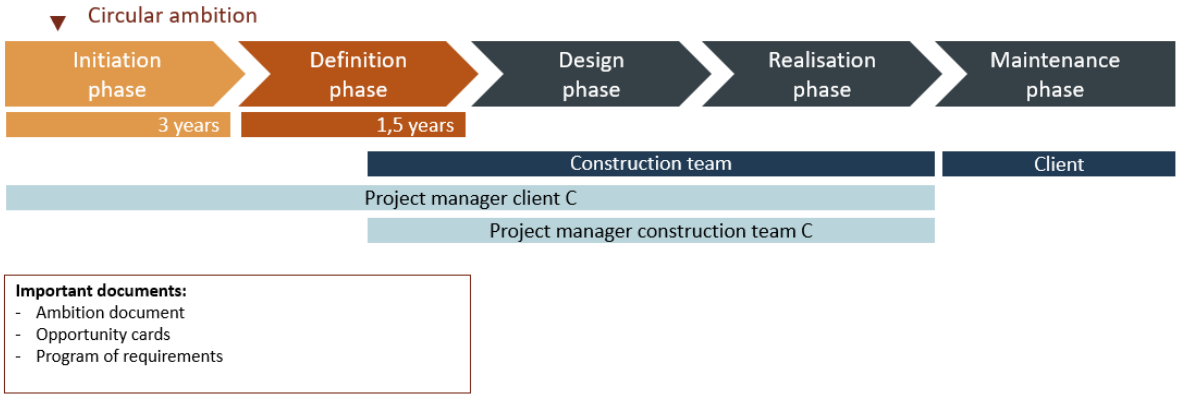

Figure 4. 9 - Process project C (Author, 2021).

Involved stakeholders

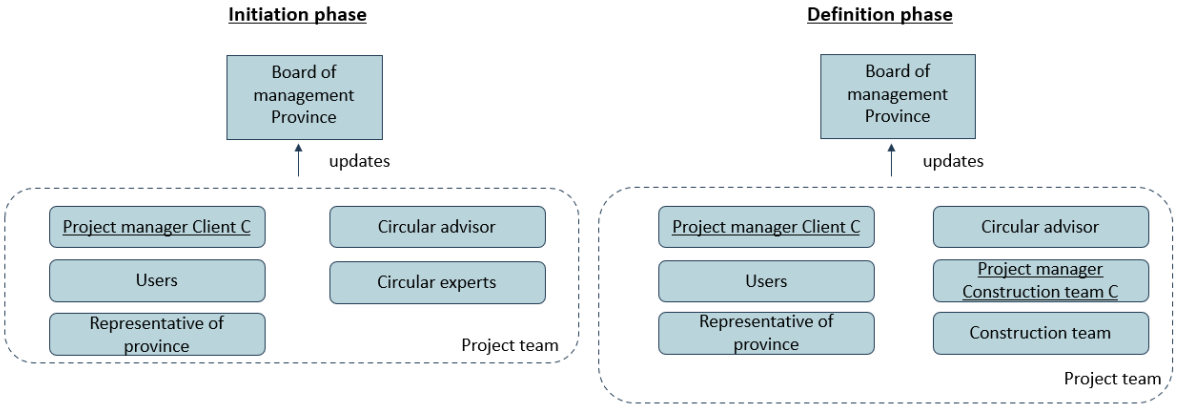

Figure 4. 10 - Organisation chart project C (Author, 2021).

4.2.2.4 Summary of project D

The project concerns a new building to be constructed. Project D has a circular ambition from the start but leaves the options and the definition for a circular approach to the market parties. In the initiation phase, the client performs the project management and, from the definition phase, this is assigned to the engineering firm. An architect is also contracted to the client. In this project, an independent expert in the field of circularity was desired. In addition, this project with circular aspects proved to be 15% more expensive than traditional construction.

Project management

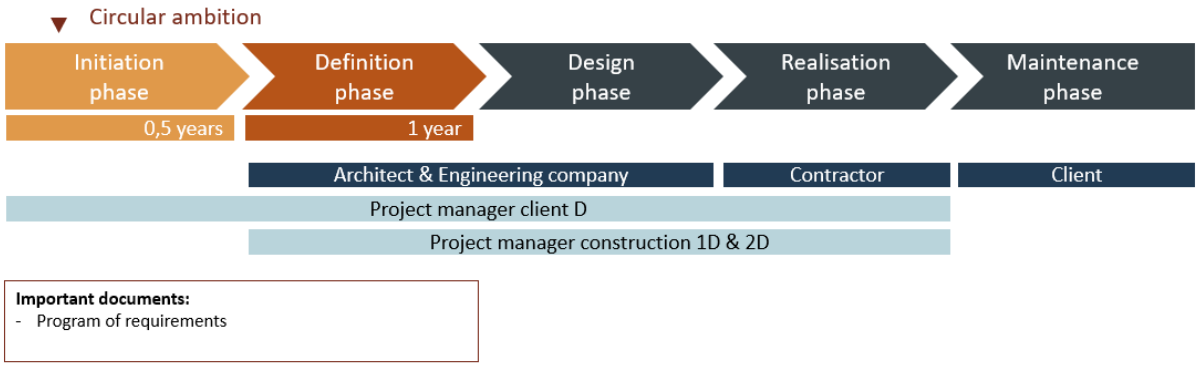

Figure 4. 11 - Process project D (Author, 2021).

Involved stakeholders

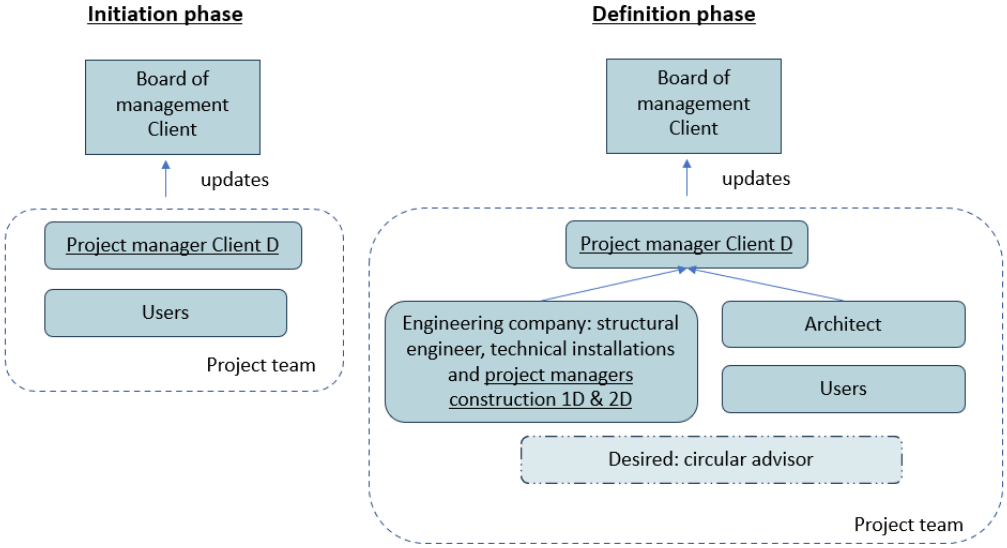

Figure 4. 12 - Organisation chart project D (Author, 2021).

4.2.2.5 Summary of project E

The project concerns a new building to be constructed. During an advanced design phase, the project was interrupted because the client's sustainability ambitions were not being met. At that time, some parts of the building had already been realised. The project entered the definition phase again, in which the circular ambitions were formulated and the schedule of requirements was revised. A circular project manager was appointed to ensure the realisation of the circular ambitions. Various designing and executing parties were already present from track 1 and they were also involved during track 2. In addition, a team member was added who encouraged the team to reflect and the project team consisted of participants who could think out-of-the-box. The project was 25% more expensive than originally budgeted and was also delayed because phases had to be repeated.

Project management

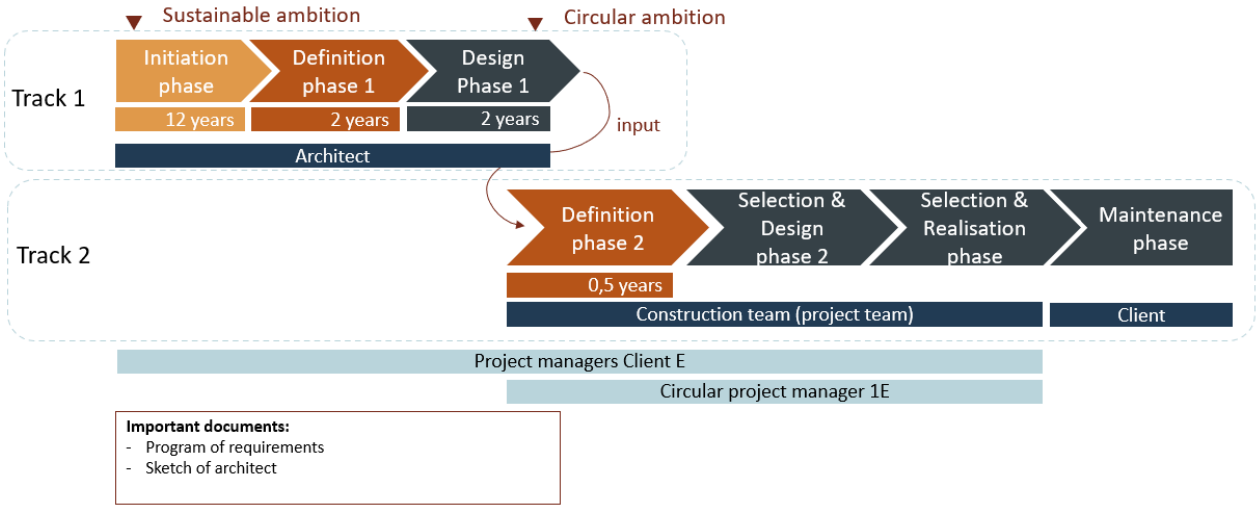

Figure 4. 13 - Process project E (Author, 2021).

Involved stakeholders

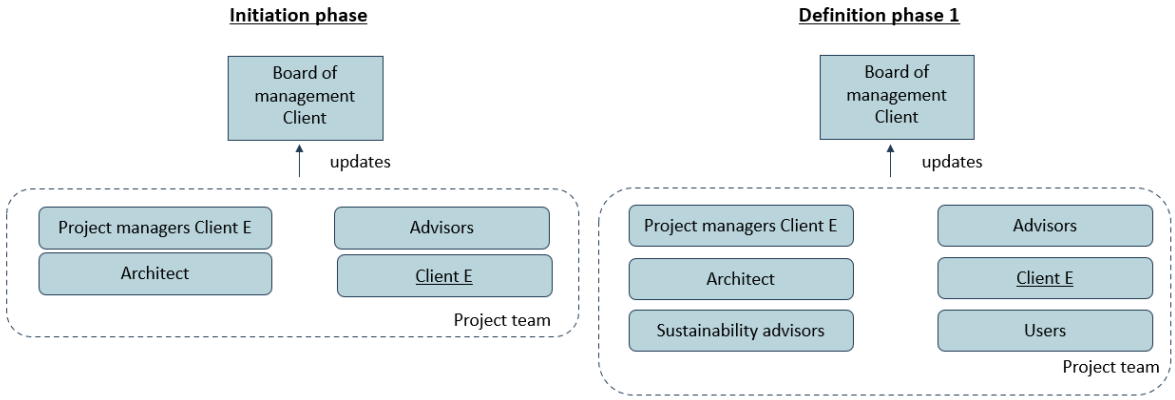

Figure 4. 14 - Organisation chart 1 Project E (Author, 2021).

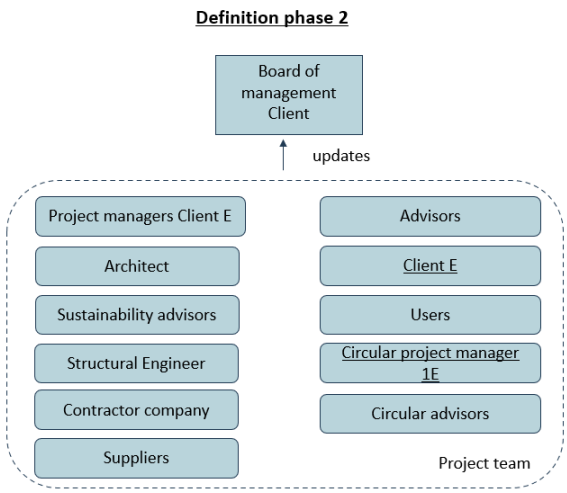

Figure 4. 15 - Organisation chart 2 project E (Author, 2021).

4.2.2.6 Summary of project F

The project concerns a new building for the municipality. The project was started traditionally and a circular ambition emerged at the end of the definition phase. Due to time constraints, the ambition was not further elaborated in the programme of requirements. The market parties were challenged to achieve the highest possible circularity in the project within the set traditional budget constraints.

Project management

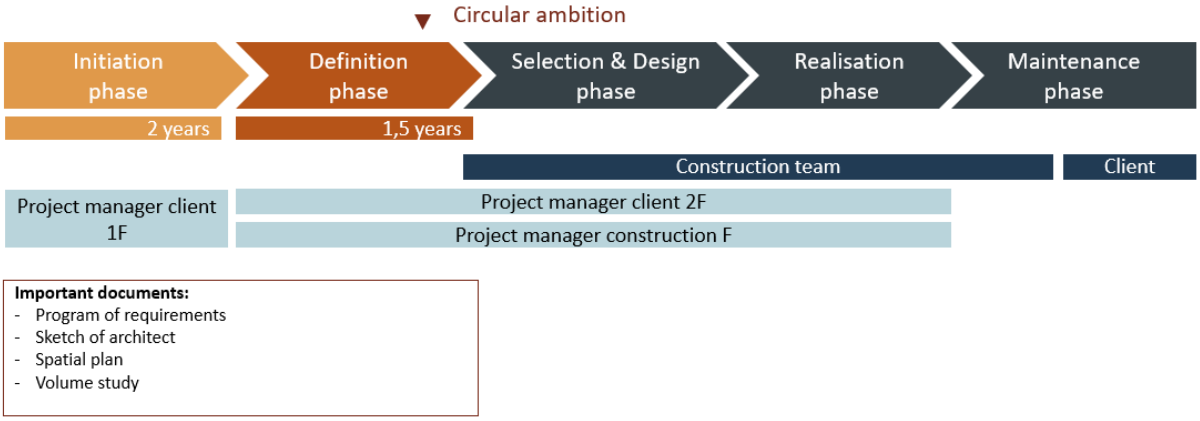

Figure 4. 16 - Process project F (Author, 2021).

Involved stakeholders

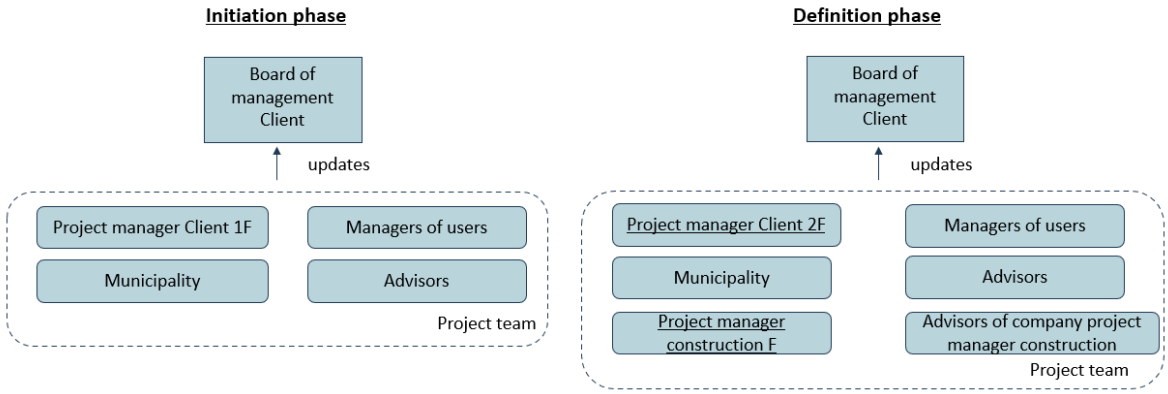

Figure 4. 17 - Organisation chart project F (Author, 2021).

4.2.2.7 *Cross Case analysis*

The cross case is used to compare the analysed cases. The cross case is divided in a general comparison and several topics. These topics are the initiation and definition phase, the project management, the role of the project manager, the involved stakeholders and the circular ambition.

General comparison

The general information of the projects have been represented in *Table 4. 2*.

Table 4. 2 - General comparison of the six analysed cases (Author, 2021).

	Type of client	Aim of project	Type of project	Circular ambition
Project A	Private	relocating	traditional	no
Project B	Public-private	New building	traditional	no
Project C	Public	New building	(semi-)circular	Yes, initiation phase
Project D	Private	New building	(semi-)circular	Yes, initiation phase
Project E	Private	New building	(semi-)circular	Yes, design phase
Project F	Public	New building	(semi-)circular	Yes, definition phase

When comparing the two traditional projects and the four (semi-)circular projects, no major difference can be seen in the various phases that are completed, as each project performs the same phases. However, the difference lies in the timing of the involvement of (external) market parties. As with traditional projects, there is no universal approach to (semi-)circular projects, but different options are possible in the approach of a project. These options will be discussed during this comparison.

Initiation and definition phase

The analysed traditional projects are both divided into sub-projects. The analysed (semi-)circular projects are not divided. Traditional project B and the (semi-)circular projects D, E and F have been paused for a while due to policies or financial reasons. The circular ambitions of all (semi-)circular projects were initiated by the clients. Clients wanted to take social responsibility and/or the ambition was written into the policy of the organisation. The moment of initiating a circular ambition does have an influence on the completion of the phases. As can be seen in project E, some project phases had to be repeated in order to redefine the project. In project F, the initiative for a circular approach occurred at the end of the definition phase, which is why the project team did not clearly formulate the ambition due to time pressure. The initiation phase is used in all six projects to turn an initiative into a new project and to create support among the administrative steering committees within the organisation. Only the initiation phase in project C is used to define the circular ambition and to draw up opportunity cards, which reflect opportunities in the environment, and an ambition document. The definition phase is used in all projects to draw up the programme of requirements and in some projects also to start the design. In addition, in projects C, D and E, the definition phase was used to incorporate circularity into the programme of requirements. Project D, however, used the market parties to incorporate circularity in the project. The most important documents produced in the initiation and definition phases are shown in *Figure 4.18*. The black coloured text are the documents that are also produced in the traditional projects. The documents in red text colour, which consist of an ambition document and opportunity cards, were documents that are used in (semi-)circular projects.

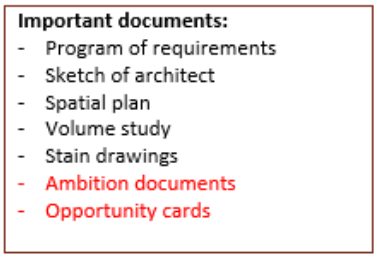

Figure 4. 18 - Cross case - documents produced in initiation and definition phase (Author, 2021).

Project management

The (semi-)circular projects C, D, E and F are managed on the aspects time, money and quality, and the traditional projects A and B on the Grotik-aspects, which add the aspects organisation, information and risks. Project manager client C (*Appendix I*) indicates that the project management of traditional

projects does not need to change in order to manage circular projects, but (circular) objectives should be added. It is important for a project team to be flexible with regard to possible opportunities. In project E, the client has accepted most of the risks in order to stimulate ideas and creativity of the contractor. Circular project manager E (*Appendix I*) indicates that with a circular project, new contract forms, extra people involved and digitalisation will play a major role in the management.

When considering the duration of the phases and the planning of the six different projects, no conclusion can be drawn between traditional projects and (semi-)circular projects, since it are different types of projects with their own needs and decisions and the research has not focussed on the planning. However, in project C, extra time of 1 to 2 months was needed for drawing up and formulating circular ambitions.

Because of the different types of projects analysed, no conclusion can be drawn about the total budget of projects. However, it can be concluded that financing circularity in the projects is handled differently. Projects C, D and E show that a (semi-)circular project is on average 5 to 25% more expensive. Project F challenges the market to be as circular as possible within the established traditional estimated budget. The extra money needed for projects D and E came from learning and sustainability budgets of their organisation. Project manager 1D (*Appendix I*) indicates that when a project has to be managed on money, a circular approach is not recommended. None of the projects worked with a residual value that might be released at the end of the project's life. The financing concept product as a service was only used in project E for the elevator facilities as the market was not yet ready to apply this concept to other building components.

The six projects all used a different approach for tendering market parties and the moment of the procurement. No focus have been on the content of contracts and the selection procedure in this research. However, the focus was at the moment of selection and the different options have been visualised in Figure 4.18. This figure assumes that a circular ambition has been adopted in the initiation or definition phase. The traditional projects A and B and the (semi-)circular projects E and F selected market parties after the definition phase. Project C conducted a selection phase for a construction team in the definition phase. Integrating a construction team is a common method when executing circular projects and is also used by the traditional projects, which makes it not a new approach. Project D selected the designing parties after the initiation phase. The maintenance phase shows the responsible stakeholder. In *Figure 4.19*, the client is named, but this can also be a user or a maintenance team of the client. In addition, the client and the project manager are not included in *Figure 4.19* as this is about the selection procedure, but they are present in all phases. The (semi-)circular projects used UAC-ic contracts, such as a Design, Build and Maintain contract and the traditional projects used an UAC contract or an UAC-ic contract.

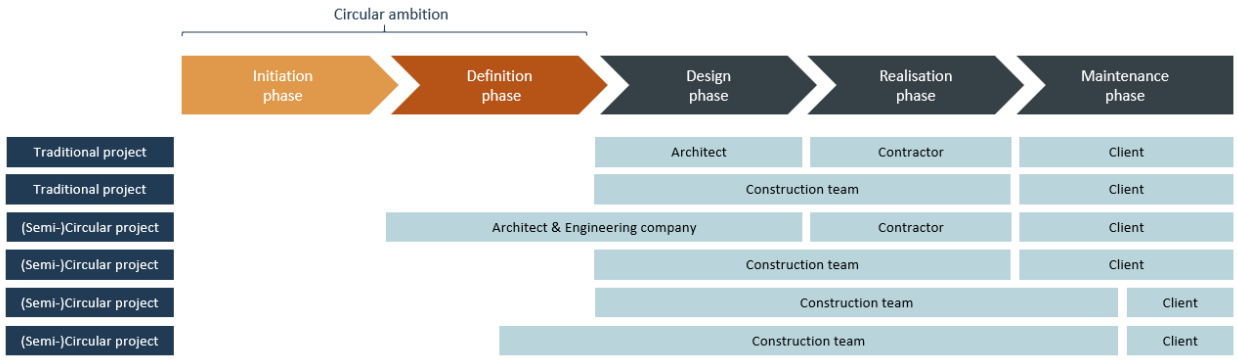

Figure 4. 19 - Cross case - moments to involve market parties (Author, 2021).

Role of the project manager

In both the traditional projects and the circular projects, the role of the project manager is to relieve the client of their concerns, to advise the client proactively, to write or complete the programme of requirements, to supervise the tendering procedure and to supervise the execution of the project. The clients of project A and project D (*Appendix I*) also indicated that they expect from the project manager to bring extra knowledge on top of the standard management knowledge, for example introducing new concepts such as circular construction or energy-neutral construction. Project manager client C (*Appendix I*) indicated that one role of the project manager and the team is to keep your ears and eyes open for possible opportunities for your project. In project E, an extra project manager has been appointed to formulate, ensure and realise the circular ambitions. Circular project manager E (*Appendix I*) also indicates that a project manager should always have the ambition to realise the highest possible circularity within the set preconditions of the client. The project manager should also be critical to the client, know what the constraints and restrictions of the project are, ask to the origin of the constrains and explain to the client what the effect of a shift in the constraints means. The project manager should take the lead in the transition to circular projects.

Involved stakeholders

The client, consultants and a project manager are involved at every stage and in every type of project. Several projects have multiple project managers such as a client project manager and construction project manager. The other external parties are selected from previous connections or selected with a tender. In all (semi-)circular projects a circular advisor was present or desired. The inclusion of a circular advisor in the initiation and definition phase is a big difference to traditional projects. In addition to a circular advisor, a circular project manager was also appointed in the definition phase in project E. Project manager client C (*Appendix I*) indicates that the most important success factor for a circular project is the project team itself, since people have to accomplish the goals of the project. Creating a good atmosphere for cooperation and support for the circularity approach within the team proved to be important. Project D and E indicated that reflection must take place within the team and that this function has been assigned to someone in the project team. *Figure 4. 20* shows which stakeholders participate in the project per phase. The black coloured text represent the stakeholders involved in the traditional projects and in red coloured text those stakeholders involved in the (semi-)circular projects.

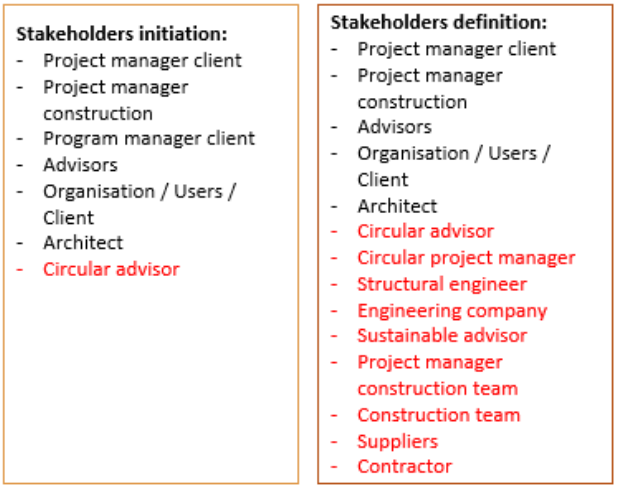

Figure 4. 20 - Cross case - involved stakeholders (Author, 2021).

Circular ambition

The traditional projects had no circular ambition included in the project. In project A, the addition of circularity was not seen as an added value for the realisation of the main objective of the project. The concept did arise in the design and realisation phases, and building materials were reused, but this was not named with a circular approach. In project B, there was a sustainability ambition but circularity was not mentioned, since the concept did not exist at the time of the initiation phase. However, circularity was included in the client's policy but have not been adopted in the construction approach. Both traditional projects indicated that they would be open to a circular approach in a subsequent project, on the condition that this was included from the start and that someone with expertise in this area was added to the team. In the (semi-)circular projects C, D and F, the circular ambition originated from the client. In (semi-)circular project E, the initiative to do more with the project than standard sustainability solutions originated from the client as well. The idea for a circular

approach in project E was generated by the architect but was immediately supported by the client. Even though all (semi-)circular projects have a circular approach, formulating the definition of circularity in the project is approached differently. Projects D and F let the market parties determine what circularity meant and could mean for the project, where only the concept of circularity was mentioned by the client in the programme of requirements and the tender documents. In contrast, the clients of projects C and Evdefine the concept of circularity together with the market parties and also establish documents for this purpose such as opportunities maps, ambition documents and a programme of requirement. However, the difference between Projects E and C is that in Project E, the market parties were already partly present and phases in the process had to be done twice, while Project C, procured parties who could support to define circularity in the project. Project manager client C (*Appendix I*) indicates that there should be a time reservation to define the concept of circularity in the initiation phase. The questions need to be asked: what is a good definition for circularity in the project, how will parties be procured, what are the objectives for circularity and how is circularity incorporated into the project? Project manager client 2F (*Appendix I*) indicates that if the ambition had been known earlier in the project, the market request would have been formulated in the same way, only more time would have been spent on defining the vision and describing the ambition. To describe the circular ambitions, the 10R model of Cramer (2014) and the 6s model of Brand (1994) were important. In addition, in the (semi-)circular projects different circular strategies have been used and the focus was, for example, on using secondary materials, using renewable materials, detachability, including material passports or the consideration of whether people feel comfortable with the project. In project C, the monetary value of materials was used in the requirements instead of the quantity of materials. The projects shows that the circular strategies are used to define ambitions or to formulate circular objectives. Since the concept of circularity is still developing, all (semi-)circular projects indicate that a project cannot be 100% circular, but that something is learned today that can be used tomorrow. A fully circular building is not possible at the moment due to the lack of government guidelines, preconditions in the design or barriers in the implementation. Projects C, D and E indicate that these barriers relate to guarantee certificates for constructive materials, the digitalisation of project information, the maintenance of project information in the management phase, the measurement of circularity and the availability of materials in the construction phase. These barriers mainly occur in the design and implementation phases, which have not been addressed further in this study.

4.2.3 Discussion and conclusion - SQ 2

To answer sub-question 2 and to clarify the differences between traditional and semi-circular project management in the initiation and definition phases, the input from interview A, interview B and six cases were used. Sub-question 2 is: *What are the differences between traditional and (semi-)circular project management regarding the initiation and definition phase in terms of the process, the project management, the involved stakeholders, the role of the project managers and the working method?*

From the input of the interviews it can be concluded that the working method, the project management and the role of the project manager will change for a circular project compared to a traditional project. The working method will first of all require awareness and support for a circular approach from the client. This is usually achieved through a dialogue in which the customer must be convinced to adopt a circular approach, which has to happen as early as possible. The initiative for a circular approach can originate from the project manager of from the client if there is already support. Adopting a circular approach will lead to circular ambitions. Secondly, circular objectives need to be defined, ensured and measured. The objectives should be as specific and complete as possible and the circular ambition has to be a precondition of the project. The formulated objectives have to be ensured which can be done with several methods. Furthermore, indicators should be defined to measure the objectives. Adopting a circular approach will not result in different work activities, but in different starting points whereby circularity is an addition to the current work. Circularity should be

integrated within meetings and adopted by the project team. Furthermore, collaborations with market parties, which are involved earlier in the project, and with circular advisors are recommended. A construction project has a start and an end and the objectives formulated in the project should be managed. The project management process remains the same but circularity affect the management aspects. The project manager should draw the client's attention to circularity and has to make sure that the circular target of the client is achieved. Some extra information is given on the aspects finances, ownerships, risks, collaborations and procurement. The project manager manages the process of a project from idea to realisation, whereby a project is divided into phases and certain products are delivered per phase. A project manager needs to be an all-rounder; he or she needs to be able to deal with people, have technical affinity, process affinity and financial insights. When adopting a circular approach, the project manager's task is to encourage circularity, to add it formally to the project, to provide the client with an impression of building with a circular approach and to ensure that a demand arises with circular ambitions for the project.

From the input of the cases it can be concluded that all projects include the same phases and that there is no universal approach for (semi-)circular projects. The moment of initiating a circular ambition does have an influence on the completion of the phases. This complements with the information gathered in the interviews. In all analysed projects, the initiation phase is used to turn an initiative into a new project and to create support among the administrative steering committees within the organisation. The definition phase is used to create the programme of requirements and in some projects also to start the design. Traditional management do not need to change in terms of adding (circular) objectives and additional consequences for management aspects. Moreover, a circular project will involve new contract forms, extra people involved and digitalisation of project information. Furthermore, some extra time is recommended to formulate circular ambitions, two financing options are given and the different options to procure are explained. The role of the project manager is to relieve the client of their concerns, to advise the client proactively, to write or complete the programme of requirements, to supervise the tendering procedure and to supervise the execution of the project. The project manager should take the lead in the transition to circular projects. The client, advisors and project manager(s) are involved at every stage and in every type of project. It is recommended to involve a circular advisor in a circular project. The circular ambitions in the analysed (semi-) circular projects all originated from the client. Incorporating a definition for circularity in projects is recommended. In order to describe the circular ambitions, the 10R model of Cramer (2014) and the 6S model of Brand (1994) are used, which complements with results from *chapter 4.1.* Furthermore, it became clear that a project cannot be 100% circular.

After analysing the cases, it can be concluded that different circular strategies are used in the (semi-)circular project, such as using secondary materials, using renewable materials, detachability, including material passports or the consideration of whether people feel comfortable with the project. These strategies are of interest for the research, but this was not the focus of the research. As a result, it is recommended for future research to investigate the different circular strategy options and the considerations for a certain strategy or what the result for the project will be. In the interviews, it was noted that the method is based on three steps; creating awareness and support, defining circular ambitions and formulating project objectives. Because the (semi-)circular cases all had circular ambitions, the first step of creating awareness and support was already done by the organisations themselves and did not require a project manager. Project C did the second step and defined circular ambitions. Projects C and E have formulated circular objectives and in projects D and F the market parties had to formulate the objectives. In projects C, E and F, the measurement indicators were determined. In addition, the interviews revealed that circularity has consequences for the aspects finances, ownerships, risks, collaborations and procurement. The analysed cases confirmed this and provided additional information regarding the management aspects of budget, planning procurement, organisation, risks and information.

4.3 Circular knowledge among project managers

This chapter will focus on orienting the current knowledge and the desired knowledge of the project managers in the field of circularity. To get a better idea of the current knowledge and the desired knowledge, this chapter uses interview A and interview B to answer sub-question 3. Sub-question 3 is: *What is the knowledge of project managers in the field of circular economy, which knowledge would they still like to have and what is their approach to integrate circularity (or a new concept) in the construction process during the initiation and definition phase?*
This chapter will provide an answer to the project managers' current knowledge of a circular economy, what knowledge the project managers still require in order to be able to apply it in construction projects and how a new concept normally gets off the ground.

4.3.1 Current knowledge

The 8 project managers interviewed in interview B were asked what their current knowledge of circularity was and if they could classify themselves in one of the five classes. The 5 classes included:

- 1 = hardly any or no knowledge. I would not know how to integrate circularity into my projects
- 2 = moderate knowledge. I know some aspects of the concept of circularity but I have no idea how to integrate it into my projects or I hire an expert for this part of the project.
- 3 = reasonable knowledge. I know several aspects of the concept but I still need help from an expert because I can not manage circularity on my own in the projects.
- 4 = good knowledge. I know what the concept entails and I sometimes need an expert for some parts of the project, but I can do the preparation by myself.
- 5 = excellent knowledge. I still need to learn but I know how to integrate circularity into a project and I do not need an expert.

All 8 project managers classify themselves between class 2 and 4. Six project managers indicated class 3 or a mix with class 3. The project managers estimate themselves to be project managers with knowledge of various aspects of the concept, but still in need of help from an expert. CPM 1, 2 and 5 (*Appendix G*) indicate that they understand various aspects and would also like to implement them in projects, but that they encounter various barriers. These barriers include the fact that it takes much more time to formulate circularity in a project and that there is little or no support from the client. CPM 3 (*Appendix G*) indicates that support from a circular advisor is needed to integrate the concept into the projects. CPM 1, 7 and 8 (*Appendix G*) indicate that the advisor is needed for the technical aspects in a project concerning circularity. CPM 1, 2 and 8 (*Appendix G*) indicate that they have tried to integrate circularity into a project but that this did not succeed due to a lack of support from the client, losing the tender, the unwillingness of suppliers and financial reasons. CPM 2 (*Appendix G*) indicated to have used exploitation-oriented budgeting in projects, which is in line with the future idea of circularity, but that no circular approach was applied to the project.

CPM 3 and 5 (*Appendix G*) indicate that they have executed projects in which circularity was applied in the project. CPM 3 (*Appendix G*) integrated circularity in three projects in which it was applied in different ways, ranging from interior changes to implementing a circular approach to the entire building. CPM 5 (*Appendix G*) supervised a demolition project in which various market parties also joined earlier to analyse the materials in the project with a raw material analysis. CPM 4, 5 and 7 (*Appendix G*) have not yet applied circularity in their projects.

The 8 project managers unanimously indicate that the internet and advisors or colleagues within the company are the current source of information for integrating circularity in projects. CPM 7 (*Appendix G*) also indicates that the Internet is a very large source of information where the overview of the most important aspects is often lost.

The project managers were asked to name aspects relating to the concept of circularity. The following terms were answered in the interview: reuse, sustainable, costly, innovative, craddle to craddle, no waste, good for the environment, future-oriented, demountability, making a design that can be dismantled so that it can be reused, reuse building materials and resources, complete circle, smart design, long-term cost-saving and materials passport. CPM 8 (*Appendix G*) considers circularity in two respects: what to do with the material resources released when a building is demolished - reuse, recycling or incineration - and what to do with a new building; how sustainable and how renewable is it to build it. These terms given by the project managers reflect the essence of circular construction. However, the interview revealed that some project managers use more terms than others. The knowledge is therefore divided. Even though the terms reflect a definition of circular construction, some concepts are still missing; such as closing cycles, value retention of materials and value creation of materials. In addition, there is also no element mentioned reflecting the reason for circularity: scarcity of materials, high CO2 emissions and the hundred percent circular ambition of the Dutch government. Besides, some tools like the shearing layers, 10R model or circular strategies have not been mentioned.

4.3.2 Needed knowledge to integrate circularity

The project managers and the circular advisors answered the question of what knowledge is required for a project manager to be able to execute a circular project.

CPM 6 (*Appendix G*) indicates that a project manager does not need to know all the technical aspects, but that more knowledge about the concept of circularity is desirable in order to be more confident about advising the client properly when circularity occurs in a project. CPM 3 and 4 (*Appendix G*) indicate that especially the developments that are required by legislation and regulations should be followed and known by the project manager. CPM 4 (*Appendix G*) indicates that a project manager can convince the client of matters that are required and advise the client on matters that are optional, but these optional matters do not have to be implemented if the client does not want to include them in the project. Matters that are mandatory and therefore mentioned in legislation and regulations give more support to the project manager to integrate that concept in the objectives of a project (CPM4, *Appendix G*). CPM 3 (*Appendix G*) indicates that the knowledge shared regarding new concepts and rules from the employers' organisation, since this should be offered to the client, is desirable and necessary to integrate innovation in a project. CPM 1 (*Appendix G*) indicates that it is sufficient for a project manager to know what the impact is per phase of the project of integrating circularity. It is important to know the impact of circularity and how it should be implemented in a project. The technical knowledge is not important for a project manager and can be provided by an advisor (CPM 1, *Appendix G*). CPM 4 (*Appendix G*) is interested in more knowledge about how circularity can be ensured in projects.

The circular advisors from interview A were asked what the knowledge of a construction project manager should be in order to execute a circular project. A distinction is made between general knowledge, substantive knowledge, knowledge of the changes needed, knowledge about making an impact and securing knowledge in the project

General knowledge

CE advisor 1, 2, 4, 5 and 6 *(Appendix C)* indicate that project managers need to have basic knowledge of the concept of circularity, understand what the concept is attempting to achieve and be able to involve an advisor when necessary. The basic information is needed to start a conversation with the client, to be able to answer the client's questions (how and why) and challenge the client to be more sustainable than they currently are (CE advisor 1 and 5, *Appendix C*). It is important to know the 'why' of integrating the concept of circularity, because this makes the story better and it allows to motivate others, such as a client (CE advisor 6, *Appendix C*). CE advisor 2 (*Appendix C*) indicates that

understanding and commitment are needed from project managers for a circular approach. In order to create understanding and commitment general knowledge of the need for a different approach is required (CE advisor 5, *Appendix C*).

Substantive knowledge
A project manager is the knowledge provider in most cases at a project (CE advisor 2, *Appendix C*). CE advisor 5 and 6 (*Appendix C*) agree with this and mentioned that a project manager is the expert on the process. However, the project manager also need to know something about the content and that they are the expert for the client (CE advisor 5 and 6, *Appendix C*). The client must be able to rely on the project manager's knowledge. It is therefore important to know that integrating circularity may be a challenge for the client. The project manager must therefore have a basic knowledge of what is possible on the market in terms of reuse, new materials, a material passport and what is possible in terms of circularity (CE advisor 5, *Appendix C*). CE advisor 7 (*Appendix C*) indicates that project managers should realise that there are also other methods to build with, such as building with wood or modular building, and that these methods results in a different way of organising. CE advisor 4 (*Appendix C*) states that Stewart Brand's model, in which a building is divided into several layers, is important for project managers to understand. CE advisor 6 (*Appendix C*) indicated that being able to make a life cycle cost analysis as a project manager would be useful, but that it is not necessary.

Knowledge of the changes needed
CE advisor 1 (*Appendix C*) indicates that it is recommend for a project manager to be aware of the changes that are needed and the shifts that are currently taking place in the interest in a circular economy.

Knowledge about making an impact
CE advisor 2 (*Appendix C*) explains that it is essential for a project manager to understand the components of a circular economy and that it can be converted into projects. It is also important what influence or impact the integration of circularity has on the projects. For the influence and impact of the project, CE advisor 5 (*Appendix C*) indicates that it is important to know the impact and the desired achievability's for each phase of the project. CE advisor 6 (*Appendix C*) adds that understanding how to make an impact is important in order to make the right choices in a project.
CE advisor 1, 3 and 4 (*Appendix C*) are convinced that circularity does not stop with the construction project and that the environment of a building and the later phases of the project should be considered at the start by a project manager. Project managers must know that circularity could also have a low threshold and that certain parts can be tried out and do not have to be applied at once (CE advisor 1 and 3, *Appendix C*).

Ensuring knowledge
Knowledge about circularity must also be ensured in a project. In this regard, both CE advisor 1 and 5 (*Appendix C*) advise a sustainability manager or a circularity advisor to provide circular opinions and advices to the team members and assess them for validity and relevance.

4.3.3 Integration of new concepts

The project managers were asked whether they take the initiative to integrate a new concept and how they deal with integrating new concepts.

CPM 4 and 6 (*Appendix G*) indicate that they are not pioneers or initiators but that they are open to development. CPM 4 (*Appendix G*) indicates that if a client wants a new concept or if there are tools within my organisations to advise or support a client, then I am certainly open to integrate new concepts. CPM 2 and 5 (*Appendix G*) indicate that they take initiative for a new concept, but that they need colleagues to be able to communicate it to the client and to advise in a project. CPM 3, 7 and 8

(*Appendix G*) describe themselves as initiators and dare to approach a project differently as long as there is knowledge of the concept and confidence in the project manager at the client.
From these answers from the construction project managers it can be concluded that knowledge about a concept is important, there must be trust with the client and that the project managers show initiative or are open to development.

CPM 2 and 6 (*Appendix G*) indicate that new sustainability concepts are constantly being introduced in the construction world and that many concepts overlap with other concepts which makes it difficult to keep up with the newest concepts. There are a lot of new concepts that at some point you have to choose what you think is most important and take this as a starting point (CPM 2, *Appendix G*). CPM 5 (*Appendix G*) complements this by stating to always analyse a concept first and determine whether the benefits can be seen in it. CPM 6 (*Appendix G*) states that there is actually no time to fully immerse yourself in a new concept, as this time is at the expense of other projects. CPM 4 (*Appendix G*) adds that the integration of new concepts depends on whether the client is interested. CPM 8 (*Appendix G*) states that a step-by-step plan is needed to integrate a new concept, which the project manager can go through on paper or in your head.

4.3.4 Discussion and conclusion - SQ 3

This chapter concludes and discussed sub-question 3 which is: *What is the knowledge of project managers in the field of circular economy, which knowledge would they still like to have and what is their approach to integrate circularity (or a new concept) in the construction process during the initiation and definition phase?*

The interviewed project managers estimate themselves to be project managers with knowledge of various aspects of the circular concept, but still in need of help from an expert to include substantive knowledge and to overcome some barriers. These barriers include, but are far from comprehensive, a lack of support from the client, the unwillingness of other stakeholders involved in the project and financial reasons. The internet, advisors or colleagues are the information sources of the project managers. The knowledge of the interviewed project managers is divided.

The project manager does not need to know all the technical aspects of a circular approach but more knowledge is desirable to be able to properly advise the client. The impact of circularity, how it should be implemented and the relation between circularity and regulations could be defined as desirable knowledge. The project manager should have basic knowledge of the concept of circularity, understand what the concept is attempting to achieve and be able to involve an advisor when necessary. This is needed since the project manager is an expert for the client and the client must be able to rely on the project manager's knowledge. Besides, integrating circularity could be a challenge for the client. Furthermore, a project manager should be aware of the changes that are needed and the shifts that are currently taking place regarding the interest in a circular economy. The project manager should understand the components of a circular economy in order to be able to converted it into projects. A circular advisor can help the project manager to ensure the knowledge of circularity, to provide circular opinions and advice and assess options for validity and relevance.

In order to innovate or to integrate new concepts, the client has to trust the project manager. The interviewed project managers show initiative for new concept and are open to innovations. However, the amount of new concepts and the overlap of concepts makes it difficult to keep the knowledge up to date. A plan that describes the different steps that need to be taken is desired to integrate a new concept.

4.4 Identifying success factors

This chapter focuses on collecting success factors that should be added to the process of a project to realise a circular project. First of all, the definition of a success factor will be explained. Subsequently, success factors will be identified in literature and in the results of this study. This chapter will answer sub-questions 4 and 5 of this research.

4.4.1 Definition of a success factor

A success factor is a factor that needs to be added to the process of a project in order to adopt a circular approach. In addition, it will influence the successful management of a circular project. Success factors include key elements, drivers and other factors that contribute positively to the realisation of circular projects. As this research focuses on the initiation and definition phase, the success factor should also relate to this initial phases of a project. The success factors should give the project managers more capabilities and knowledge about how the project and the project management changes by adopting a circular project approach.

4.4.2 Success factors identified in literature

First of all, the available success factors in the literature will be examined. This will answer sub-question 4 of this research, which is: *Which success factors can be identified in literature and should be integrated during the initiation and definition phase of a circular project to realise a circular building?*

Limited research has been conducted on managing projects with a circular approach in the construction sector. This also results in limited knowledge and data regarding changing the project management for a circular approach and therefore also limited identified success factors in the literature. Subsequently, it can also be concluded, as was described in *chapter 1 - introduction*, that performed studies focus on all aspects and phases of the project. It is emphasised again that this research, which specifically focuses on the initial phases of the project and takes the role of the project manager into account, is of interest.

The research of Venselaar et al., (2019) has identified factors that need to be added to the management of projects to achieve a circular approach. For this thesis, the phases of the initial and definition phase are important, as well as the partner selection phase. Venselaar et al. (2019) indicates that in the initiation phase, detailed described project ambitions formed the basis for a project. In the initiation and definition phase, intensive cooperation with external parties such as the municipality, demolishers, contractors, consultants and parties granting subsidies will be recommended. In addition, the study of Venselaar et al. (2019) concludes that the definition phase should focus on a cooperation model rather than on technical requirements for the project. Furthermore, when selecting market parties the focus should be on the vision presented by the party instead of the lowest price.

Versteeg Conlledo (2019) conducted graduation research on the differences in management between traditional and circular projects, again focusing on the entire process of utility projects. Several success factors can be identified from this research. First of all, an ambition will have to be defined and requirements will have to be set with the entire project team. According to Castelein (2018), it is important to formulate achievable requirements and to be able to achieve more circularity in subsequent projects. In addition, the budget will have to be shared with the team in a transparent manner. Furthermore, the team members will share the same circular commitment, vision and philosophy. Also for the tender process, factors are mentioned that contribute positively to a circular project, such as plan tender process early in the project, involve suppliers early in the project, select parties with the entire project team and use new contract forms or agreements that ensure the

building does not end up demolished (Versteeg Conlledo, 2019). The report of CLIMATE-KIC (2019) also adds that circularity should be integrated into the selection criteria and into the design guidelines. In addition, The research of Versteeg Conlledo (2019) states that the client should take more risks to stimulate innovation and to distribute responsibility and risks to ensure innovation and creativity. Furthermore, non-hierarchical and cooperative organizational structures should be used and project knowledge should be shared in a transparent way (Versteeg Conlledo, 2019). The report of Castelein (2018) also agrees that it is advisable to cooperate in a transparent way with the parties involved, as this promotes the development of new concepts and more sustainable collaboration.

Research by Adams et al. (2017) describes several challenges for the clients of construction projects to adopt a circular approach. In the paper, they listed critical success factors where the client can play a major role. The main focus is on the role of the client who can be a major force in ensuring circular economy outcomes at a project level. The most important factor are the vision, strategy and objectives of the client, in which long-term thinking should be considered. In addition, the client has to provide enabling conditions for collaboration and innovation across the supply chain and the sharing of data. The research of Rijk (2020) also focuses on factors that promote the implementation of a circular ambition. First of all, it is established that clients have to formulate circularity clearly in their requests and tenders and construction companies need to increase their demand for circular materials. In addition, if the client has a circular ambition, other stakeholders of the project will have to loosen their routines and structures and take more risks. Subsequently, according to Castelein's (2018) research, concessions will have to be made and projects cannot be optimal circular at once. Furthermore, working in a consortium, based on trust instead of tenders and money, seems to be an important accelerator. However, sometimes the regulations make it more difficult to innovate and the project team should seek for flexibility within those regulations (Rijk, 2020). The research of Castelein (2018) also concurs with this and concludes that the most important aspect in a circular project is the attitude and motivation of those involved. Whereby Debacker et al. add that the project team must have an increasing awareness of sustainability and circular economy if it should be applied in projects.

In addition, to the report of Versteeg Conlledo (2019), project information should be shared efficiently in order to avoid reinventing an innovation of knowledge (Castelein, 2018). The study of Berg (2019) also concluded to create and use priori and posterior design information and priori and posterior demolition information. To ensure this information, it is advised to integrate a materials passport (Debacker, Manshoven, Peters, Ribeiro, & De Weerdt, 2017). Finally, in order to foster circularity in the construction sector, connections between all phases in the value chain are necessary in order to support communication and information transfer across the whole of the value network (Debacker et al., 2017).

4.4.3 Success factors identified in research results

This paragraph will reflect on the results of interviews A and B and the analysed cases and identify success factors from them. It will answer sub-question 5 of this study, which is: *Which success factors can be identified within the results of the used methods of this research and should be included during the initiation and definition phase of a circular project to realise a circular building?*

Interview A

A project manager should have the courage to enter into a dialogue with the client in order to respond to the client's circular objectives. In this dialogue, it should be discussed whether you understand each other and what the objectives are. In addition, the project manager should make the client wonder whether more should be done with its circular objectives, should be critical to the client, and should introduce the circular concept for discussion. The project manager will have an important role in raising the demand for circularity among clients in order to create awareness and support and to get the client to adopt a circular approach, whereby a clear ambition on the part of the client and the

vision are important. The reasoning that is used to convince a client must be motivating, accurate and in line with the client's perspective in order to generate support and awareness for a circular approach. To start this conversation with a client, a project manager must have basic knowledge of the concept of circularity, understand the concept, understand what the concept aims to achieve and be able to call in a consultant when necessary. This basic information is needed to start a conversation with the client, to be able to answer the client's questions (about how and why) and to challenge the client to be more sustainable than they are at the moment. Basic information for the project manager is also needed to translate the circular concept into the projects and to know the legislation and regulations on the topic. Furthermore, the project manager must also be able to explain to the client what the consequences are of the project and be able to take calculated risks. A project manager will therefore need understanding and commitment for a circular approach. In addition, they will have to dare to change, be curious about the concept of circularity, want to try out new techniques and realise the urgency of the new concept. A circular approach requires changes and this may be a challenge for the client. However, a project manager must also know that circularity can be accessible and that not everything has to be applied at once. It is not possible to immediately adopt a 100% circular approach, but it is necessary to focus on what is within the scope and is achievable. By giving examples, it can be made clear that circularity can also be accessible. In addition, it is important that circularity does not stop with the project and that the environment and later phases of the project should be examined.
Enthusiasm and intrinsic motivation of the project manager can help to convince the client to include the circular concept in the project. The project team should also support the choice to include circularity in the project.

The goal to be pursued can be outlined, but there should be flexibility to change. When defining objectives, a definition for circularity and the objectives of the project will have to be formulated. The circular objectives can be ensured with the same methods as traditional objectives. The project managers have to outline circular construction including building with wood or modular construction. Standardisation of the construction process or building with a Lego cube approach could also be identified as a success factor.

The initiative for a circular approach or a discussion can be initiated by the client or by the project manager. The very first step in a project is to make the client aware of the ambitions, followed by documenting those ambitions. Ambitions must become part of the project objectives and must be clearly formulated on paper. A circular ambition must be a precondition, otherwise circularity is the first thing to be eliminated when saving cuts are made. A reference point should always be taken into account by formulating project objectives. Formulating a clear objective also consists of giving a good definition of a circular economy in the project and determining the indicators to be measurable. The objectives and knowledge of circularity should be ensured, which can be done with the assistance of a circular advisor. Besides ensuring, the objectives should also be made measurable. Attention should be paid to defining ambitions and objectives as early and as explicit as possible. Circular construction means that all phases of the building are included in the project; from initiative to dismantling phase. A circular approach can also include circular services; thinking up a solution at the front end, providing the solution and remaining involved throughout the lifecycle so that solutions remain as optimal as possible.

It is crucial to have room in the process for innovation and for ideas from the market. In this respect, smaller companies are more willing to innovate. For innovation, there must be confidence in the market and the contract must not be tightly nailed. Market parties should be involved early in the process in order to obtain detail and specific solutions. Establishing a construction team is commonly used with a circular approach. Including circularity in the specifications has a very positive effect even as including circularity in circular award criteria, which can be divided into qualitative and quantitative

criteria. The selection of market parties can also be accomplished by means of a competition-oriented dialogue.

Reflection time will have to be included to evaluate the project, to reflect team members, to inspire and to challenge the project team. An external party can be hired to keep the team and the project manager focused. Considering project choices more carefully will cost time and money, but delivers a more future-proof end product.

Project data will have to be included and processed in the project. More knowledge is needed at the front end of a project by means of a materials analysis. In addition, good documentation of project information is important to design in a sustainable and circular way, to make circular processes transparent and to have information about the output of the project.

The subject of circularity will have to be addressed at the agenda of meetings as a reminder. The key to a circular approach will be to assign value to materials and the ability to harvest them again in a normal way. However, residual value helps in the budget but it only appears at the end of the project's life. The remaining value is therefore only interesting at the start of the project if the client can include it as a deduction from the investment. The government will therefore have to introduce more regulations in order to measure and guarantee circularity.

Interview B
A project manager should inform a client of the opportunities in the field of circularity. The project manager should be able to make the client aware of circularity and sustainability but can involve someone for the substantive knowledge. In this respect, client's trust is very important in order to be able to present new concepts. New concepts should be applied in order to learn.

Case-based research
Circularity should always be an ambition for the project manager within the constraints set by the client. The project manager will have to discuss with a client what the constraints of the project are and why these are the constraints. Clients with a social responsibility are more likely to initiate a circular approach. In order to formulate circular ambitions more time is needed and they could be formulated in an ambition document. In addition to an ambition document, opportunity maps can also be formulated that provide the tendering party with insight into the opportunities of the location and the market party can use this to their advantage. Circularity will also have to be included in the programme of requirements in the form of circular objectives. The requirements can be tested by means of a market consultation. In the initial phases, the definition of circularity has to be defined with questions such as: what is a good definition, how to ask the right question, what is the aim of the project in terms of circularity and how is circularity included in the project. If a circular choice is hindered by a requirement, the project manager has to determine whether that requirement is very important. If the requirement is more important than the choice then the requirement is formulated well, if not then the requirement will have to be adjusted.

For a circular project, 5-25% extra money must be made available. Making an inventory of extra funds within the organisation can help to get an extra budget. It is also possible to ask market parties to achieve the highest possible level of circularity within a traditionally estimated contract. Involving parties with circular knowledge in an early stage will incorporate knowledge about the highest achievable possibilities in the market. Market parties will have to be involved earlier in the process of a project such as a construction team in the definition phase. By involving market parties at an earlier stage, ambitions can be described together with the client. Both market parties and the client have to innovate. Trust in one another should be the starting point. However, contracts will be required. The human factor for the team and the cooperation is important. There has to be support for a circular

approach among the project team, the team leaders and all users of the building. The project team will need to include participants who can think out-of-the-box. In addition, the interests of all parties will have to be shared to understand certain choices and points of view. A circular advisor will have to be added to the project team. In addition, someone who will ask critical questions and reflect on the project could be added to the project team. An interactive process in the design and realisation phases has to be ensured. In addition, flexibility is needed in order to revise requirements or to approach the process differently. A sustainability aspect, such as circularity, will have to be included in selection criteria. It is also possible to use a fictitious discount, which rewards circularity, when selecting market parties.

4.4.4 Discussion and conclusion - SQ 4&5

This section concludes and discusses sub-question 4 and 5 which are:

SQ4. *Which success factors can be identified in literature and should be integrated during the initiation and definition phase of a circular project to realise a circular building?*

SQ5. *Which success factors can be identified within the results of the used methods of this research and should be included during the initiation and definition phase of a circular project to realise a circular building?*

A success factor is a factor that needs to be added to the process of a project in order to adopt a circular approach and will influence the successful management of a circular project. The success factors identified are related to the initiation and definition phase.

Limited research has been conducted on managing projects with a circular approach in the construction sector. However, all the performed studies focus on all phases rather than specifically on the initiation and definition phase. The success factors resulting from the literature focus, for instance, on describing ambitions, formulating objectives, cooperation with external parties, selection of market parties, the project team, the sharing of project information and the role of the client.

The success factors resulting from the results of this research focus, for instance, on the role of the project manager in the initial phases, conducting a conversation with client and project manager, defining circular ambitions and formulating project objectives, the selection market parties, the documentation of project information, including reflection time, and budget related aspects.

Several topics of the success factors correspond between literature and research results. The factors that correspond are mainly general actions such as defining ambitions, formulating project objectives, dealing with project information and forming the project team. However, more success factors emerge from the results of this study than from the literature. In addition, the research results provide more in-depth factors such as how the circular ambitions should be secured rather than only formulating them. Furthermore, the most significant difference is the lack of success factors for a project manager in the literature. The research results did provide success factors for the project manager.

Chapter 5.1 will validate the success factors. The origin of the factors, either literature or research results, of the factors that will actually be validated are listed in *Appendix M - Input data for Fuzzy Delphi method and end result* . This appendix will be further discussed in chapter 5.1.

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5. Phase 2 – Solution Design

The second phase of the design cycle, also called phase 2 – solution design, will assess the identified success factors in *chapter 4.4.* Furthermore, the format and content for the framework for the project managers will be defined. Finally, the framework will be created. This phase will answer four sub-questions of this research.

5.1 Assessing identified success factors

This chapter focusses on the selection of success factors that need to be integrated in the initiation and definition phase of a project to include a circular approach successfully. This chapter will therefore answer sub-question 6: Which success factors have to be included in the initiation and definition phase of a circular project to realise a circular building?

The last chapter of phase 1, *chapter 4.4*, collected several success factors by studying the literature and identifying factors from the interviews and cases conducted. To obtain an overview of the most important success factors within the initiation and definition phase to enhance realising circular projects, a Fuzzy Delphi Method (FDM) has been applied. In this chapter the results of the FDM method will be explained.

The methodology of the Fuzzy Delphi method has been explained in *chapter 3.4* and identified five steps to conduct a Fuzzy Delphi method. These five steps, consisting of 'validate predefined list of factors', 'collect opinions of expert group', 'set up overall triangular fuzzy number', 'defuzzification' and 'screen evaluation indexes' will be elaborated and discussed.

5.1.1 Validate predefined list of factors

The first step of the Fuzzy Delphi method is obtaining and selecting the input data. Several steps have been taken to prepare the list of factors to validate. The process of the steps taken to predefine the list of factors has been visualised in *Figure 5. 1*.

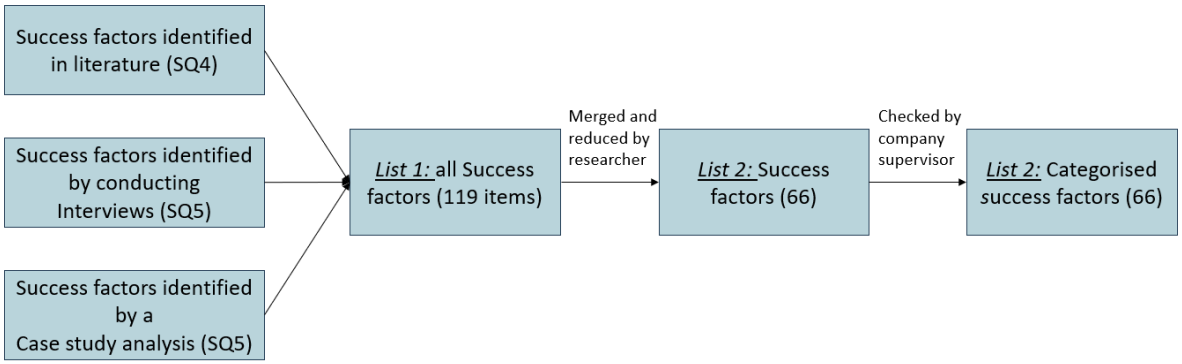

Figure 5. 1 - Process of validating the predefined list of success factors (Author, 2021).

Several success factors have been identified in *chapter 4.4* and this will be the input data for this Fuzzy Delphi method. The input data consist of a list of 119 success factors, which is called list 1. This enormous list of success factors would have been too extensive for validating by the expert panel and too ambitious for this research. A list of 60 to 70 factors would be more appropriate for this study. Therefore, list 1 with all the success factors identified in *chapter 4.4*, have been re-examined. It has been noticed that some factors are described differently but represent the same thing. The factors that have been described with different terms have been merged to one factor. Besides, some factors include advise, contain information that has to be part of a factor or describe a result of a factor instead of being a success factor that could be applied to the project. Main subjects could be identified within these advisory, informative and describing results factors. Therefore, these factors have been removed and it has been decided to include it later in the study (for example in the framework) if the prior main factor of this advising or describing factor is identified as a success factor that should be

included within the approach for a circular project by the construction project manager. An example of an advisory factor is: '*The government has to introduce regulations to ensure and measure circularity*'. This could be a successful factor, but it is not a factor that can be applied by the project team, since it is beyond the reach capacity to implement. An example of an identified success factor which describes results is: '*It is better to describe an ambition than to set specific requirements and have no flexibility within the project*'.
After re-examining, merging and reducing the identified success factors of list 1, list 2 has been created with the success factors that has to be assessed by the expert panel. This second list has been checked by the company supervisor, who has knowledge about the concept of circularity and construction project management, on linguistics, the formulation of the success factor and if it is possible to validate the factors.
The success factors of list two have been classified within categories. The two main categories are project preparation and project management. These two categories were created because of the differences in the type of success factors. There are factors that belong to the tasks that needs to be performed in the initiation and definition phases. Since a project is formed and prepared in the initiation and definition phases, this main category is called project preparation. The second category covers the general task of a project manager, namely managing the project and the is therefore called project management. The success factors classified within the main category project management consist of management related factors. The main categories are further subdivided into sub-categories. *Table 5. 1* shows the two main categories and the sub-categories for the classification of the success factors. List two, with the re-examined success factors, is the input data for the Fuzzy Delphi method and listed in *Appendix M - Input data for Fuzzy Delphi method and end result*. Furthermore, List two have divided the success factors by their origin, either literature (L) or research result (RR).

Table 5. 1 - Main categories and sub-categories to classify the success factors (Author, 2021).

Project preparation	Project management
Approach project preparation	Approach project management
Objectives	Management aspects
Ambition	Project team
Role project manager	Procurement
	Role project manager

5.1.2 Collect opinions of expert group

As discussed in *chapter 3.4*, 3 steps have to be taken to collect opinions of the expert panel. First of all the expert panel has to be formulated, secondly the Likert scale and the corresponding triangular fuzzy numbers have to be determined and finally the survey has to be created.

Within *chapter 3.4*, it has been discussed that 30 potential respondents have been contacted to participate in the survey. These respondents were known by the researcher and can be divided in 3 groups and are:

I. Circular advisors (group 1 in the questionnaire)
II. Construction project managers (group 2 in the questionnaire)
III. Both knowledge fields

A time reservation of half an hour for filling in the survey has been made with the respondents to make sure that enough respondents would have time to fill in the questionnaire. Respondents needed 10 to 20 minutes to complete the questionnaire.

The second step contains determining the Likert scale and the corresponding triangular fuzzy numbers. This has been determined and elaborated in *chapter 3.4*. A five point Likert scale has been chosen and the triangular fuzzy numbers consist of 0, 0.25, 0.5, 0.75 and 1.

The final step to collect the opinions of the expert group is to create a survey. The questionnaire has been developed with the free survey system ThesisToolsPro. The questionnaire starts with an introduction followed by a page where the respondent should fill in their knowledge group. The respondent received its corresponding knowledge group by e-mail with sending the link to the questionnaire. The researcher knows the expert panel due to (in)formal interviews and conversations conducted and is therefore able to classify the respondents within the knowledge group.
The third page contains information on how to score the success factors. The researcher provided two considerations. The respondents with knowledge of circularity were asked to rate per factor how successful they regard the factor in terms of circularity and projects with a circular approach. The respondents with knowledge of project management were asked to rate the possibility of integrating the factor into the project. A difference is made because the circular advisers have knowledge of circularity but to a lesser extent of project management. The project managers on the other hand have little or no knowledge of circularity and it is assumed that they are less able to assess the importance of a circular approach but do know whether that factor can be added to the process.
The respondents associated with both knowledge fields gave one rate per factor and examined both considerations. In addition, it has been explained in the questionnaire that the success factors have been divided into categories, which is also represented in *Table 5. 1*. Furthermore, the choice of the five rating options has been explained to the respondents.
The respondents were asked to rate the sixty-six (66) success factors in the carefully designed questionnaire. The questionnaire is in Dutch because of the Dutch target audience and can be found in *Appendix N – Questionnaire Fuzzy Delphi method*.

The link to the questionnaire has been sent to the respondents on the 7th of December and was available for one week. The respondents were directly contacted by email. The link with the questionnaire have been send to thirty respondents. Twenty-five respondents completed the questionnaire and four respondents started but did not accomplish the questionnaire. The results of twenty-nine respondents were downloaded and opened in excel. The value of the four respondents that not fulfilled the questionnaire had been filtered out, whereas 25 results are left to analyse. On the basis of the usable results, a response rate of 83% was achieved. This is a high response rate in comparing to other researches and will probably have to do with the time reservations sent by the researcher in advance. *Figure 5. 2* shows the number of respondents categorised by their knowledge fields. The following categories have been defined to categories the respondents:

I. All respondents
II. Group 1 – consist of the circular advisors
III. Group 2 – consist of construction project managers
IV. Group 3 – consist of respondents with both knowledge expertises

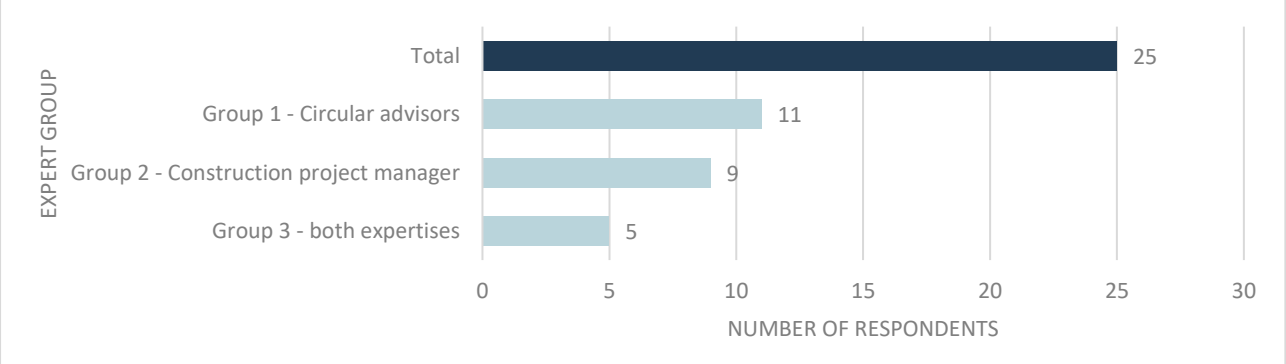

Figure 5. 2 - Number of respondents categorised within their knowledge fields (Author, 2021).

The target response was at least 10 responses per homogenous group to comply with the reliability according to Delbecq et al. (1975). Within this research a homogenous group is reached for group 1 - the circular advisors and group 2 - the construction project managers. Even though group 3 does not meet the minimum of 10 respondents, this group will be included in the results analysis as it has both fields of knowledge and is therefore considered as an important respondent group.

5.1.3 Set up overall triangular fuzzy number

The outcome of the questionnaire has resulted in a matrix as shown in *chapter 3.4*. The fuzzy weights of all success factors per respondents have been calculated. This has been done for all the respondents, for group 1, for group 2 and for group 3. The components of the fuzzy weight w_j of all respondents, which consist of aj, bj en cj, have been listed in the first rows of *Appendix O – Calculation sheet Fuzzy Delphi method*.

5.1.4 Defuzzification

This step entails converting the fuzzy weight w_j of each single success factor into single derived numbers (s_j) per success factor. These single derived numbers have been calculated for all respondents, group 1, group 2 and group 3. These single derived numbers have also been listed in *Appendix O – Calculation sheet Fuzzy Delphi method*.

5.1.5 Screen evaluation indexes

In this last step the single derived numbers (s_j) will be tested against a set threshold (α). If the single deriver number is lower than this threshold the success factor is not selected, if the value of the single derived number is equal or higher than the threshold the success factor is selected.

If $s_j \geq \alpha$	Success factor j is more successful and will be included in the framework
If $s_j < \alpha$	Success factor j is less successful and will not be included in the framework

5.1.5.1 Selecting success factors with the first set threshold

To determine the threshold, the average value, highest value and lowest value of the single derived numbers given by all respondents were examined. The average of the single derived numbers of all respondents is 0.587, the highest value 0.707 and the lowest value 0.497. It is remarkable that the lowest value equals a neutral score in the questionnaire. In addition, the difference between the lowest value that will eliminate the factor of the framework and the highest value that will include the factor in the framework is not very large. This small margin can be explained by the fact that the factors have been identified as success factors in different methods and had to be ranked to narrow down the list of success factors. The different success factors could all contribute positively to the realisation of circular projects but the aim of this validation is to identify the most successful that can make the biggest contribution to realise successful projects with a circular approach. By sorting the success factors on the single derived number of all respondents, it was determined where a significant margin could be identified between different single derived numbers. The value had to be above the average of 0.587. A significant margin has been identified between the single derived numbers of all respondents at a value of 0.600, which has been established as the first threshold.
The single derived numbers of the different categories and the first established threshold are represented in *Figure 5. 3*, *Figure 5. 4* and *Figure 5. 5* per success factor.

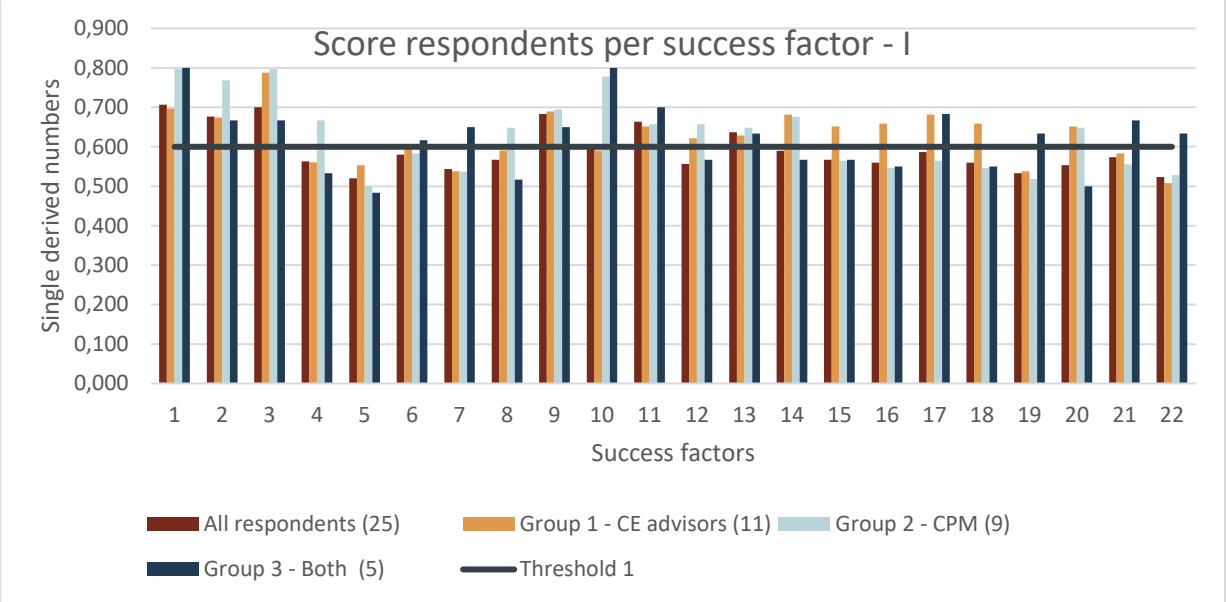

Figure 5. 3 - Overview of the single derived numbers for success factors 1 – 22 (Author, 2021).

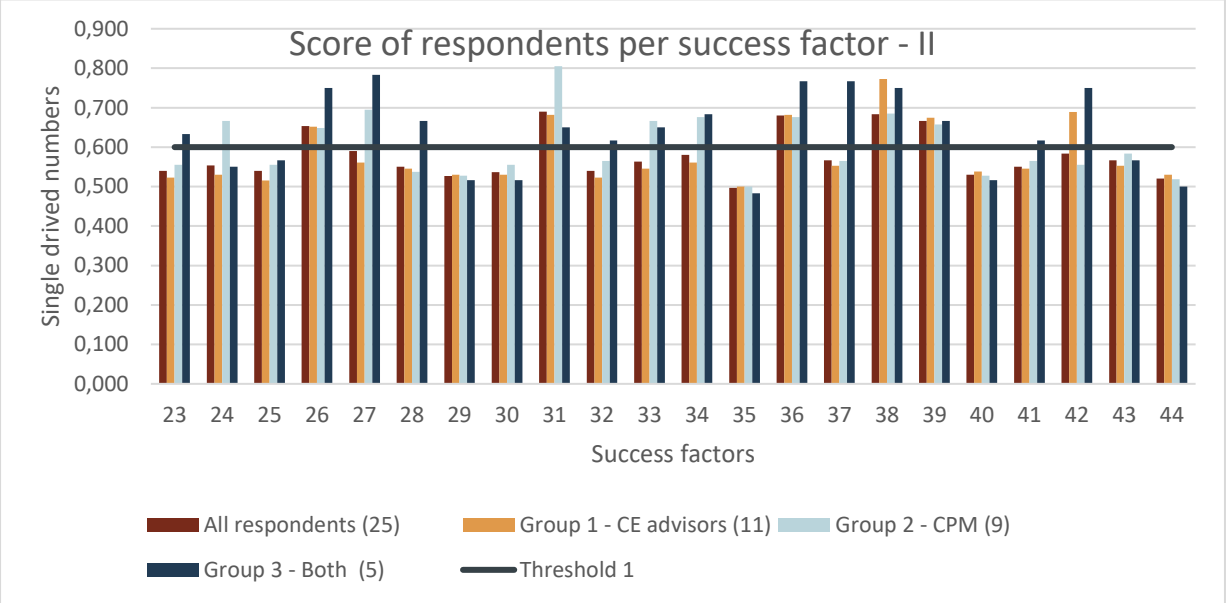

Figure 5. 4 - Overview of the single derived numbers for success factors 23 – 44 (Author, 2021).

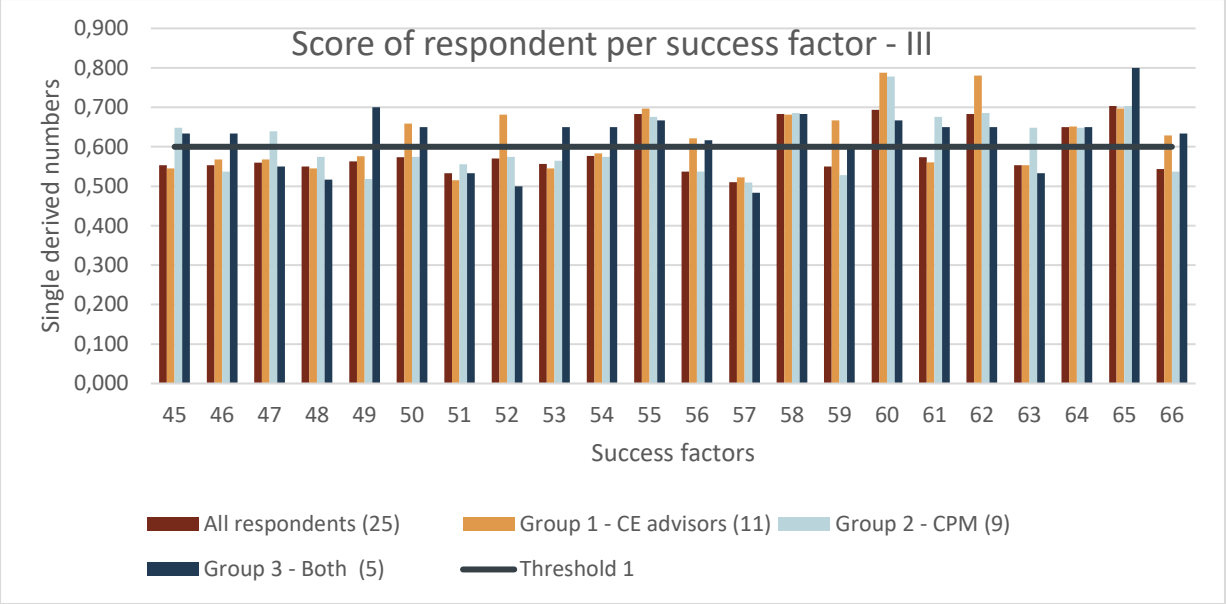

Figure 5. 5 - Overview of the single derived numbers for success factors 45 – 66 (Author, 2021).

The researcher sets a maximum of 30 accepted success factors to be included in the framework. With the first set threshold of 0.6, 18 success factors score above the value of the single derived numbers by all respondents and can be identified as success factors that need to be included in the framework.

However, the charts in *Figure 5. 3, Figure 5. 4* and *Figure 5. 5* shows that there is a difference in the answers given by the various categories on the degree of success per success factor. This means that a success factor is not taken into account due to the score of all respondents, although it has been ranked very high by a single category group. For example *Table 5. 2* represent the top 5 scored success factors by the different categories. It should be noted that a different question was asked to the different respondent groups in the questionnaire. Group 1 was asked to rate the factor in terms of circular successfulness, group 2 rated the factor on the successfulness on integrating the factor in a project and group 3 considered both.

Table 5. 2 - The top 5 scored success factors by the different respondent categories (Author, 2021).

All respondents			
Rank	**No. SF**	**Success factor**	**Sj**
1	1	There is a circular ambition and vision from the client	0,707
2	65	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach	0,703
3	3	Circular ambitions are inventoried, formulated and translated into project objectives as soon as possible	0,700
4	60	Project manager has basic knowledge of the concept of circularity, understands the concept of a circular economy, is able to involve an advisor when necessary and can translate the knowledge into his own projects	0,693
5	31	Examples of other circular projects are used to inspire, to show that circularity can also be accessible and that not everything has to be applied at once	0,690
Group 1 – Circular advisors			
Rank	**No. SF**	**Success factor**	**Sj**

1	3	Circular ambitions are inventoried, formulated and translated into project objectives as soon as possible	0,788
1	60	Project manager has basic knowledge of the concept of circularity, understands the concept of a circular economy, is able to involve an advisor when necessary and can translate the knowledge into his own projects	0,788
2	62	Project manager has the courage to change, is curious about the concept of circularity, wants to try out new techniques and sees the urgency of a transition to a circular economy	0,780
3	38	The project team has knowledge of the concept of circularity	0,773
4	1	There is a circular ambition and vision from the client	0,697
4	65	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach	0,697
4	55	Circularity must be clearly formulated in invitations to tender	0,697
5	42	All stakeholders involved in the project are motivated, both at company and personal level, to organise the project in a circular way	0,689
Group 2 – Construction project managers			
Rank	**No. SF**	**Success factor**	**Sj**
1	31	Examples of other circular projects are used to inspire, to show that circularity can also be accessible and that not everything has to be applied at once	0,806
2	3	Circular ambitions are inventoried, formulated and translated into project objectives as soon as possible	0,796
2	1	There is a circular ambition and vision from the client	0,796
3	60	Project manager has basic knowledge of the concept of circularity, understands the concept of a circular economy, is able to involve an advisor when necessary and can translate the knowledge into his own projects	0,778
3	10	Support for a circular approach from the client ensures a circular outcome at project level	0,778
4	2	An ambition document has been drawn up for the project	0,796
5	65	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach	0,704
Group 3 – respondents with both knowledge expertises			
Rank	**No. SF**	**Success factor**	**Sj**
1	1	There is a circular ambition and vision from the client	0,800
1	10	Support for a circular approach from the client ensures a circular outcome at project level	0,800
1	65	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach	0,800
2	27	Project information is shared efficiently and transparently so that information does not get lost and the idea does not have to be reinvented	0,783
3	36	The project team includes people who can think out-of-the-box	0,767

3	37	Conditions to collaborate in a project are facilitated	0,767
4	38	The project team has knowledge of the concept of circularity	0,736
5	26	In the project agreements are made (with new contract forms) so that materials do not end up as waste	0,704

Table 5. 2 reinforces *Figure 5. 3*, *Figure 5. 4* and *Figure 5. 5* with the result that the different respondent categories rate the factors differently. Considering only the success factors identified with the first set threshold of 0.6 and the single derived numbers of all respondents would not do justice to the available data and the respondents involved. Therefore, the different answers per respondent category have been taken into account by conducting a sensitivity analysis. This was done by creating 4 scenarios in which different respondent groups have more influence per scenario.

5.1.5.2 Sensitivity analysis

Making use of different scenarios can be seen as a sensitivity analysis to test the robustness of the results and to identify if other success factors should also be included in the framework. The three different expert groups have been used to develop different scenarios, in which different weights have been assigned to the expert groups. Four scenarios have been created with the use of power / interest matrices. By shifting power / interest between expert groups, the importance of the results of an expert group increases or decreases.

The following assumptions are taken into account by determining the power/interest matrices:

- The power/interest scores are based on a three point scale. The number 3 represents the most power/interest and number 1 the least power/interest.
- Each score is used once except for the scores in scenario 4.
- The power and interest scores of each expert group are multiplied with each other to determine the importance value of each expert group in the specific scenario.
- This importance value is converted to a weight by comparing it to the total importance value of all experts and normalise the weight.

The different created scenarios are explained below.
The first theoretical scenario assumes that group 1 with advisors on circularity and group 3 with knowledge of both expertises can collectively make the best estimate of what the most successful factors are. The scenario is determined by giving group 1 medium power(2) and high interest(3). Group 3 gets a high power (3) and a medium interest (2) and group 2 gets a low power(1) and a low interest(1). As can be observed in *Table 5. 3*, group 1 and 3 have an equal and high weight and group 2 has a low weight.

Table 5. 3 - Weight of scenario 1 in the sensitivity analysis (Author, 2021).

Scenario 1	**Power**	**Interest**	**Importance value**	**Weight**
Group 1 – CE advisors	2	3	6	0,46
Group 2 – CPM	1	1	1	0,08
Group 3 - both	3	2	6	0,46
Total			**13**	**1**

In the second theoretical scenario, it was assumed that group 2 with the project managers would know best which success factors could be applied, since all factors that has to be validated were already been identified as success factors. Furthermore, group 3 also has more power since it also includes project managers. Within this scenario, the importance value of group 2 is increased, see *Table 5. 4*.

This is done by decreasing the importance value of group 1 and 3. The starting point of scenario 2 is that the project managers have a medium power and a high interest in these examined factors.

Table 5. 4 - Weight of scenario 2 in the sensitivity analysis (Author, 2021).

Scenario 2	Power	Interest	Importance value	Weight
Group 1 – CE advisors	1	2	2	0,18
Group 2 – CPM	2	3	6	0,55
Group 3 - both	3	1	3	0,27
Total			**11**	**1**

In the third theoretical scenario, it is assumed that group 3, the respondents with knowledge of both expertises, should have the most influence because they can make both considerations and have already performed circular projects in the role of project manager. Within this scenario, the importance value of the circular advisors (group 1) have been remained the same compared to scenario 2. The importance value of group 3 have been increased in value and group 2 have been decreased in value comparing to scenario 2. This results in a high weight for group 3 – the project managers with circular knowledge, see *Table 5. 5*.

Table 5. 5 - Weight of scenario 3 in the sensitivity analysis (Author, 2021).

Scenario 3	Power	Interest	Importance value	Weight
Group 1 – CE advisors	1	2	2	0,18
Group 2 – CPM	3	1	3	0,27
Group 3 - both	2	3	6	0,55
Total			**11**	**1**

The fourth theoretical scenario is based on equality between the different groups. Every group has an equal weight, see *Table 5. 6*. It should be noted that this scenario is different comparing to the all respondent values, since the numbers of respondents differ per group.

Table 5. 6 - Weight of scenario 4 in the sensitivity analysis (Author, 2021).

Scenario 4	Power	Interest	Importance value	Weight
Group 1 – CE advisors	1	1	1	0,33
Group 2 – CPM	1	1	1	0,33
Group 3 - both	1	1	1	0,33
Total			**3**	**1**

The different weightings of each scenario have been used to calculate the single derived numbers of the scenarios per success factor. These new values are illustrated in the *Figure 5. 6*, *Figure 5. 7* and *Figure 5. 8*. These graphs show the 4 scenarios, the basic scenario, which is called all respondents, and the second set threshold value. The value for the second set threshold will be explained after displaying the figures. The values of the single derived numbers per success factor are also calculated for each scenario and are included in *Appendix O – Calculation sheet Fuzzy Delphi method*.

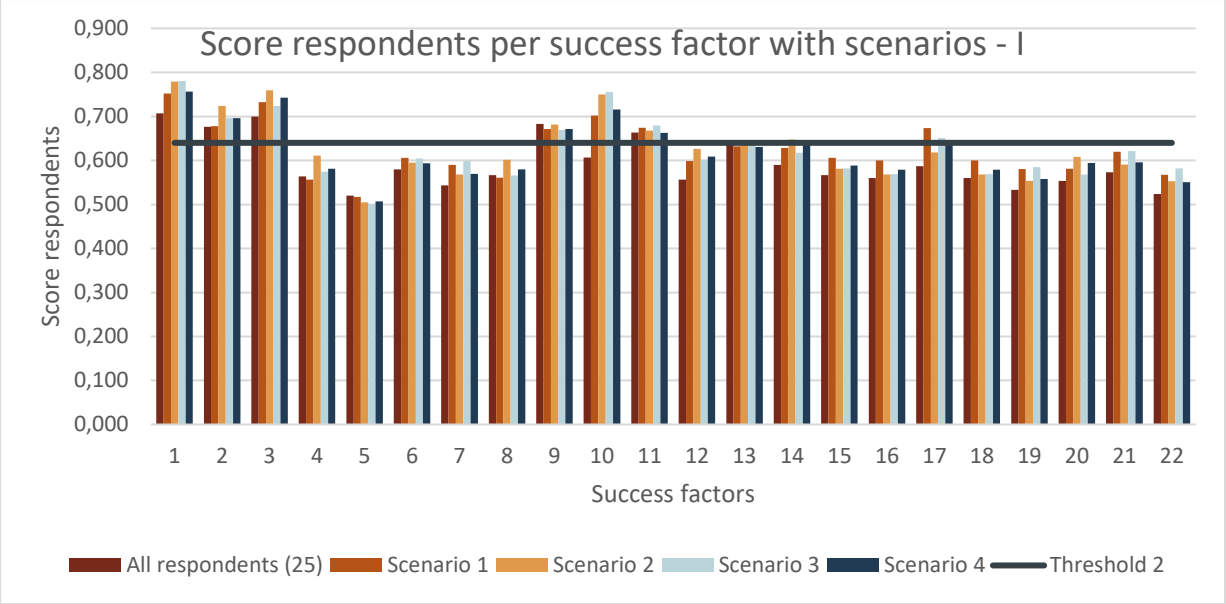

Figure 5. 6 - Overview of the single derived numbers per scenario for success factors 1 - 22 (Author, 2021).

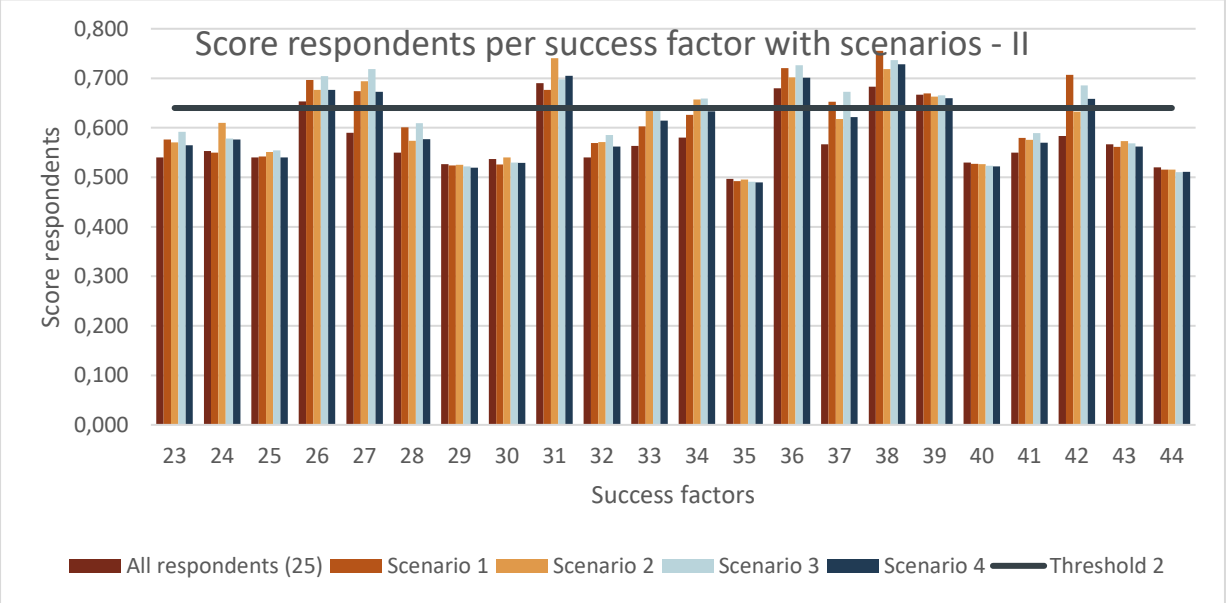

Figure 5. 7 - Overview of the single derived numbers per scenario for success factors 23 – 44 (Author, 2021).

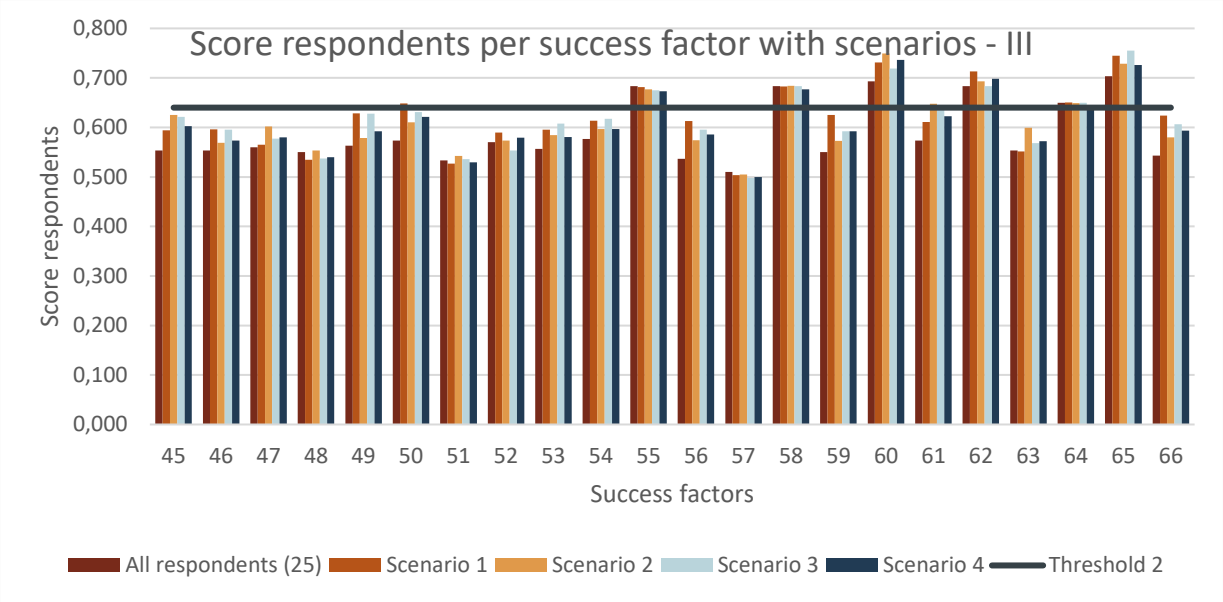

Figure 5. 8 - Overview of the single derived numbers per scenario for success factors 45 – 66 (Author, 2021).

The sensitivity analysis provides insight into whether the accepted success factors, which are accepted with the determination of the first set threshold, are robust. *Figure 5. 6*, *Figure 5. 7* and *Figure 5. 8* show that the accepted success factors, which were accepted with the first set threshold, are robust and are also accepted when applying different scenarios.
The figures show another phenomenon which is that some factors with a theoretical scenario score above the set threshold but the basic scenario does not. For example, this is shown at success factors 10 and 27. This phenomenon was already suggested in *Figure 5. 3*, *Figure 5. 4* and *Figure 5. 5*, where some groups of respondents rated the factors much higher than others. This phenomenon cannot be ignored and is therefore included in the selection of success factors. The success factors that score above the first set threshold 0.6 with 1 scenario or more are also added to the accepted success factors that should be included in the framework. This results in a total of 35 success factors. This amount is above the limitation of 30 success factors set by the researcher. This is why a second set threshold is determined. Instead of choosing the best-fit scenario, all four scenarios that were created were used.

5.1.5.3 Selecting success factors with the second set threshold

The second threshold is set at 0.64. The threshold is based on the upper and lower score of the single derived numbers and therefore between this range set at 75% corresponding to a threshold of 0.64. This new set second threshold result in 27 success factors, which can be subdivided into 8 factors associated to project preparation and 19 success factors corresponding to project management (as discussed in *Table 5. 1*).
The accepted factors corresponding to project preparation can be found in *Table 5. 7* and the accepted factors corresponding to project management can be found in *Table 5. 8*. An overview of the accepted and rejected success factors and the rank have been added to *Appendix M - Input data for Fuzzy Delphi method and end result*.

Table 5. 7 - The 8 accepted success factors corresponding to the category project preparation (Author, 2021).

No. SF	Sub-category	Success factor
1	Ambition	There is a circular ambition and vision from the client
2	Ambition	An ambition document has been drawn up for the project
3	Ambition	Circular ambitions are inventoried, formulated and translated into project objectives as soon as possible
9	Approach	Circular project requirements will be drawn up

10	Approach	Support for a circular approach from the client ensures a circular outcome at project level
11	Approach	Additional time will be reserved for setting ambitions, drawing up an ambition document and formulating objectives
13	Role project manager	The project manager should question the client whether the project can be connected to (other) existing circular/sustainability ambitions of the company
14	Role project manager	The project manager should be able to explain to the client what the consequences of a circular approach are in relation to the project

Table 5. 8 - The 19 accepted success factors corresponding to the category project management (Author, 2021).

No. SF	Sub-category	Success factor
17	Approach	All phases in which the building is involved are included in the project; both the construction phases from initiation to realisation and the subsequent maintain and disassembly phases
26	Procurement	In the project agreements are made (with new contract forms) so that materials do not end up as waste
27	Management	Project information is shared efficiently and transparently so that information does not get lost and the idea does not have to be reinvented
31	Management	Examples of other circular projects are used to inspire, to show that circularity can also be accessible and that not everything has to be applied at once
33	Management	Time for reflection is included in the process to evaluate the project, to reflect on the team members, to inspire each other and to challenge each other whether the ideas can be made even more sustainable and efficient
34	Management	Projects are digitized by means of BIM, a digital twin or a materials passport
36	Project team	The project team includes people who can think out-of-the-box
37	Project team	Conditions to collaborate in a project are facilitated
38	Project team	The project team has knowledge of the concept of circularity
39	Project team	The project team understands each other and the members share the same circular goals, vision and philosophy
42	Project team	All stakeholders involved in the project are motivated, both at company and personal level, to organise the project in a circular way
50	Budget	An inventory is made of additional financial resources at the client's organisation for sustainable/circular alternatives (such as tuition fees, sustainability budget)
55	Procurement	Circularity must be clearly formulated in invitations to tender
58	Procurement	The concept of circularity is included in selection criteria
60	Role project manager	Project manager has basic knowledge of the concept of circularity, understands the concept of a circular economy, is able to involve an advisor when necessary and can translate the knowledge into his own projects
61	Role project manager	Project manager knows that circularity can be a challenge for the client
62	Role project manager	Project manager has the courage to change, is curious about the concept of circularity, wants to try out new techniques and sees the urgency of a transition to a circular economy
64	Role project manager	The project manager is critical towards the client and discusses the established requirements of the project and asks why these requirements exists

65	Role project manager	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach

As can be observed in *Table 5. 7*, there are no success factors accepted associated with the sub-category objectives from *Table 5. 1*. Formulating objectives is an important conclusion from the interview method conducted in this study. However, formulating circular objectives is included in success factors 3 and 9.
The accepted success factors of *Table 5. 7* and *Table 5. 8* will be included in the framework to be developed for the project managers to integrate circularity in the construction projects.

5.1.6 Discussion and conclusion – SQ 6

This section discusses and concludes on sub-question 6: *Which success factors have to be included in the initiation and definition phase of a circular project to realise a circular building?*

The success factors identified in chapter 4.4 have been re-examined, merged and reduced to a list of 66 success factors that has to be assessed by the expert panel. The 66 success factors have been classified within the main categories 'project preparation' and 'project management', which are divided in several sub-categories. Thirty potential respondents have been contacted to rate the success factors with a five point Likert scale in a carefully designed questionnaire. Twenty-five respondents completed the questionnaire. The respondents can be divided in the following groups; (1) circular advisors, (2) construction project managers, and (3) respondents that have knowledge of circularity and construction management.

Given answers of the respondents with the five point Likert scale were converted to single derived numbers per all respondents, group 1, group 2 and group 3. These single derived numbers were tested against a set threshold and the success factors have been selected if the value of the single derived number was equal or higher than the threshold. The different identified success factors could all contribute positively to the realisation of circular projects, but the aim of the validation was to identify the most successful factors that could make the biggest contribution to realise successful projects with a circular approach. The margin between the highest given value and the lowest given value was limited. This small margin can be explained by the fact that the factors have been identified as success factors through different methods and had to be ranked to narrow down the list of success factors.

The researcher set a maximum of 30 accepted success factors. The first threshold was set at 0.6 which led to 18 success factors that scored above the threshold if the single derived numbers of all respondents were used. However, there was a significant difference in the answers given by the various categories on the degree of success per success factor. This means that a success factor might not be taken into account due to the score of all respondents, although it would have been ranked very high by a single category group. Considering only the success factors identified with the first set threshold of 0.6 and the single derived numbers of all respondents would not do justice to the available data and the respondents involved. Therefore, a sensitivity analyses was conducted by creating four scenarios in which different respondent groups have more influence than others. All four scenarios were created on the basis of assumptions. Two additional scenarios, which could also have been interesting but were not included in this study, are:

- Scenario 5: in which group 2 and group 3 are equally important as group 3 already has knowledge of project management and circularity and group 2 can assess whether the factors can be applied. Hereby, the importance value can be divided over group 1 with 0.08, group 2 with 0.46 and group 3 with 0.46.

- Scenario 6: in which group 1 gets the most influence as they have the most knowledge about circularity. Hereby, the importance value can be divided over group 1 with 0.55, group 2 with 0.08 and group 3 with 0.27.

As mentioned before, scenario 5 and 6 are not included in this study but could examined in future research.

The values of the single derived numbers per success factor were also calculated for the four created scenario's. The phenomenon that some groups of respondents rated the factors much higher than others could not be ignored. Therefore, the scenarios have been included in the selection of the success factors. The threshold was increased to 0.64 in order to meet the requirements set by the researcher. This second set threshold resulted in 27 success factors, in which eight factors are associated to project preparation and 19 success factors to project management. These should be included in the framework for the project managers to integrate circularity in construction projects.

It should be described that these 27 identified success factors were assessed from two perspectives; the success concerning applicability and the success concerning circularity.

5.2 Determining the layout and requirements for the framework

This chapter will focus and examine the type of assistance the framework should provide. Firstly, it will look at the wishes and advice of the circular advisors and construction project managers given in interview A and B for the framework. This input will then be converted into design propositions that will form the requirements for the framework. In addition, it will be further explained what a framework is, which frameworks already exist in the construction industry and what the layout will be for the framework in this research. This will answer sub-question 7: *Which frameworks do already exist for the construction sector to integrate circularity and how should the new framework look like?*

5.2.1 Wishes and advice gathered with the interviews

Type of assistance

CE advisor 1 (*Appendix C*) indicates that there should be a basic model for the project managers to get off the ground. A roadmap or information to start the conversation with the client is important for a framework (CE advisor 2,3 and 7, *Appendix C;* CPM 5, *Appendix G*). CE advisor 4 & 6 (*Appendix C*) add that there should be tools to divide the project into steps and to deal with circularity. CPM 1, 2 and 4 (*Appendix G*) indicate that there is a need for an overview of the various aspects, interventions and tools that can be applied to achieve the objectives. CPM 8 (*Appendix G*) indicates that a project manager needs a tool to convince the client to adopt circularity and also to support applying circularity in the project.

CE advisor 5 (*Appendix C*) states the importance of a project manager knowing what can be done in which phase and what the impact of the actions are. In addition, it is also important for construction project managers to know what the government's definition of circularity is, since they will be assessed on it by the client, and to know what the legislator requires and will require in the future (CE advisor 5 and 6, *Appendix C;* CPM 4, *Appendix G*).

CPM 3 and 5 (*Appendix G*) indicates that the framework should reflect the circular approach and the points for attention in the process.

The framework should support explaining to the client why a circular approach is needed, how to realise it and what it means for the project (CPM 3, 6 and 7, *Appendix G*). Besides, a project manager would be helped by a tool that gives insight critical questions to ask to bring the concept to the attention of a client (CPM 8, *Appendix G*).

A demand arises for a checklist with points for attention to avoid missing steps, important elements or delays (CPM 4, 6 and 8, *Appendix G*). This checklist can also be used as a roadmap to explain the steps to be completed (CPM 8, *Appendix G*).

In addition, extra knowledge is desired to be more certain about the subject when it comes to addressing the topic with the client (CPM 6 and 7, *Appendix G*). A folder with essential information would be desirable (CPM 7, *Appendix G*). The tool should give project managers the freedom to determine their own approach with the help of the tool (CPM 8, *Appendix G*).

Tools that support the transition process could also be considered, such as measuring tools, ambition tools and data tools (CE advisor 1, *Appendix C*). Tools that can help to understand and describe the concept are the 10R model, Sweco's circularity cards, CB'23 guidelines and the Ellen Macarthur Foundation's butterfly model (CE advisor 2, 4 and 5, *Appendix C*). In addition, CE advisor 4 (*Appendix C*) states that Stewart Brand's shearing layers model is important to divide the design in various layers and in order to formulate requirements.

Recipe model

The Recipe model, which was developed by Sweco, provides guidelines for the desired knowledge for a project manager (CE advisor 1, *Appendix C*).

CE advisor 2 (*Appendix C*) indicates that the framework to be developed is in line with the policy and organisation part, since this part focuses on the initiation and definition phase. The policies can be

viewed in the project manager's own organisation as well as in the client's organisation (CE advisor2, *Appendix C*).

Examples
There are countless solutions for including circular components in a project. A project manager should therefore be able to provide a number of examples to a client and show what the possibilities are (CE advisor 1, *Appendix C*). CE advisor 2 (*Appendix C*) objects to provide the project managers with a standard list of examples and options, since this will always be outdated. This task of providing examples and options should, at this stage, remain with the circular advisers (CE advisor 2, *Appendix C*). However, both CE advisor 3 and 5 (*Appendix C*), and CPM 4 and 7 (*Appendix G*) indicate that examples are important for project managers and for clients, because examples can inspire and show a different way of working. Both CE advisor 3 and 5 (*Appendix C*) indicate that examples show the accessibility of circularity in projects and the option to include circularity within certain components instead of apply everything at once. Examples will help to give content to circularity and to make the content your own in projects (CPM 1, 2, 3, 6 and 7, *Appendix G*). It would be useful to have a search function for the examples (CPM 4, *Appendix G*).

5.2.2 Design propositions

As described above, the content of the framework can be different as the needs vary. Within this research there is not enough time or capacity to fulfill all wishes. Therefore, from these wishes and recommendations of the circular advisors and the construction project managers, 4 design propositions have been drawn up to which the framework must comply. The design propositions were drawn up according to the CIMO-logic method of (Denyer et al., 2008).

To help the project manager integrate circularity in the initiation and definition phase of the project (C), the circular framework designed for the project managers can be used as a basic model (I) to illustrate the process of a circular approach and the consequences of a circular approach for the project (M) to realise projects according to the circular concept (O).

To help the project manager integrate circularity in the initiation and definition phase of the project (C), the circular framework designed for the project managers can be used (I) to explain to the client why a circular approach is required, how it can be achieved and what a circular approach means for the project (M) to realise projects according to the circular concept (O).

To help the project manager integrate circularity in the initiation and definition phase of the project (C), the circular framework designed for the project managers can be used (I) both by the project manager to consider the approach and interactively with the client to discuss a circular approach for the project (M) to realise projects according to the circular concept (O).

To help the project manager integrate circularity in the initiation and definition phase of the project (C), the circular framework designed for the project managers can be used as a checklist (I) for the necessary elements per phase and the points of attention for a circular approach (M) to realise projects according to the circular concept (O).

5.2.3 Format for the framework

In this research, the term framework refers to a guidance that organise (new) ideas in an overall picture such that it is easy to remember and apply the (new) concept.

Before creating the framework in chapter 5.4, thought was given to the format of the framework. As the research of Eberhardt et al. (2019) states, few frameworks have yet been developed for the

complex problem of the construction industry. However, there are currently a few frameworks developed for implementing circular construction (Kubbinga et al., 2018; Platform CB'23, 2019; van Leeuwen et al., 2018). Furthermore, a guidance for clients has been developed on how to apply circular economy in construction projects (UKGBC, 2019). These developed frameworks explain different aspects of the circular economy and provide a clear overview in one document, with the format of a report, but with a size of 28 to 41 pages.
In addition, interactive forms are also used to share the knowledge of circular building, but this form also takes a 31-page document (RVO, MVO Nederland, & Het Groene Brein, 2018).
Taken this information into account, there are already some interactive documents and reports available for download. Within interview B, the project managers indicate they do not have time to fully immerse themselves in the concept because this time would be at the expense of project time. A document with more than 20 pages would therefore not work in favour of the project managers working method. However, the developed frameworks and informative documents could be used as background information or to specify on the subject. In addition, a 20 to 40-page document will not be conducive to working interactively with the project manager and the client and fulfilling the third design proposition.
In this study, the researcher sets a maximum of 4 pages to the framework to be able to fulfil the third formulated design proposition of being able to use it as an interactive tool with the customer and to comply to the working method of project managers and their time constraints. This results in the idea of a placemat or infographic that compactly illustrates the most important information at a glance, such as the three infographics created by Circular impacts (2018). An infographic can easily be printed and used physically but can also be displayed in an online session with client and project manager.

5.2.4 Discussion and conclusion – SQ 7

Chapter 5.2 answered sub-question 7: *Which frameworks do already exist for the construction sector to integrate circularity and how should the new framework look like?*
The wishes and advice of the circular advisors and the construction project managers have been divided in type of assistance, recipe model and examples. Within this research there was not enough time or capacity to fulfill all desires, so for that reason four design propositions have been drawn up to which the framework must comply. The framework should be used:

- as a basic model to illustrate the process of a circular approach and the consequences of a circular approach for the project
- to explain to the client why a circular approach is required, how it can be achieved and what a circular approach means for the project
- both by the project manager to consider the approach and interactively with the client to discuss a circular approach for the project
- as a checklist for the necessary elements per phase and the points of attention for a circular approach

The term framework refers to a guidance that organises (new) ideas in an overall picture so that it is easy to remember and apply the (new) concept. Currently, a few frameworks have been developed for implementing circular construction, but these documents consist of more than 25 pages, which will not work in favour of the project managers.
The framework for the project managers has to be designed as an infographic that compactly illustrates the most important information at a glance with a maximum of 4 pages, which can easily be printed or displayed in an online session.

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5.3 Determining the content for the framework

This chapter will focus on the required content of the framework. The most important knowledge and essential tools will be identified that need to be part of the framework to support the project managers. The required information will be extracted from phase 1 problem investigation and sub-question 6. This chapter will therefore answer sub-question 8: Which 'general' knowledge and essential tools should be available for all project managers to convert their management and realise circular construction projects?

The problem investigation phase reveals that a successful circular approach requires knowledge of the part of the project manager and the project team. In addition, a client needs to have knowledge of circularity in order to generate awareness and support for a circular approach in the projects. Creating awareness and support is one of the first steps to be completed in the early stages of a project. Once this awareness is present, ambitions and objectives should be formulated for the project. These circular objectives will lead to a working method of the project manager whereby the additional objectives have to be managed. These circular objectives result in consequences for the management aspects, which must be taken into account in the initial phases of a project. For the management aspects money, time, organisation, information, procurement and risks, consequences were collected in this study. The process for successful implementation of circularity can be divided into three steps. The first step is to gain and share **knowledge about the concept of circularity**. The second step is to create awareness and support for a circular approach and to formulate circular ambitions and circular objectives during the initiation and definition phase. Step 2 is called **project preparation**, since the project is defined in the initial phases of a project. Subsequently, the circular objectives will lead to consequences for management aspects of the project. On account of the function of the project managers, step 3 is called **project management**. Step 2 and Step 3 will interact with each other, as information about the content and management aspects will be needed to have the conversation with the client and formulate the ambitions and goals. By dividing the framework into several steps to be completed, the first design proposition will be met. The relationship between the various steps that needs to be taken in order to perform a successful circular project, should also be indicated in the framework. The content of the different steps to include in the framework will be further elaborated in the upcoming sections.

5.3.1 Step 1 - knowledge of a circular economy

As described in *chapter 4.1* and *chapter 4.2*, a project manager will need knowledge of circular construction and basic knowledge of a circular economy. In addition, the project managers would like to have a timeline. In order to fulfil this need, the timeline of *Figure 1. 1* will be included. As this timeline also reflects the necessity and the desire of the government for the transition, it will contribute to explaining why a circular economy should be applied and therefore to the why question discussed in the second design proposition. In order to provide project managers with basic information, the framework will include a part of *Figure 2. 1* that illustrates the differences between a circular and a linear economy, the definition of a circular economy, the definition of circular building and the circular strategies discussed in *chapter 2.2*, *chapter 4.1* and *chapter 4.2*. In addition, *chapter 4.1* showed that the Ellen Macarthur Foundation's butterfly model, the 10 R model visualised in *Figure 4. 1* and the shearing layers model visualised in *Figure 4. 4* are of interest and are often used.
In addition, some links will need to be included for more detailed information such as the link to the government website with the climate change agreement document that outlines the need for change, to the Ellen MacArthur Foundation website that explains the principles of a circular economy and to the platform CB'23 website where the designed framework and associated documents are explained and can be downloaded (Ellen MacArthur Foundation, 2017; Platform CB'23, 2019; Rijksoverheid, 2021). Furthermore, a link of project examples of the 'De Circulaire bouweconomie' should be included (De circulaire bouweconomie, 2021).

5.3.2 Step 2 – Project preparation

Step 2 entails the formation of a project, which happens in the initiation and definition phases. During this project preparation, awareness and support for a circular approach at the client must be created by starting a conversation. This awareness and support will hopefully rise to circular ambitions, which will subsequently have to be translated into circular objectives. These objectives must be defined, ensured and measured. As soon as circular objectives are defined, they have to be managed and this leads to the interaction with step 3 project management.

Creating awareness and support for a circular approach should be generated as early as possible in the process and should preferably take place in the initiation phase and otherwise as soon as possible in the definition phase. Awareness and support of a circular approach will hopefully results in circular ambitions for the project. These circular ambitions could be used to formulate circular objectives, which should be done in the definition phase.
This process is visualised in *Figure 5. 9.*

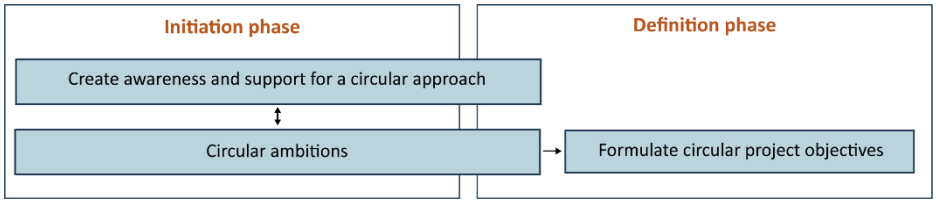


Figure 5. 9 - Process of the project preparation (Author, 2021).

Creating awareness and support for a circular approach
Awareness and support can be created by starting a conversation with the client, in which the need for a circular economy, the definitions of a circular economy and circular building and design strategies are explained. In order to do this, there should be a conversation between client and projectmanager. Questions should be addressed as: "What means circularity to you?", "What are your goals?" and “what can be achieved?”. This conversation can be initiated by the projectmanager or the client. However, the projectmanager needs basic knowledge in order to start the conversation with the client, in which step 1 of the framework can help.

Circular ambitions
Awareness will results in support and hopefully in circular ambitions. It is the job of the projectmanager to draw the clients attention to new developments such as a circular approach, which has been one of the results of *paragraph 4.2.1.1*.
To formulate the circular ambition, the 10R model and 6S model could help which are included in step 1. The focus of the ambitions could be on several circular strategies and the ambitions can be documented in opportunity cards and ambition documents as resulted from *paragraph 4.2.2.7*.

Circular objectives
In order to formulate circular objectives, a defintion for circularity within the project should be expressed. Defining circularity could also be done within the initiation phase. The following questions could be asked:

- What is a good definition for circularity in the project?
- How is the proper request made?
- What is the target for circularity?
- And how is circularity included in the project?

Furthermore, circular objectives should be formulated, ensured and made measurable in the second step. First of all, clear circular project objectives should be formulated and documented. Possibilities to require are: certain parts of the building should be demountable, parts should be designed in a

modular way, using bio-based materials, using renewable materials, the building should be designed according to the Stewart Brand layers model, a building consist of x% reused materials or the amount of reusing materials is based on the monetary value rather than the quantity. The objectives can be documented in the programme of requirements. For ensuring the circular objectives a tender, plan of approach and circular award criteria divided in qualitative (objectives, ambitions, plan of approach) and quantitative (environmental cost indicator, materials passport) could be used. Furthermore, for ensuring and monitoring the objectives use can be made of: GPR, BREEAM, WELL, Life cycle analysis, material passport, environmental cost indicator, 10 R ladder with a weighting per R, the MPG score, detachability measurments and the CPG- score.
A circular advisor can be added to the process in order to formulate, ensure and measure the ambitions and objectives.

Step 2 project preparation will explain the how question of 'The Golden Circle of Sinek', since it will answer how a circular project should be approached in the early stages of a project (Strategischmarketingplan, 2020).

5.3.3 Step 3 – project management

This step will contain information on how a circular project can be managed and how circularity affects the various management aspects. Within *chapter 4.2* and *chapter 4.3*, it has become clear
that the project management of a project itself will not change but extra circular objectives will be added when adopting a circular approach in a project and his circular objectives should be managed. Managing the circular objectives will be an addition to the current work of a project manager. The circular objectives, which will be defined in step 2, lead to consequences for management aspects of the project. For a project manager, it is important to know what the consequences of a circular objective are and to communicate this with the client. There is an interaction between step 2 project preparation and step 3 project management since the objectives leads to consequences and visa versa. *Chapter 4.2* identified consequences for the management aspects budget, planning, information, organisation, procurement and risks.

Budget
A circular project appears to be 5-25% more expensive or it is possible to challenge the market to realise the highest achievable circularity within a traditional estimated budget. In order to increase the project' budget, it is possible to ask for learning and sustainability budgets within the client's organisation. Another financing method is product as a service, which could be used for lift (facilities), light and furniture. However there are some drawbacks of this method, such as will the service company exist throughout the life cycle of the building, the administrative contracts has to be maintained and the fragmentation of ownership (and its legal aspects). In order to increase projects budget, it is also possible to apply for a Mia and Vamil grant (Rijksdienst voor Ondernemend Nederland, 2021).
The remaining value of the building or materials is the drive of the economy, but it is still difficult to work with. The residual value could be interesting if it can be included as a deduction from the investment.

Planning
The circular ambition should be formulated in time to prevent delay and to be able to execute every phase of a project once. Furthermore, 1 to 2 months extra are required to set and formulate circular ambitions.

Information

The project information should be well documented and preferably input and output information of the project should be gathered and created. The input information could be a material analysis or an inventory scan. The output information could be a material passport.

Organisation

The organisation of the project team is a result of the chosen procurement. Chapter 4.2 made it clear that market parties should be involved earlier in the process comparing to a traditional building process. Examples of market parties that should be involved earlier are a demolisher, a contractor and a cost expert. A construction team is commonly used in circular projects. Furthermore, a circular advisor should be included to the project team and if needed a circular project manager. The project, the project team and the process have to be reflected in order to achieve the best possible results. Finally, circularity should be part of the agenda to remember the team and project managers of the extra objectives.

Procurement

As described at the management aspect organisation, market parties has to be involved earlier in the process. Different moments of selection are possible, which have been concluded in *paragraph 4.2.2.7.* The identified circular procurement options have been visualised in *Figure 5. 10.*

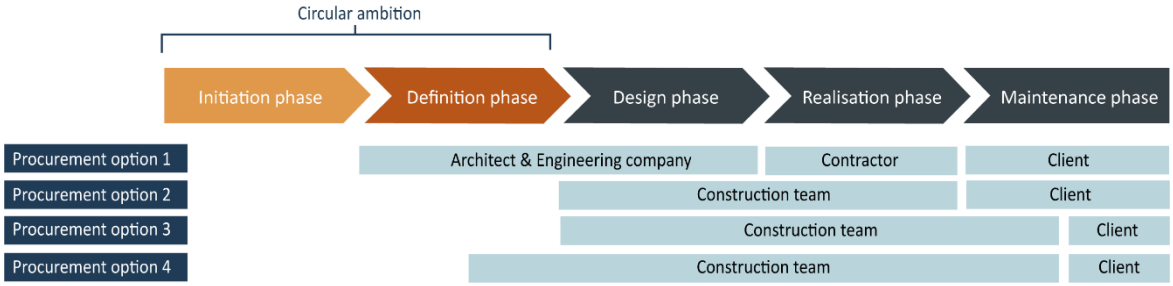


Figure 5. 10 - Procurement options for project with a circular approach (Author, 2021).

The main used contract is an UAC-ic contract applied as a design, build, maintain contract. Furthermore, circularity has to be included in tenders by means of a competitive dialogue or including circular award criteria. Circular award criteria can be divided within qualitative award criteria, which consist of objectives, ambitions and a plan of approach, or quantitative award criteria, which entails an environmental cost indicator or the request for a materials passport. In order to check the market, a market consultation can take place, which has a duration of approximately 1 or 2 months.

Risks

Chapter 4.2 reveals that the client should be more willing to take risks in order to stimulate the market. The other identified risks can be described as barriers in the design and realisation phases but it is recommended to discuss this with the client. Obtaining guarantee certificates for constructive reused materials are difficult. Furthermore, the digital project information should be maintained in the maintenance phase, which could be seen as an additional task for clients. Due to the lack of a universal measurement method, measuring circularity is difficult and it can occur that with a universal measuring method the building is less circular than initially conceived. Finally, the availability of secondary materials in the construction phase should be considered as a risk.

Step 3 project management will explain the what question of 'The Golden Circle of Sinek', since it will answer what will change and what the consequences are for the project in terms of management aspects when adopting a circular project (Strategischmarketingplan, 2020).

Eventually, the 27 identified success factors in *chapter 5.1* should be incorporated within the framework. The success factors could form a checklist for the project managers in order to check the

focus aspects when adopting a circular approach. Furthermore, the checklist can also be used as an interactive tool to determine with the client in which areas the focus should be and what the project should achieve. Including the success factors will contribute to design proposition 3 and 4.

5.3.4 Discussion and conclusion – SQ 8

Chapter 5.3 answered sub-question 8: *Which 'general' knowledge and essential tools should be available for all project managers to convert their management and realise circular construction projects?*

The most important knowledge and essential tools that should be integrated in the framework have been identified.
The problem investigation phase has revealed that a successful circular approach requires knowledge on the part of the project manager and the project team. In addition, a client needs to have knowledge of circularity in order to generate awareness and support for a circular approach in the projects. Creating awareness and support is one of the first steps to be completed in the early stages of a project. Once this awareness is present, ambitions and objectives should be formulated for the project. These circular objectives will lead to a working method of the project manager whereby the additional objectives have to be managed. These circular objectives result in consequences for the management aspects, which must be taken into account in the initial phases of a project. For the management aspects money, time, organisation, information, procurement and risks, consequences were collected in this study.
The process for successful implementation of circularity can be divided into three steps. The first step is to gain and share knowledge about the concept of circularity. The second step is to create awareness and support for a circular approach, to create circular ambitions and to formulate circular objectives during the initiation and definition phase. This second step is called the project preparation phase. Subsequently, the circular objectives will lead to consequences for management aspects of the project, which is called step 3 project management. Finally, as additional information the 27 identified success factors in *chapter 5.1* should be incorporated within the framework.

5.4 Creating the framework

This chapter will focus on designing the framework. The framework is designed for project managers involved in the early stages of a construction project. The input from sub-questions 7 and 8 will be used to design the framework.
In this way, this chapter will answer sub-question 9: How to design a framework for project managers to apply circularity in the initiation and definition phase of a construction project?

The four established design proposition and the established layout of *chapter 5.2*, namely an infographic of maximum four pages, have been taken as input of sub-question 7. In addition, the different steps and knowledge identified in *chapter 5.3* to answer sub-question 8 are included as content for the framework.

5.4.1 Layout sketches

First of all, six layout sketches were made to determine a layout for the framework. In the layout sketches, the 3 most important steps, identified in *chapter 5.3*, were taken into account. Furthermore, the relations between the steps were made clear and the success factors, identified in *chapter 5.1*, were included. In addition to the visualisation of the layout, an explanation of the idea and comments have been placed in *Appendix P – 6 layout sketches for the framework*.

After a validation round with the company's supervisor and a colleague architect who likes conceptual thinking, it was decided that layout sketch no. six best represents the design propositions, the three identified steps and the relations between the different steps. However, all six layout sketches assign the same focus and attention to all three steps while steps two and three include the new added value to science and practical application. Concluding, step one can be described as 'a nice to have' and step two and three can be described as 'a must have' for the framework. Steps two and three should get more attention in the framework in terms of space. Taken the six layout sketches into account a final sketch design has been made. This final sketch design is shown in *Figure 5. 11*.

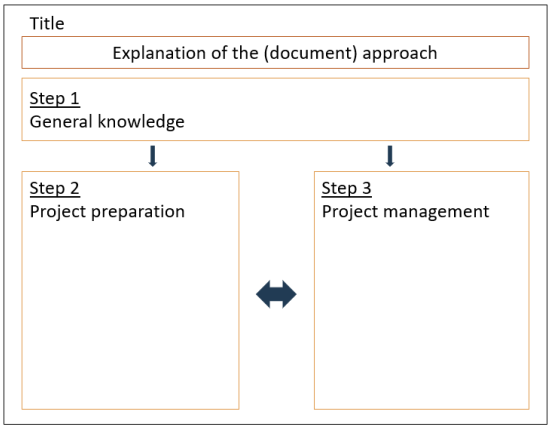


Figure 5. 11 - Final sketch design framework (Author, 2021)

5.4.2 Final framework design for project managers

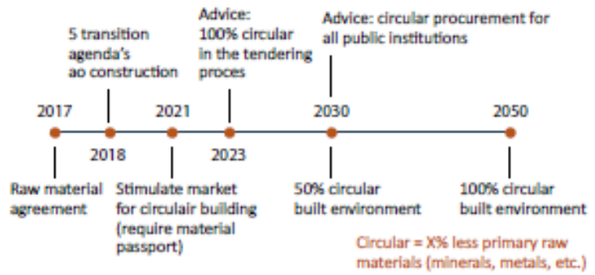
Subsequently, the final design was completed with the information gathered in *chapter 5.3*. This results in a framework of 2 sheets of A3 format, which illustrates the relationship of the three steps and explains the content of the 3 steps on the first page. The second page contains additional background information that can be used to supplement step 1 or step 2. In addition, the success factors identified are also included in the form of a checklist on the second page. These success factors have been formulated more concisely. This concise written form has also been added to *Appendix Q – Success factors concisely*. The framework has been designed with Adobe Indesign and is exported as a PDF.
The described framework above is ready to validate. The validation of the framework will be described in *chapter 6.1*. After validation some textual changes were made to the content of the framework. This adjustments after validation results in a finalised design for the framework for the project managers to integrate circularity within the initial phases of construction projects. The developed framework is shown on the following two pages.

Framework for project managers to integrate circularity in the initial phases of construction projects

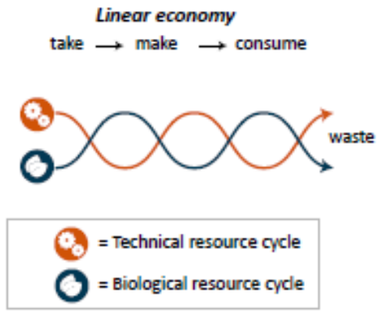
This framework provides tools for project managers to implement a circular approach in a construction project during the initiation and definition phase.

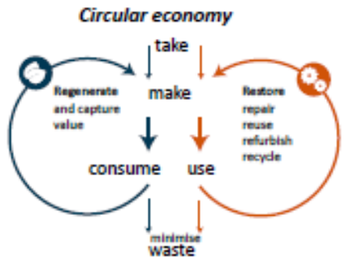
A succesful circular project approach = **1** Knowledge of circular economy in the construction sector + **2** Integrate circularity in project preparation + **3** Integrate circularity in project management

1 CIRCULAR ECONOMY IN THE CONSTRUCTION SECTOR



There are no rules yet in the building code regarding circularity





A circular structure has been designed and implemented in accordance with circular design principles and has been realized with circular products, elements and materials

Design principles = prevention, value retention and value creation

Circular strategies = design out waste, design for adaptability, design for disassembly, use secundary materials, use renewable materials or use biobased materials (wood)

Circular models

- Butterfly model by Ellen Macarthur Foundation (EMF)
- 10R model (see second page)
- Shearing layers model (see second page)

Links to more information

- Need to change - *Dutch government*
- Definition circular economy - *EMF*
- Circular building defined by platform CB'23 - *Framework + Lexicon*
- Project examples - *circulairebouweconomie*

2 PROJECT PREPARATION

Initiation phase	Definition phase
Create awareness and support for a circular approach	
↕	
Circular ambitions	→ Formulate circular project objectives

Create awareness and support

- Start conversation

What is circularity for the client? What are the circular goals? What can be achieved? What knowledge does the client have in the area of circular construction? Is there already a circular ambition or objective in the organisation or in the project? Is the purpose of a circular economy clear?

Information of step 1 can be used to explain the 'why' of a circular economy and to start the conversation.
Information of step 3 can be used to explain the 'what' of a circular approach and the consequences for the project.

Define circular ambitions

- Choose a circular strategy

Examples of circular strategies can be found in box 1

- Use models to explain and formulate ambitions

10R model, shearing layers (see second page)

- Document the ambitions

Use an ambition document and/or opportunity cards (opportunity cards contains opportunities of the environment for the project)

Formulate a circular definition for the project

What is the purpose of the project? Which circular strategy is used? How will circularity be included in the project?
Circularity can also be defined during the initiation phase

Formulate circular project objectives

- Formulate and document

Possibilities to require: demountability, modular building, biobased, renewable materials, design according shearing layers, x% reused materials, on the basis of the monetary value rather than the quantity of materials
The choosen circular strategy has influence on the requirements
Document the objectives: *Programme of requirements*

Ensure

- *Plan of approach, circular award criteria*

Measure or monitor

- *There is no universal accepted measurement method yet. Options: GPR, Breeam, Well, Life cycle analysis, material passport, environmental cost indicator, 10 R ladder with a weighting per R, the MPG score, detachability measurments and the CPG- score.*

It is recommended to add a circular advisor to the project in order to formulate, ensure and monitor circular objectives

3 PROJECT MANAGEMENT

Budget (construction)

- Project is 5-25% more expensive or challenge the market within traditional estimated budget
- Ask for Clients' learning and sustainability budgets
- Drive of the circular economy is the residual value of the building / materials
- Product as a service; *elevator (facilities), light and furniture*
- Grants; *Mia and Vamil*

Planning

- Formulate circular ambition early in the process
- Reserve 1 to 2 months extra to set and formulate circular ambitions

Information

- Document project information
- Obtain project's input information *Material analysis or inventory scan*
- Create project's output information *Material passports*

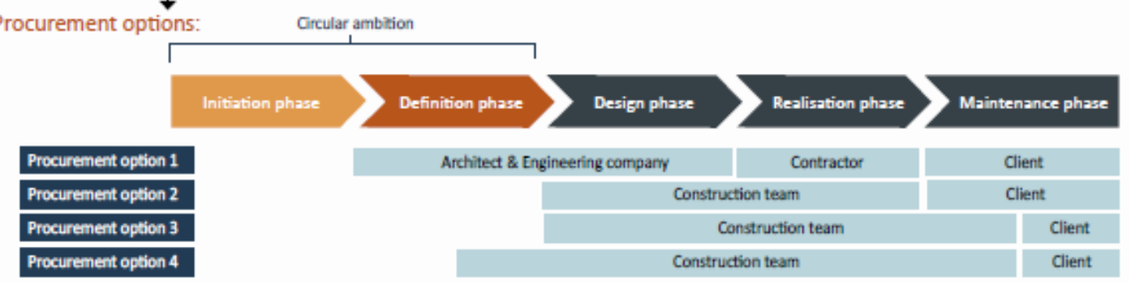
Organisation

- Is a result of the chosen procurement
- The market should be involved earlier *demolisher, contractor or cost expert*
- A construction team is commonly used in circular projects
- Include a circular advisor and if needed a circular project manager
- Reflect the project, team and process
- Introduce circularity to the agenda

Procurement

- Involve market parties earlier *Different moments of selection possible - see figure procurement options*
- Use UAC-ic contracts *such as a design, build, maintain contract*
- Include circularity in tenders. *Select market parties with a competitive dialogue or use circular award criteria (qualitative; objectives, ambitions, plan of approach or quantitative; environmental cost indicator, materials passport). Use a market consultation (approx. 2 months).*

Procurement options:



Client and project manager are involved in all phases. It is recommended to involve a circular advisor

Risk

- Client can take more risks to stimulate the market.
- Obtain guarantee certificates for constructive reused materials
- Maintain digital project information
- Availability of materials

This framework is related to the master thesis of Jeanine Tobben

EXTRA BACKGROUND INFORMATION

Definitions

A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems

Circular construction is the development, use and reuse of buildings, areas and infrastructure, without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems by using as many renewable raw materials as possible. Building in a way that is economically, socially, culturally and ecologically responsible. Here and there, now and later.

A circular structure is a structure that: as been designed and implemented in accordance with circular design principles and has been realised with circular products, elements and materials

10R model

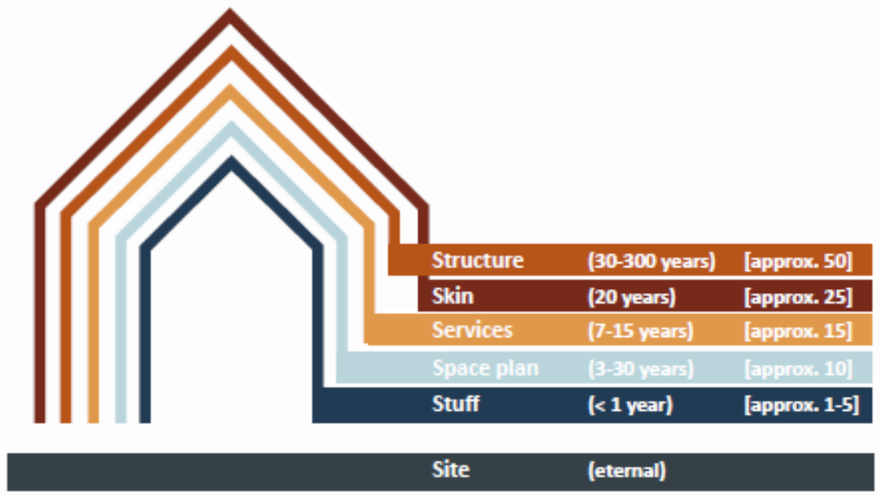
(Cramer, 2015; Potting, 2017)

Circular economy ↑ Linear economy

Smarter product use and manufacture	R1	Refuse	Make product redundant by abondoning its function or by offering the same function with a radically different product
	R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
	R3	Rethink/Redesign	Make product use more intensive or redesign product in view of circularity
Extend lifespan of products and its parts	R4	Reuse	Reuse by another customer of discarded product which is still in good condition and fullfils its original function
	R5	Repair	Repair and maintenance of defective product so it can be used with its original function
	R6	Refurbish	Restore an old product and bring it up to date
	R7	Remanufacture	Use parts of discarded product in a new product with the same function
	R8	Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of materials	R9	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R10	Recover	Incineraton of materials with energy recovery

Shearing layers

(Brand, 1994; Crowther, 2001)



THE 27 MOST SUCCESSFUL FACTORS FOR CIRCULAR CONSTRUCTION PROJECTS

Checklist with factors that effect the success of a construction project with a circular approach. The Success factors are applicable in the begin phases of a project.

Checklist project preparation:

Approach project preparation:

- ☐ Client (including organisation) supports circular approach
- ☐ Reserving time for setting ambitions, drafting an ambition document and formulating objectives

Ambition:

- ☐ Client has a circular ambition and vision
- ☐ Draw up an ambition document
- ☐ Identify and formulate circular ambitions and translate them into project objectives

Objectives:

- ☐ Draw up circular project objectives

Role of the project manager:

- ☐ Project manager questions the client for possible connections to (other) circular/sustainability ambitions (of the company)
- ☐ Project manager explains the consequences of a circular approach for the project to the client

Checklist project management:

Approach project management:

- ☐ All phases in which the building is involved are included in the project (including management and dismantling phases)

Budget

- ☐ Inventory of additional financial resources for a circular approach in the clients' organisation (such as learning money or sustainability budget)

Planning

- ☐ Reflection time is included in the process to evaluate, to reflect the team members, to inspire and to challenge each other for a different approach

Information:

- ☐ By sharing project information efficiently and transparently, information (for follow-up projects) will not be lost
- ☐ Circular example projects are used to inspire and demonstrate that circularity can be easily accessible and that not everything has to be applied at once
- ☐ Project is digitalised (through BIM or material passport)

Procurement:

- ☐ Agreements (and contract forms) ensure that material does not end up as waste
- ☐ Circularity is clearly formulated in tenders and procurements
- ☐ Circularity is included in selection criteria

Organisation:

- ☐ All stakeholders in the project are motivated to adopt a circular approach, both at company and personal level
- ☐ Project team includes members who can think out-of-the-box
- ☐ Facilitating conditions for cooperation
- ☐ The project team has knowledge of the concept of circularity
- ☐ Project team understands each other and have the same circular goals, vision and philosophy in mind

Role of the project manager:

- ☐ Project manager has basic knowledge of the concept of circular construction, can translate it into a project and engages a consultant when necessary
- ☐ Project manager is aware that circularity can be a challenge for the client
- ☐ Project manager dares to change, is curious about the concept of circularity, wants to experiment with new techniques and sees the urgency of a transition to a circular economy
- ☐ The project manager is critical towards the client, discusses the constraints of the project and asks why the constraints exist
- ☐ The project manager is intrinsically motivated and enthusiastic, convincing the client for a circular approach

Discussion and conclusion – SQ 9

Chapter 5.4 focussed on designing the framework for project managers involved in the initial phases of a construction project. Therefore, it focussed on sub-question 9: *How to design a framework for project managers to apply circularity in the initiation and definition phase of a construction project?*

The design proposition, the established layout and the different steps identified in previous chapters have been assumed as the basis for the framework.
Six layout sketches were made to determine a layout for the framework. These sketches reveal that steps two and three include the new added value to science and practical application.

The insight of the sketches and the basic content identified, resulted in a framework of two sheets of A3 format. The relationship of the three steps and content of the steps is explained and illustrated on page one and the second page contains additional background information and a checklist with the identified the success factors.

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6. Phase 3 – Solution validation

The third phase of the design cycle, also called phase 3 – solution validation, will validate the designed artefact. This phase will answer one sub-questions.

6.1 Validating the framework

This chapter will focus on validating the framework. First of all, the goals have been explicated and a validation strategy has been chosen. Subsequently, validation has been performed. This chapter will answer sub-question 10: *Would the framework be able to support and provide the project managers with knowledge in order to transform their current project management into circular project management during the initiation and definition phase?*

6.1.1 Validation strategy

The validation of the framework will make use of a predictive evaluation also called the Ex ante evaluation, which is performed in order to estimate and evaluate the impact of future situations (Venable et al., 2016). Several purposes can be identified in literature to evaluate an artefact. This research will concur with the purpose stated in the study of (Hevner, March, Park, & Ram, 2004), in which the artefact can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization and other relevant attributes. This purpose is also in line with the rigor goal described in the study by Venable et al. (2016) who created a framework for evaluation. With a rigor goal, the effectiveness can be evaluated by testing if the artefact works in a real situation.
Even though different goals are mentioned in the literature, little guidance has been provided on how and why a certain method is chosen. In order to determine the method for evaluation, the framework of Venable et al. (2016) will first be followed. The framework of Venable et al. (2016) consist of four steps. The first step is to explicate the goal, which has been done in the previous section. To include the rigor goal a summative evaluation purpose will be used. A summative evaluation is used to produce empirically based interpretations for creating shared meanings about the evaluand. Step 2 consist of choosing a strategy. The strategy 'Human Risk and Effectiveness' has been chosen since the artefact is social and user oriented. With this strategy, care must be taken to evaluate the costs, since the strategy make use of real users (Venable et al., 2016). Within this graduation research, real users are available for free, so this strategy can be used.
Step 3 is to determine the properties to evaluate. As described, the effectiveness will be evaluated as well as the applied design propositions formulated in *chapter 5.2*. The last step of the framework of Venable et al. (2016) is to determine the evaluation periods. Due to time constraints, there will be one evaluation period in this study.

The evaluation methods can be divided in qualitative and quantitative testing. One of the easiest methods to validate the designed artefact is by asking expert opinions (Wieringa, 2014). The theory of Wieringa (2014) stated that expert opinions can be used to weed out bad designs early. In ideal circumstances, the validation according to Wieringa' theory (2014) should involve a single case mechanism experiment, but due to time constraints, this is not feasible in this research. The second best way is to use expert interviews, which will be used to validate the designed framework. The interview method, which is called interview D, has been described in *paragraph 3.3.5.* Within this research, an expert is defined as someone who has experience within the field of construction project management and experience the problem context described in *chapter 1.2*.

6.1.2 Collect expert opinions

Four experts were interviewed and the interview consisted of 3 parts; firstly, the design propositions were explained and the validation questions were shared by means of an presentation, then the framework was explained and finally the validation questions were asked. The interview questions are

included in *Appendix J – Questions Interview D*, and the presentation belonging to the validation is included in *Appendix R – Validation document*. The validation focussed on the functionality, performance and usability of the framework as was proposed by Hevner et al. (2004).
Transcripts of the interviews have been made and can be found in *Appendix K – Transcripts interview D*. A summary of the interviews per expert is given below.

Expert 1
It is an excellent framework that can be used primarily for the initial discussion with the client and as a guide for the project manager. For a project, more substantive knowledge is needed, but this can also be obtained by including an expert. This substantive knowledge is also not required for being able to apply the framework. It is a useful tool for discussing the circular approach with the client as well as for the project manager to see where the critical factors are and what needs to be considered during the initial stages. The framework meets all design propositions. Some adjustments are still suggested and consist of textual adjustments and extra information about certain aspects. Since a client wants to know what his investment returns, more information about the residual value could be given. In addition, the parties involved in the initial phases could be added to the figures that shows the procurement options. The framework can be implemented and will give the project manager enough information to address circularity and start the conversation with the client.

The suggested modifications have been incorporated into the framework. Additional information regarding the investment and the remaining value of material (components) is not available in this study and will be included as a recommendation for further research.

Expert 2
The framework is straightforward, has a clear structure and a pleasant colour scheme. It reflects the different steps that need to be followed, shows the common thread for a circular approach and functions on a scale from large to small. Furthermore, it meets all design propositions. The framework gives tools to the project managers, can be used to start the conversation with the client and can convince the client for a circular approach. During the interview, a few adjustments were suggested, such as clarifying the involvement of the circular advisor in the initial phases, the interest in a circular strategy and the drive of a client and the clarification that a materials passport is made in the realisation phase. For implementation, a detailed story and a Dutch version of the framework would be desirable. The challenge to implement a circular approach will be mainly in the required budget and the fear of a circular approach. However, these are not challenges to implementing the framework. The framework will have to be applied to find the challenges.

The proposed textual adjustments have been incorporated into the framework. The detailed story can be interpret as the content of the framework and can be found in *chapter 5.3*. The Dutch version is desired, will be made in the future by the researcher but is not included in this graduation thesis. Additional information regarding the choice of a particular circular strategy is not available in this study and will be included as a recommendation for further research.

Expert 3
The framework is very informative and represents the information in a compressed form. It reflects the steps to be completed and the consequences for the approach. The project manager is able to apply the proposed steps. However, circularity remains a specific matter that requires impactful decisions in the project. This is well covered in the framework, but I am not yet sure about applying it in a project, so I would first like to see some examples of projects. I would like to see these example projects in relation to the steps proposed in the framework, such as the transition from an ambitions to formulating project objectives. In addition, I think it would be interesting to develop a tool that takes the project manager and the client through the steps where information can be entered and the

tool will give the client a grade for the circular approach. I would also like to know whether the timeline in the framework is already related to the building regulations. The framework complies with the design propositions. However, as a project manager, I still see challenges for implementing the framework because I would like to have examples that have completed the steps of this framework.

After this validation interview, the link between timeline and building regulation was added. In addition, a link with project examples has been added to the designed framework. However, the framework has not been transformed into a fill-in tool as suggested, since the other experts validated the tool as a framework that is useful. Besides, there is no universal circular measurement tool, which makes it difficult to grade the circular approach of the client. Furthermore, during the research no project was found that had completed all the steps discussed in the framework. This means that the question for examples can only be answered after implementation of the framework and using the proposed approach. However, the various interviews and cases in this study do provide supporting arguments for completing these steps when adopting a circular approach.

Expert 4
It is a great and clear framework, which is certainly useful for a project manager in practice. I am impressed that you have created this yourself. The steps, that have to be completed, are clearly explained and are in logical sequence. The framework meets the formulated design propositions. I, as a project manager, would like to use the framework and already know a few projects where I would like to apply it. At the moment, some small details can still be changed, such as adding the word construction to the budget because it specifically concerns the construction budget, the link to the mia and vamil grants can be added, adapt that a design build and maintain contract is a form of a UAC-ic contract and a punctuation mark can be added to the material passport. I would like to use the framework immediately as it matches the market demand that exists today; how to approach a circular project.

The proposed adjustments have been incorporated in the framework.

6.1.3 Discussion and conclusion – SQ 10

Chapter 6.1 focusses on sub-question 10: *Would the framework be able to support and provide the project managers with knowledge in order to transform their current project management into circular project management during the initiation and definition phase?*

An Ex ante evaluation, which was performed in order to estimate and evaluate the impact of future situations was used to validate the framework. The goal of the evaluation was to validate the effectiveness by testing if the artefact would work in a real situation. One evaluation period has been used to validate the framework. Expert opinions could be used to weed out bad designs early. Expert interviews have been conducted in order to validate the designed framework.

During the validation interviews, the design propositions were explained, the validation questions were shared, the framework was explained and finally the validation questions were asked.

The experts described the framework as an excellent tool that can be used primarily for the initial discussion with the client and as a guide for the project manager, which would certainly be useful for a project manager in practise. Furthermore, the framework is straightforward, has a clear structure and a pleasant colour scheme. It reflects the different steps that need to be followed and considered during the initial stages, shows the common thread for a circular approach, could be used to convince the client and reflects the consequences for a circular approach. The framework meets all design propositions. One expert indicated that more substantive knowledge is needed in a project, but this can also be obtained by including a circular advisor. Another expert indicated that it is a very

informative framework that represents the information in a compressed form but finds it difficult to apply the framework in a project since circularity remains a specific matter that requires impactful decisions in the project. This expert requested more examples. Several other adjustments have been suggested. The adjustments in line with the research have been added to the designed framework.

Three out of four experts would like to implement the framework in their working method, since the framework matches the market demand that exists today: how to approach a circular project. There will probably be challenges to implement the framework, but these are not yet known or seen by the experts and will be mainly in the change management at the client's and project manager's. Information regarding the needed investment for a circular approach and the remaining value, and the choice for a particular strategy is not available in this research. This will be recommendations for future research.

The designed artefact is validated as functional, complete, consistent, performance-oriented, usable and fit with the questions of practical experience. The questions of the validation have only focused on the terms functionality, performance and usability. However, the experts validated the framework on the other terms by answering the originate questions.

7. Conclusion

The research question will be answered in this chapter. Furthermore, the chapter will elaborate on the research relevance, the research limitations and suggestions for future research.

7.1 Answering the research question

In this chapter, the research question will be answered and conclusions will be drawn. The corresponding sub-questions have already been answered within the result chapters but a summary will be given.

The Dutch government has set the goal of having a hundred percent circular economy by 2050 and to achieve an interim target of a fifty percent reduction in the use of primary raw materials by 2030. A circular building process is assumed to be different from a traditional building process and the client has a major force in adopting and ensuring circularity at a project level. However, the project manager, whose main task is to advise the client in order to achieve the client's final goal and to manage the process of a project, does not have the knowledge and capabilities to execute circular construction projects. Furthermore, limited research has been conducted on integrating circularity in the initiation and definition phase, also known as the foundation phases of a project.

To improve the capabilities and knowledge of project managers to execute the initiation and definition phase of construction projects according to the concept of circular economy, a framework has been designed for project managers, so that they have access to general knowledge of the concept and tools to transform their current management into circular management, in order to realise circular projects and to contribute to the (fully) circular economy targets set by the government.

The research question of this thesis is: *'How to design and validate a framework for project managers who are involved in the initiation and definition phase of a construction project, that improves the capabilities and knowledge to realise circular construction projects?'*

The Design Science Research method has been used to divide the goal of creating a framework for project managers in three steps. The Design Cycle is used to divide this research in collecting knowledge, designing the framework and validating the framework. Three interview methods and a case analysis have been conducted to obtain knowledge for the framework. The interviews have been conducted with circular advisors, construction project managers and stakeholders of the cases. In addition, six cases, of which two traditional and four (semi-)circular projects, have been analysed. Furthermore, success factors have been identified in literature and in the performed methods and, subsequently, they have been assessed with a Fuzzy Delphi method. A fourth interview was used to validate the developed framework with experts.

Within this research the definition of circular construction and a circular building have been explored as well as important circular models such as the 10R model and the shearing layer model. It was found that there are differences in project management in terms of working method, project management and role of the project manager. A conversation to discuss the goals and create awareness and support needs to be initiated in the initial phases of a project. Furthermore, circular ambitions need to be defined and circular project objectives have to be formulated. Besides that, several consequences have been identified for the management aspects if a circular approach is adopted. In addition, the research found that the project managers have limited knowledge of the circular concept, are open to innovate, but need some tools to support the change in their working method.
The research assessed the success factors, that were found in literature and in the results of the methods used, which lead to 27 identified success factors that should be included in the initiation and definition phase when adopting circularity. Four design propositions and the content for the framework have been determined. This made it possible to create a framework which consist of two

pages in A3 format. The framework consists of three important steps to approach a circular project successfully. These steps are elaborated on the first page of the framework and entail: 'knowledge of circular economy in the construction sector', 'integrate circularity in project preparation', and 'integrate circularity in project management'. The second page contains extra background information of definitions, two important models, and the 27 identified success factors in the format of a checklist. The framework has been validated with experts in the field of construction project management. The framework is validated as effective, ready to implement and is described as useful for the current challenges, demands and questions of the market.
The developed and validated framework answers the research question. Although the framework was validated as effective, it can be concluded that the transition to a circular economy is still in progress. For this reason the framework satisfies the needs at the moment, but has to be updated in the future with new developments and additional information. Furthermore, some extra knowledge was desired by the project managers such as information on the residual value in line with extra investments needed for a circular approach and the choice of a certain circular strategy with the consequences for project management. To conclude, the framework is developed for project managers but can also be used by other stakeholders involved in the initiation and definition phase of projects to integrate circularity.

7.2 Research relevance

Design Science Research combines and is closely related to scientifical and the practical relevance of the research topic. This is due to the fact that Design Science Research is interlinked to the environment by the relevance cycle and to the knowledge base by the rigor cycle (Hevner, 2007; Hevner et al., 2004). The relevance cycle provides the research with requirements from the contextual environment and introduces the research artefacts into the environment. Additionally, the rigor cycle provides grounding theories, methods and expertises concerning the research topic from the knowledge base and contributes to the knowledge base by providing the knowledge creation of the artefact. The exchanged information and the three cycles, which entail the design cycle, the relevance cycle and the rigor cycle are visualised in *Figure 7.1* and will be discussed in the upcoming sections.

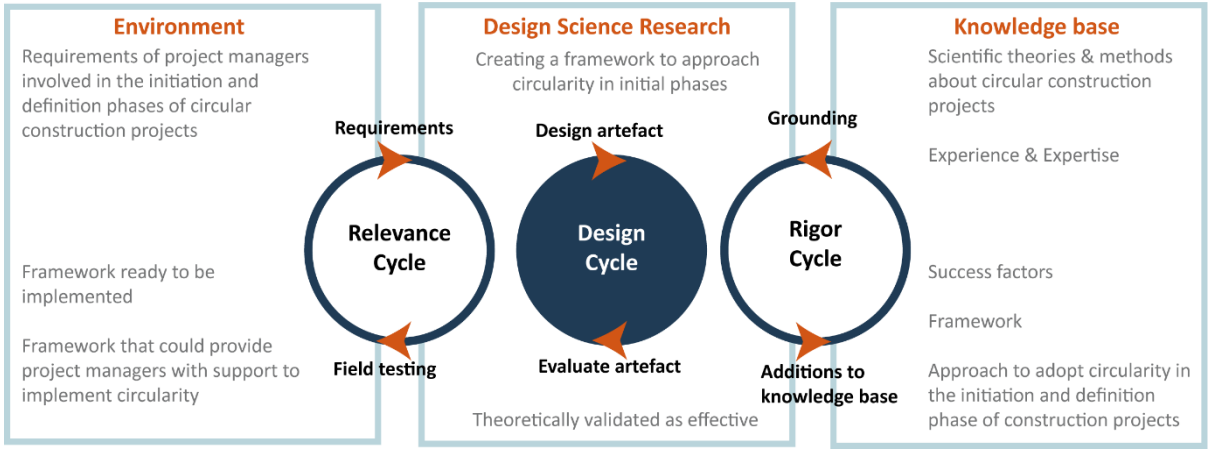

Figure 7. 1 - Research relevance (Author (2021) based on Hevner et al. (2004) and Hevner (2007))

Design cycle

Within this research, the design cycle has been used to implement the Design Science Research into this study. The Design Science Research improves the human condition by generating design alternatives which provide actionable knowledge and contribute to the body of knowledge. Within this research several knowledge questions have been answered in the problem investigation phase. Furthermore, design propositions have been formulated in paragraph 5.2.2 and that bridge the

relevance and the rigor of the artefact. Using the design cycle made it possible to design a framework for the project managers and to validate the framework by experts.

Scientifical relevance – rigor cycle

The rigor cycle provides the research with grounding theories, methods and expertises concerning the research topic from the knowledge base. As has been discussed in chapter 1.6, the knowledge base provides the scientific importance of the research. Examples of these grounding theories are the lack of understanding of how to address circularity in the initial phases of a construction project, the lack of a framework that addresses circularity and can be used as an instrument for the transition to a circular economy, and the theory that a circular building process is different compared to a traditional process. Furthermore, the rigor cycle provided input in the choice of methods such as choosing a case study analysis, a Fuzzy Delphi Method and using experts to validate the framework. Moreover, the rigor cycle gave input to chapter 4.1, which defined circular economy in the construction sector, and chapter 4.4 when identifying the limited available success factors in literature.

This research created knowledge and contributed to the body of knowledge by creating a framework which could be used as an instrument for the transition to a circular economy. Furthermore, this research identified an approach to adopt circularity in the initial phases of construction projects. This identified approach is incorporated in the framework and entails three steps: having knowledge of a circular economy in the construction sector, integrating circularity in the initial phases of a project and integrating circularity in project management. These three steps are supported and explained in the framework by definitions, visualisations, new working methods and consequences for management aspects which will also contribute to the knowledge base and are grounded by the research results. Finally, this study identified and assessed 66 success factors that affects the success of a construction project, of which 27 were labelled as most successful to implement in the initial phases of a project.

Societal relevance – relevance cycle

The relevance cycle provided the research with requirements from the contextual environment. The contextual environment within this research are (Sweco's) project managers involved in the initial phases of construction projects. As identified in the problem context, there is a lack of capabilities and knowledge of project managers to execute circular construction projects according to the concept of circular economy. The contextual environment provided the research with requirements for the framework in paragraph 5.2.1.

This research contributes with a framework, which is ready to be implemented, to the contextual environment. Despite the fact that the validation of the framework has been approached theoretically, the framework is validated as an instrument that could help the project managers to integrate circularity in the initial phases of a project and to start the conversation with the client about circularity. Furthermore, the results show the insights of the crucial task of project managers to support the client in adopting a circular project approach. Additionally, the validation of the framework revealed that the framework is eagerly desired by the project managers as three out of four wanted to use the framework immediately. This is also in line with the responses received from the interview participants of interview B and interview C. All respondents were enthusiastic to participate in the study since they considered the need for additional knowledge of integrating circularity in the initiation and definition phase as important in the transition to a circular economy. In addition, all respondents participated in this study were eager to receive the final framework in order to apply it in their projects.

The transition to a circular economy has only just begun, which means that many parties involved in construction projects are wondering how to include circularity in construction projects. This is why the results of this research can also contribute to the knowledge of all other parties involved in the initial stages of construction projects.

7.3 Research limitations

The first group of limitations lies within the scope of the research. The research has only focussed on the initial phases of construction projects. The other phases in which projects are normally divided, besides the initiation and definition phases, are not included in this study. Furthermore, this research specifically focussed on the construction project managers involved in the initial phases of a project.

The second group of limitations is related to the used research methods. With the use of the case study analysis, selection criteria were drawn up to select cases. The criteria included the focus on utility projects, which means that the developed framework and the other outcomes are not all grounded for other type of projects. Furthermore, all circular ambitions of the analysed cases have been adopted by the client due to social responsibility or the client's policies. This lead to the limitation that benefits of a circular economy has not been identified and incorporated in the framework in order to convince an organisation or client if they do not recognise the added value of circularity. Additionally, the framework is validated with expert interviews, but optimally, the validation would have been performed with the help of case analysis. The design cycle can be completed several times, but due to time constraints, the phases of the design cycle were completed only once in this study. Including only the design cycle in this research leads to the limitation of implementing the framework in the problem context.

The final group of limitations is related to the research results. First of all, the identified approach of a circular process is simplified compared to the complex reality. Indirectly, all the choices that have to be made, and which are now presented in a chronological sequence, are linked to each other and it is, in reality, an interactive process in which trade-offs have to be made. For example, a circular strategy has consequences for the circular objectives and the formulated objectives might require specific management aspects such as extra investments. Although this limitation is present, the work of a project manager consists of making choices within the constraints set by the client and the developed framework can support the reasoning process to make the trade-offs. In addition, there is no universal measuring method yet which entails that the cases analysed and the information obtained by the circular advisors cannot be validated on information that will lead to the most circular building. Furthermore, the research used design propositions as requirements for one framework but did not specify other design propositions which could lead to an alternative framework. Finally, the respondents of interview A and B indicated to include examples of circular projects in the framework. Nevertheless, examples of projects were limitedly included by a link to project examples and were still requested by one of the four project managers that validated the framework.

7.4 Suggestions for future research

Based on the results and the limitations of this research, suggestions for future research can be given. Some of the suggestions are for further development of the framework, while other recommendations are for scientific purposes.

First of all, the framework is mainly focussed on the initiation and definition phase, but can be elaborated with knowledge, additional tasks, other consequences for the management aspects and the role of the project manager when the other phases of a project will be taken into account. The other phases could consist of the design, realisation and maintenance phases or the phases after a building's life time. Secondly, within this research the analysed cases were focussed on utility projects. Other types of projects would be interesting to investigate, such as housing (complexes). Moreover, the project managers indicated in interview B that there are a lot of different sustainability concepts that could be added to a project, which makes it difficult to see the differences and advantages of the different concepts. A recommendation could be to investigate the relation between circularity and the other sustainability aspects and to combine them in one framework. Finally, the experts who validated the framework, suggested two recommendations for further research. The first one is to

investigate the necessary investment for a circular approach and the residual value at the end of a building's life time. The amount of residual value is of importance to weigh the additional investment needed for a circular approach. An assessment framework would be desired by the project managers and clients. The second recommendation given by the experts is that the choice for a particular circular strategy and the consequences for the management aspects have not been investigated in this research but would be relevant for a client and the project manager. Consequently, it is of interest to investigate the interrelation between a circular strategy and formulating circular objectives. It is possible to investigate which strategy leads to which objective or which objectives are possible for a particular strategy.

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Appendices

Appendix A – Informed consent sheet

Informed consent sheet graduation research Jeanine Többen

Dear participant,

My name is Jeanine Többen and I am currently in the final phase of my studies, namely my graduation project for obtaining the master's degree in *Construction Management & Engineering*. In this research, I aim to develop a framework for project managers, who are involved in the initiation and definition phase of a construction project, to add circularity to construction projects. The conceptual framework should provide the project manager with 'general' information about circular economy and a number of focus points for attention to realise circular projects.

I would like to thank you very much for taking part in this research and sharing your knowledge on the subject with me.

I would like to give you some information about how the results will be processed. Your knowledge, information and answers to the questions asked will not be traceable to you or the asked project. All information that will be processed in my thesis will be encoded under a type of project or a type of function.

As an example; The project 'expansion Eindhoven University' that has included circularly will be coded under the name Project C2. The architect involved in this project that I am interviewing will be named Architect C2. Under these names, Project C2 and Architect C2 will the knowledge be referred.

This means that no personal information is required from you for this research. The coding is saved with great care and is documented on a specially secured drive from the university.
Participation in this research is completely voluntary and the obtained data will only be used for research purposes.

I hope that I have informed you sufficiently. If you have any further questions, please contact me. The results will be shared with the participants in the form of the framework.

Kind regards,

Jeanine Többen

[email address of researcher]
[phone number of researcher]

Informatie blad afstudeeronderzoek Jeanine Többen

Beste deelnemer,

Ik ben Jeanine Többen en ben momenteel bezig met de laatste fase van mijn studie namelijk mijn afstudeeronderzoek voor het halen van de master *Construction management & engineering*.
In dit onderzoek focus ik mij op het creëren van een raamwerk voor projectmanagers, die betrokken zijn in de initiatie en definitiefase van een bouwproject, om circulariteit toe te voegen aan het proces. Met als doel een conceptueel raamwerk dat de projectmanager gaat voorzien van; 'algemene' informatie over circulaire economie, succesfactoren die positief bijdragen aan het realiseren van circulaire projecten en aandachtspunten voor het realiseren van circulaire projecten.

Ik wil u alvast heel hartelijk danken voor het deelnemen aan dit onderzoek en dat u uw kennis met mij over het onderwerp wil delen.

Hierbij wil ik u alvast informatie geven over het verwerken van de resultaten. U kennis, informatie en antwoorden die u geeft op de gestelde vragen zullen niet terug te herleiden zijn naar u of het project waar de vraag over gaat. Alle informatie die verwerkt zal worden in mijn thesis wordt gecodeerd onder een type project of een type functie.

Als voorbeeld; Het project 'uitbreiding universiteit Eindhoven' dat circulair is uitgevoerd zal worden gecodeerd onder de benaming Project C2. De betrokken architect bij dit project die ik interview wordt benoemd als Architect C2. Onder deze benamingen, Project C2 en Architect C2 zal er ook gerefereerd worden.

Dit betekent dat er van u geen persoonlijke informatie benodigd is voor dit onderzoek. De codering wordt met veel zorg bewaard en staat genoteerd op een speciaal beveiligde drive vanuit de universiteit.
Deelname aan dit onderzoek is compleet vrijwillig en de verkregen data zal alleen worden gebruikt voor onderzoeksdoeleinden.

Ik hoop u hiermee voldoende te hebben geïnformeerd. Mocht u nog vragen hebben, neem dan contact met mij op. De resultaten zullen gedeeld worden met de deelnemers in de vorm van het raamwerk.

Met vriendelijke groet,

Jeanine Többen

[email adress of researcher]
[phone number of researcher]

Appendix B – Questions interview A

This appendix includes the interview questions from interview A. The questions are included in both Dutch and English. The interviews were conducted in Dutch. Questions 3, 12 and 16 were only asked in the test interview of A1 and were not asked in the other interviews.

English questions

Part 1: Circular economy - the introduction

Q1. When have you first dealt with the concept of circularity?
Q2. How did you develop from the 'introduction of circularity' to a consultant who can give advice in the field of circularity?
Q3. Of which achievement are you most proud in applying circularity?

Part 2: Circular economy - the definition

Q4. How do you define circularity or a circular economy?
Q5. How would you define circularity in the construction sector?

Part 3: Project managers - the required knowledge

Q6. In your opinion, what should be the standard knowledge of project managers about circularity in the construction sector?
Q7. What knowledge and essential tools has to be to supplemented to project managers' current knowledge of circularity? What knowledge or tools have helped you to obtain the current knowledge?

Part 4: Project managers – the working method

Q8. If we look at project managers who normally use 3 management aspects: time, money and quality. How do you think circularity would fit in? Should it be seen as part of a management aspect or should another aspect be added such as sustainability?
Q9. How would you propose to ensure circularity by project managers?
Q10. Do you think managing circular projects will be different comparing to traditional projects, which have no circular ambitions?
Q11. If so, to what extent do you think the purpose and role of a project manager changes with circular projects?

Part 5: Integration circularity - success factors

Q12. You mentioned in questions 10 and 11 that the management is changing, what would change in your opinion in the initiation and definition phases?
Q13. What would you define as success factors for integrating circularity in the initiation and definition phases?
Q14. Are other tools or procedures needed in projects to make a project circular? And do you have examples of this?
For example; creating a construction team, phrasing another question, approach budget differently, ask for a lower MPG score, use the residual value, asking for a materials passport, use product as a service, etc?
Q15. Do you think that project managers need guidance to integrate circularity? If yes, what could help a project manager to integrate circularity in a project?

Part 6: Conclusion

Q16. Do you have any other tips for project managers to integrate circularity that not have been discussed yet?

Q17. Is there anything that remained undiscussed during the interview that could be important for my research?

Dutch questions

Deel 1: Circulaire economie – de introductie

Q1. Wanneer was het eerste moment dat u met het begrip circulariteit in aanraking kwam?

Q2. Hoe bent u van de 'introductie met circulariteit' gegroeid tot een adviseur die advies kan geven op het gebied van circulariteit?

Q3. Waar bent u het meest trots op, wat u heeft bereikt met het toepassen van circulariteit?

Deel 2: Circulaire economie – de definitie

Q4. Hoe definieert u circulariteit of een circulaire economie?

Q5. Hoe zou u circulariteit definiëren in de bouwsector?

Deel 3: Projectmanagers - de benodigde kennis

Q6. Wat zou, volgens u, de standaard kennis van projectmanagers over circulariteit in de bouwsector moeten zijn?

Q7. Welke kennis en essentiële tools zijn essentieel om de huidige kennis van project managers over circulariteit aan te vullen? Welke kennis of tools heeft u geholpen om tot de huidige kennis te komen?

Deel 4: Projectmanagers - de werkwijze

Q8. Als we kijken naar projectmanagers die normaliter 3 speerpunten hebben: tijd, geld, kwaliteit. Hoe zou circulariteit hier volgens u bij passen? Moet dit als onderdeel worden gezien per speerpunt of als een apart speerpunt duurzaamheid bijvoorbeeld?

Q9. Welke manieren heeft een bouwprojectmanager, volgens u, om circulaire doelstellingen te borgen?

Q10. Verandert het management voor huidige – ik noem ze traditionele projecten ten opzicht van circulaire projecten?

Q11. Zoja, In hoeverre denkt u dat het doel en de rol van een projectmanager verandert?

Deel 5: integratie circulariteit - succesfactoren

Q12. U gaf aan in Vraag 10 en 11 dat het management verandert wat zou volgens u veranderen in de initiatie en definitiefase? Is het belangrijk om een transitie te maken in deze fases naar ander management?

Q13. Wat zou u definiëren als succesfactoren voor het integreren van circulariteit in de initiatie en definitiefase?

Q14. Moeten ze nieuwe tools of een werkwijze introduceren in hun projecten om een project circulair te kunnen maken? En heeft u hier voorbeelden van?

Denk bijvoorbeeld aan het creëren van een consortium, het stellen van een andere vraag, anders omgaan met budget, aanpassingen aan MPG, vragen om calculatie voor restwaarde bij de uitvraag, materialenpaspoort, product as a service, etc?

Q15. Wat zou een Projectmanager kunnen helpen om circulariteit te integreren, of denkt u dat dit niet nodig is. Welke handvaten moeten hun geboden worden?

Deel 6: Afronding

Q16. Heeft u nog andere tips over circulariteit of aanwijzingen voor project managers om de transitie in gang te kunnen zetten die ik nog niet heb benoemd of heb gevraagd?

Q17. Is er nog iets onbesproken gebleven tijdens het interview maar wat van belang kan zijn voor mijn onderzoek?

Appendix C – Transcripts interview A

Transcript A1 is included below. All transcripts of interview A are presented in the related appendices book. This appendices book can be requested at the Construction Management & Engineering (CME) secretariat at the Technical University of Eindhoven. To reach the secretariat please contact i.m.dekkers@tue.nl**.**

Transcript interview A1

Geïnterviewde:	Advisor CE 1
Interviewer:	Jeanine Többen
Datum:	29 september 2020
Manier van afname:	Online via Microsoft Teams
Specialisatie geïnterviewde:	Civiele techniek, adviseur duurzaam en circulair bouwen
Duur:	55 minuten

Deel 1: Circulaire economie – de introductie

Q1. Wanneer was het eerste moment dat u met het begrip circulariteit in aanraking kwam?
A1. Dat is in 2016 geweest. Als onderdeel van duurzaamheid kwam circulariteit aan de orde. Bij een extern project werd de aandacht getrokken om een keer mee te denken over een project.

Q2. Hoe bent u van de 'introductie met circulariteit' gegroeid tot een adviseur die advies kan geven op het gebied van circulariteit?
A2. Sinds 2018 heb ik het label circulair aan mijn naam verbonden. Ik ben met nul kennis over het concept begonnen. Ik heb mij gericht op netwerken(via linkedin) en mij daarbij aan gesloten. Geprobeerd om aan te sluiten bij lopende projecten en circulariteit onder de aandacht te brengen in de organisatie. Daarnaast gekeken wat de vraag is vanuit de markt en hier handig op in gespeeld. Tegelijkertijd heb ik ook zelf kennis ontwikkelt met afstudeerprojecten formuleren en mijzelf te onderwijzen en vat te krijgen op circulair bouwen / circulaire economie door innovatie projecten in de gaten te houden.
In het begin de ruimte gekregen om mijzelf te ontwikkelen door 40% werktijd hieraan te mogen besteden.

Mee geven voor anderen: Durf te veranderen, nieuwsgierig te zijn en nieuwe technieken uit te proberen.

Q3. Waar bent u het meest trots op, wat u heeft bereikt met het toepassen van circulariteit?
A3. Kinderen bij een vak op de middelbare school, genaamd Technasium, begeleidt met het ontwikkelen van een circulair spel. Daarnaast dat ik mij binnen 3 jaar tijd zo snel heb ontwikkelt. Een bewijslast dat het kan en dat je het je eigen kan maken, zolang je maar wil meegaan in vernieuwingen en de urgentie er zelf van inziet.

Deel 2: Circulaire economie – de definitie

Q4. Hoe definieert u circulariteit of een circulaire economie?
A4. Ik spreek zelf niet graag van een circulaire economie omdat het bedrijf is gekoppeld aan bouwactiviteiten. Richt zichzelf vooral op circulair bouwen. Dit houdt in: van initiatiefase tot daarna beheerfase en demontagefase.

Q5. Hoe zou u circulariteit definiëren in de bouwsector?
A5. Ik volg de richtlijnen van CB'23 en de drie doelstellingen:
1. Materiaal behoud

2. Milieu impact
3. economische waarde behoud van materiaal
Deze drie doelstellingen zijn belangrijk, makkelijke te begrijpen maar moeilijk samen te combineren.

Q5a Wordt er in projecten gevraagd om een definitie voor circulariteit?
A5a In alle 3 de doelstellingen zitten verschillende aspecten waar je op kan richten binnen een project. Hiermee moet je met elkaar het gesprek aangaan; of je elkaar begrijpt en of je hetzelfde doel voor ogen hebt.
vb. een project wordt al snel circulair genoemd als het product voldoet aan 1 van de doelen, daarmee ben je het thema circulariteit aan het downsizen. De kunst is om alle 3 de doelen te integreren want dan ben je circulair bezig.
Totdat dit bereikt kan worden is het prima om eerst op 1 doel te richten. Hierbij is het belangrijk dat je met elkaar dezelfde taal spreekt en dat je met elkaar het gesprek heb: 'Wat is circulariteit voor jou? Wat zijn jouw doelen?' om dan vervolgens te kijken wat er samen bereikt kan worden.

Deel 3: Projectmanagers - de benodigde kennis

Q6. Wat zou, volgens u, de standaard kennis van projectmanagers over circulariteit in de bouwsector moeten zijn?
A6. Ik denk dat het goed is als de Bouwprojectmanager kennis hebben over hetgeen dat op platform CB'23 te vinden is over de algemene kennis van circulariteit. Hiermee bedoel ik de definitie, modellen die eronder vallen. Dit is vrij compact opgeschreven met daarnaast ook de relevantie van de verschillende aspecten.
Het zou mooi zijn als de bouwprojectmanagers een vertaling kunnen maken van deze kennis naar hun projecten. Daarnaast zou het goed zijn om een methode te hebben die afwegingen in een ontwerpproces geeft: ‘Is het project nodig?’, ‘Heb ik er alles aangedaan om vrijgekomen materialen her te gebruiken’ en ‘zijn alle componenten in mijn ontwerp noodzakelijk of is een reductie in materiaal ook mogelijk?’. Kortom hoe om te gaan met je ontwerp in relatie tot circulariteit.
Daarnaast denk ik dat we met materialen hetzelfde moeten omgaan als met geld, met gezond verstand. Nadenken over materialen, hebben we het echt nodig, kunnen we de materialen behouden, kunnen we het materiaalgebruik minimaliseren

Ik geloof in bouwprojectmanagers met basiskennis, die het concept snappen en een adviseur kunnen inschakelen wanneer nodig.

Q7. Welke kennis en essentiële tools zijn essentieel om de huidige kennis van project managers over circulariteit aan te vullen? Welke kennis of tools heeft u geholpen om tot de huidige kennis te komen?
A7. Een proces van grof naar fijn werken zal helpen. Tools die dit proces ondersteunen zijn van belang. Hierbij denk ik aan meettools, ambitietools en gegevenstools zoals materialenpaspoorten. Hierdoor zou iedereen op dezelfde manier bezig zijn.
Daarnaast denk ik dat het helpt om aan de voorkant van een project een materialenanalyse te doen; wat is er, wat komt er vrij, en wat kunnen we hergebruiken. Wanneer je deze analyse koppelt aan de circulaire doelstellingen; wat is je milieu impact, wat is de hoeveelheid primair en secundair materiaal, wat zijn de uitputtende materialen. Wanneer je deze aspecten in beeld brengt heb je meteen inzicht waarin je wil verbeteren. We hebben dus ook tools nodig die aangeven in het begin van het project wat de nul situatie is en waarvandaan we vertrekken en waar verbeteringen door te voeren zijn.
Je hoeft niet op alle tools te richten maar het kan je helpen om gestructureerd aan de slag te gaan.

Deel 4: Projectmanagers - De werkwijze

Q8. Als we kijken naar projectmanagers die normaliter 3 speerpunten hebben: tijd, geld, kwaliteit. Hoe zou circulariteit hier volgens u bij passen? Moet dit als onderdeel worden gezien per speerpunt of als een apart speerpunt duurzaamheid bijvoorbeeld?
A8. Sturen op tijd, geld en kwaliteit is wel erg volgens de oude stempel. Geeft wel aan dat we geld heel erg belangrijk vinden, is een erg lineaire gedachte. Terwijl ik misschien vind dat grondstoffenbehoud of waarde van mijn grondstoffen wel belangrijker is. Ik ben benieuwd hoelang het management model van de 3 speerpunten nog houdbaar is in een circulaire economie.
Geld is in plaats van een middel gegaan naar een doel in projecten.
Vaak wordt circulariteit onder kwaliteit onder gebracht. Dit vind ik zelf niet in verhouding staan met het begrip en de verhouding tussen kwaliteit tijd en geld. Ik heb hier geen duidelijke mening over.

Projectmanagers moeten in het begin van een project gaan kijken naar de randvoorwaarden van een project en hier ook zeker kijken naar circulariteit in relatie met duurzaamheid. Circulariteit kan wel een doel zijn maar staat niet alleen en heeft altijd een relatie met energietransitie en klimaatadaptatie.

Q9. Welke manieren heeft een bouwprojectmanager, volgens u, om circulaire doelstellingen te borgen?
A9. Net als andere doelstellingen in een project heeft de projectmanager deze zelfde manieren ook voor de doelstelling circulariteit. In de offerte kan je verschillende aspecten meenemen ook als de opdrachtgever hier niet naar vraagt. In een plan van aanpak kan je vervolgens ook van alles opnemen, hoe je dit opneemt hangt af van je doelstellingen maar het kan wel. Een makkelijke eis om op te schrijven is: alle vrijkomende materialen van het project moeten worden opgenomen in het project. Ook in de fase van een contract zijn verschillende mogelijkheden: verplichten van een MKI berekening, opnemen van een materialenpaspoort. Deze mogelijkheden kosten je niks maar je gaat er wel mee aan de slag om bij te dragen aan een circulaire economie.

Eigenlijk is er geen enkele belemmering om het mee te nemen maar ligt het heel erg aan de persoon of die het aandurft, los of je opdrachtgever het wil doen. Het aandurven zie ik als het gesprek aan gaan, inhaken op circulaire doelstellingen die een opdrachtgever heeft en de opdrachtgever laten afvragen of we hier dan niet iets meer mee moeten. Over welke mogelijkheden er zijn is dan wel handig om antwoord te geven op de klant, waar ik weer terug grijp naar enkele basis informatie die een projectmanager moet hebben.

In elk project is er ruimte voor circulaire gunningscriteria. Hierin heb je kwantitatieve en kwalitatieve gunningscriteria. Onder kwantitatieve gunningscriteria valt bijvoorbeeld een MKI berekening. Onder een kwalitatieve gunningscriteria vallen doelstellingen, ambities, hoe ga je een proces inrichten, etc. Deze kwalitatieve gunningcriteria's zijn de zachte kant en is altijd toe te passen, zolang je maar goed afspreekt hoe je de markt gaat bevragen.

Q10. Verandert het management voor huidige – ik noem ze traditionele projecten ten opzicht van circulaire projecten?
A10. Het is belangrijk om van te voren het gesprek aan te gaan over de ambities zodat iedereen de doelen snappen maar ook gezamenlijke de kaders zijn afgebakend. Dit scheelt later veranderingen in het project.
Eventueel kan een duurzaamheidssessie geïnitieerd worden in het begin van een project om de doelstellingen helder te krijgen als dit nog niet het geval is zowel voor de opdrachtgever als voor het projectteam.
Vervolgens is het ontzettend belangrijk om van een duurzaamheidsessie, waarbij ambities worden geformuleerd, naar een persoonlijke drive te gaan voor de opdrachtgevers of de teamleden.

Q11. Zoja, In hoeverre denkt u dat het doel en de rol van een projectmanager verandert?
A11. Op dit moment vind ik dat we projecten op een lineaire manier doen: vraag, beantwoorden, opleveren en we zijn weer weg. Moeten we niet naar een circulaire dienstverlening: voorkant oplossing bedenken, oplossing aanreiken en gedurende de levensduur betrokken blijven en oplossingen zo optimaal mogelijk behouden.
Iemand die een project in grote lijnen in de gaten houdt, noem het een projectmanager, zul je altijd behouden. Een specialist zal je ook altijd behouden.
Echter denk ik wel dat de samenwerking met de opdrachtgever gaat veranderen. Je zal veel meer in de keten gaan samenwerken. Het is goed om je bewust te zijn van de veranderingen en verschuivingen. Hierin moet je je afvragen welke rol we hierin gaan nemen. De werkzaamheden zullen niet anders worden. Echter zal je wel andere uitgangspunten krijgen.
De rol van de projectmanager is om te zorgen dat er een andere vraag gaat ontstaan op alle transitiethema's niet alleen op circulariteit maar ook op klimaatadaptatie en energietransitie.

<u>Deel 5: integratie circulariteit - succesfactoren</u>
Q12. U gaf aan in Vraag 10 en 11 dat het management verandert wat zou volgens u veranderen in de initiatie en definitiefase? Is het belangrijk om een transitie te maken in deze fases naar ander management?
Vraag niet gesteld

Q13. Wat zou u definiëren als succesfactoren voor het integreren van circulariteit in de initiatie en definitiefase?
A13. Aan het begin van een project is het belangrijk om een circulariteitsambitie te hebben van de klant. Je zal ten allertijden in het begin de duurzaamheidsambitie formuleren.
Zorg dat je zo snel mogelijk zo concreet mogelijk bent. Liever later erachter komen dat je te concreet bent geweest dan dat je te algemeen blijft en nergens komt.
Ik denk ook zeker dat je de komende jaren mag meegeven aan je opdrachtgever dat je in transitie bent en dat je hier gezamenlijk van gaat leren.
Je kan niet meteen een 100% circulair project te draaien. Je moet doen wat je kan. Richt je erop om te doen wat dicht bij je ligt en bij de scope ligt. Probeer jezelf wel uit te dagen. Probeer niet de hele wereld te veranderen want dat gaat toch niet lukken. Probeer wel te kijken wat binnen je hand bereikt ligt.

Q14. Moeten ze nieuwe tools of een werkwijze introduceren in hun projecten om een project circulair te kunnen maken? En heeft u hier voorbeelden van?
Denk bijvoorbeeld aan het creëren van een consortium, het stellen van een andere vraag, anders omgaan met budget, aanpassingen aan MPG, vragen om calculatie voor restwaarde bij de uitvraag, materialenpaspoort, product as a service, etc?
A14. Een samenwerkingsverband is wel belangrijk. De meest eenvoudige vorm hierin is een bouwteam. Circulariteit wordt al snel afgedaan als recyclen. Wil je circulariteit op een goede manier toepassen dan heb je hier ook goede kennis van nodig. Het is zinvol om de kennis te borgen. Dit kan met de mensen in het team zelf of met een duurzaamheidsmanager/circulariteitsadviseur. Een duurzaamheidsmanager of circulariteitsadviseur kan helpen om de meningen/adviezen van de teamleden bij elkaar kan brengen en op waarheid kan beoordelen.
Een andere werkwijze is om veel verder in de keten te kijken bij de leverancier bijvoorbeeld. Dit is in elke fase waardevol maar hoe eerder in het proces en dan wel voor de ontwerpfase hoe beter. De oplossingen zullen dan veel gedetailleerder zijn en specifieker voor het project.

Q15. Wat zou een Projectmanager kunnen helpen om circulariteit te integreren, of denkt u dat dit niet nodig is. Welke handvaten moeten hun geboden worden?

A15. Recipe model geeft handvaten waar een projectmanager kennis over zou moeten hebben. De noodzaak komt erin terug, hoe het georganiseerd moet worden, welke risico's zijn er, hij zal voorbeelden moeten kunnen aanreiken, hij zal een opdrachtgever moeten kunnen helpen met de afweging van goede circulaire principes en welke partijen heb ik nodig tijdens mijn project. In dit recipe model zit ook de vraag van de klant, dus als je hier antwoord op kan geven door de projectmanagers handvaten te geven dan ben je al een heel eind.

Deel 6: Afronding

Q16. Heeft u nog andere tips over circulariteit of aanwijzingen voor project managers om de transitie in gang te kunnen zetten die ik nog niet heb benoemd of heb gevraagd?

Vraag niet gesteld

Q17. Is er nog iets onbesproken gebleven tijdens het interview maar wat van belang kan zijn voor mijn onderzoek?

A17. Ja, ik denk niet dat je elke projectmanager kan opleggen om met circulariteit aan de slag te kunnen gaan. Wat wel gaat werken is mensen die erin geïnteresseerd zijn en er mee aan de slag willen. Deze geïnteresseerde partij heeft ook niet veel ruimte nodig om zicht te ontwikkelen. Een basismodel moet er wel zijn om van de kant af te kunnen komen. Circulariteit zie ik ook niet op zich zelf staan maar is een toevoeging aan je huidige werk.

Daarnaast denk ik dat technisch gezien circulariteit niet onmogelijk is maar dat het een mindset is aan de menselijke kant. Als je als projectmanager ervoor kiest om het mee te nemen in je project en je er enthousiast over bent dan zal je opdrachtgever dat ook worden. De oplossingen zijn voor het oprapen. Als je vandaag iets met circulariteit gaat doen, dan leer je er weer van en kan je het morgen weer iets beter doen.

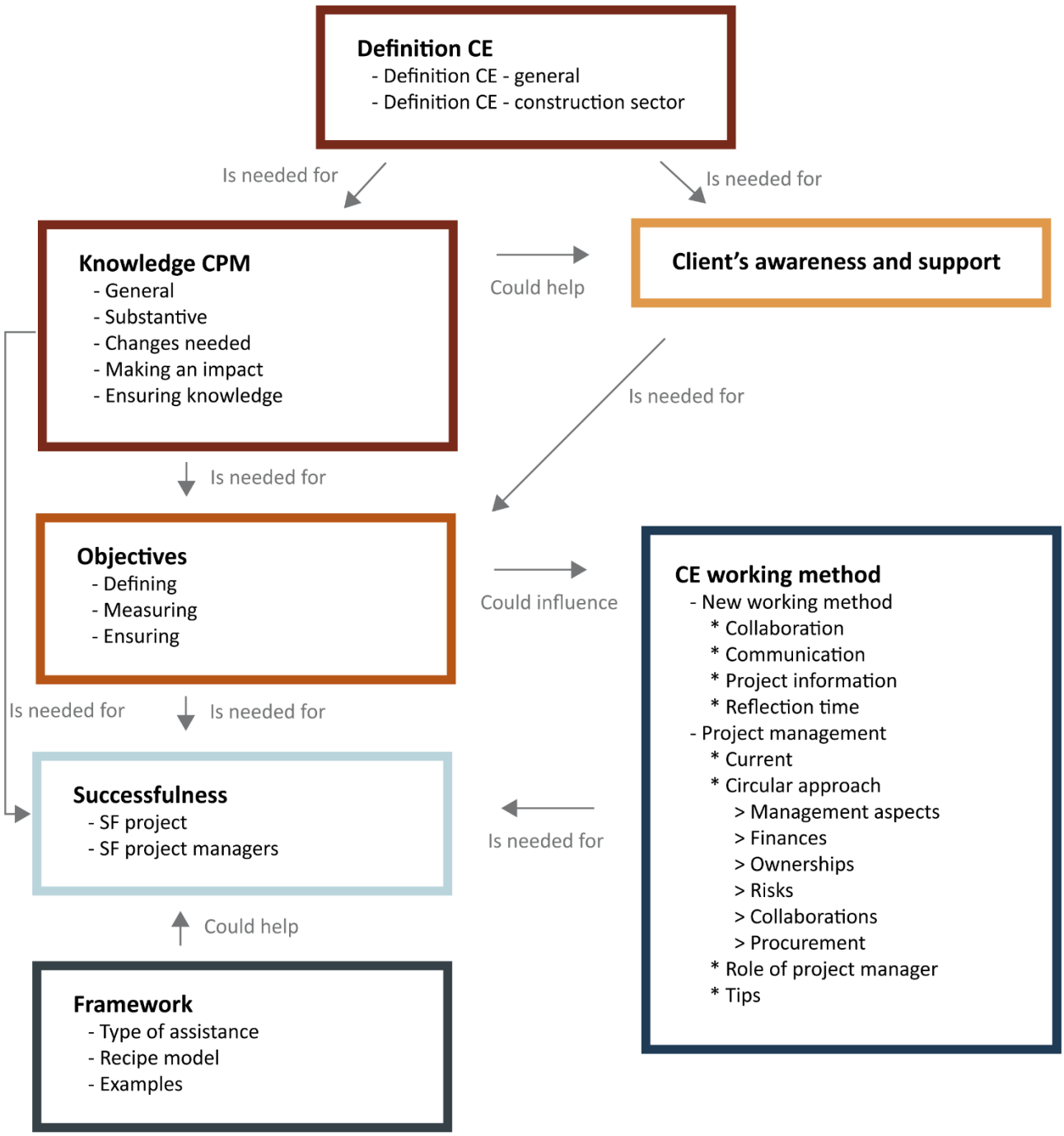
Appendix D – Example used coding techniques

Below is an example given of the open and axial coding of transcript interview A1. It can be seen that the open codes have been recategorised within the axial codes. This visualisation was made for clarification purposes. The real coding techniques were applied in Atlasti. However, the visualisation from Atlasti was not clear enough to use.

Part of interview A1	Open codes	Axial codes
Deel 2: Circulaire economie – de definitie		
Q4. Hoe definieert u circulariteit of een circulaire economie?		
A4. Ik spreek zelf niet graag van een circulaire economie omdat het bedrijf is gekoppeld aan bouwactiviteiten. Richt zichzelf vooral op circulair bouwen. Dit houdt in: van initiatiefase tot daarna beheerfase en demontagefase.	Def construction CE	Definition CE - construction sector
Q5. Hoe zou u circulariteit definiëren in de bouwsector?		
A5. Ik volg de richtlijnen van CB'23 en de drie doelstellingen: 1. Materiaal behoud 2. Milieu impact 3. economische waarde behoud van materiaal Deze drie doelstellingen zijn belangrijk, makkelijke te begrijpen maar moeilijk samen te combineren.	Def construction CE	Definition CE - construction sector
Q5a Wordt er in projecten gevraagd om een definitie voor circulariteit?		
A5a In alle 3 de doelstellingen zitten verschillende aspecten waar je op kan richten binnen een project. Hiermee moet je met elkaar het gesprek aangaan; of je elkaar begrijpt en of je hetzelfde doel voor ogen hebt. vb. een project wordt al snel circulair genoemd als het product voldoet aan 1 van de doelen, daarmee ben je het thema circulariteit aan het downsizen. De kunst is om alle 3 de doelen te integreren want dan ben je circulair bezig.	Define objectives; Communication; Formulating ambitions	Objectives - defining; New working method - communication; SF project managers
Totdat dit bereikt kan worden is het prima om eerst op 1 doel te richten. Hierbij is het belangrijk dat je met elkaar dezelfde taal spreekt en dat je met elkaar het gesprek heb: 'Wat is circulariteit voor jou? Wat zijn jouw doelen?' om dan vervolgens te kijken wat er samen bereikt kan worden.	Define objectives; Formulating ambitions	Objectives - defining; SF project managers
Deel 3: Projectmanagers - de benodigde kennis		
Q6. Wat zou, volgens u, de standaard kennis van projectmanagers over circulariteit in de bouwsector moeten zijn?		
A6. Ik denk dat het goed is als de Bouwprojectmanager kennis hebben over hetgeen dat op platform CB'23 te vinden is over de algemene kennis van circulariteit. Hiermee bedoel ik de definitie, modellen die eronder vallen. Dit is vrij compact opgeschreven met daarnaast ook de relevantie van de verschillende aspecten.	General knowledge	Knowledge of CPM - general
Het zou mooi zijn als de bouwprojectmanagers een vertaling kunnen maken van deze kennis naar hun projecten.	Change role CPM	CE working method CPM - role of CPM
Daarnaast zou het goed zijn om een methode te hebben die afwegingen in een ontwerpproces geeft: 'Is het project nodig?', 'Heb ik er alles aangedaan om vrijgekomen materialen her te gebruiken' en 'zijn alle componenten in mijn ontwerp noodzakelijk of is een reductie in materiaal ook mogelijk?'.	Reflection	SF project managers; CE working method CPM - reflection time
Kortom hoe om te gaan met je ontwerp in relatie tot circulariteit.	Substantive knowledge	Knowledge of CPM - substantive
Daarnaast denk ik dat we met materialen hetzelfde moeten omgaan als met geld, met gezond verstand. Nadenken over materialen, hebben we het echt nodig, kunnen we de materialen behouden, kunnen we het materiaalgebruik minimalistischer maken?		

Appendix E – Overview results interview A

This overview provides an insight into the topics discussed with the respondents of interview A. The topics are all covered in the body of this report. The topics visualised correspond to the axial codes used with the coding techniques. The colours associated with the topics are related to the overview results of interview B in *Appendix H*.



Appendix F – Questions interview B

This appendix includes the interview questions from interview A. The questions are included in both Dutch and English. The interviews were conducted in Dutch.

English questions

Part 1: Circular economy - introduction with circularity

Q1. In this interview, you are defined as a construction project manager. What kind of projects do you perform? For example, care or office facilities and for which type of clients?
Q2. How do you describe project management?
Q3. Have you ever been exposed to the concept of circularity in your projects? And if so, how did you approach this?

Part 2: Construction project managers and circularity in projects

Q4. When you think of circularity, what terms do you think of?
Q5. Could you classify yourself in the classes 1-5?

a) *1 = hardly any or no knowledge. I would not know how to integrate circularity into my projects*
b) *2 = moderate knowledge. I know some aspects of the concept of circularity but I have no idea how to integrate it into my projects or I hire an expert for this part of the project.*
c) *3 = reasonable knowledge. I know several aspects of the concept but I still need help from an expert because I can not manage circularity on my own in the projects.*
d) *4 = good knowledge. I know what the concept entails and I sometimes need an expert for some parts of the project, but I can do the preparation by myself.*
e) *5 = excellent knowledge. I still need to learn but I know how to integrate circularity into a project and I do not need an expert.*

Q6. Why do you classify yourself in this class? What knowledge do you need to be able to apply the concept?
Q7. Do you know where to find information on the concept of circularity (in construction)?

Part 3: Project Managers - Methodology

Q8. If we look at project managers who normally use 3 management aspects: time, money and quality. How do you think circularity would fit in? Should it be seen as part of a management aspect or should another aspect be added such as sustainability?
Q9. Recently, new concepts or rules have been introduced to the construction sector. Think of cradle to cradle, BIM, BREEAM, energy/co2 neutral building, climate adaptation, etc. How do you deal with these changes or the integration of new concepts? And what knowledge do you need to integrate it in projects?
Q10. Are you an initiator in using new concepts or do you first need to see examples of how it can be implemented?

Part 4: Project managers - The framework for BPM

Q11. What kind of help would you like to have to integrate circularity into projects? And in what form?
Q12. What kind of support should it provide?

Part 5: Conclusion

Q13. Is there anything that remained undiscussed during the interview that could be important for my research?

Dutch questions

Deel 1: Circulaire economie – introductie met circulariteit

Q1. In dit onderzoek wordt u gedefinieerd als bouwprojectmanager. Wat voor een soort projecten draait u? In de zorg of kantoorpanden en voor welk type opdrachtgevers?
Q2. Hoe beschrijft u projectmanagement?
Q3. Bent u ooit al een keer in aanraking gekomen met het begrip circulariteit in uw projecten? En zo ja hoe heeft u dit toen aangepakt?

Deel 2: Bouwprojectmanagers en circulariteit in projecten

Q4. Aan welke termen denkt u, als u denkt aan circulariteit?
Q5. Als u zich mag indelen in een klasse van 1-5 in welke klasse bevindt u zich?

a) *1 = nauwelijks tot geen kennis. Ik zou niet weten hoe ik circulariteit moet integreren in mijn projecten*
b) *2 = matige kennis. Ik weet enkele aspecten van het concept circulariteit maar ik heb geen idee hoe ik dit moet integreren in mijn projecten of ik schakel een expert in voor dit gedeelte van het project.*
c) *3 = redelijke kennis. Ik weet verschillende aspecten van het concept maar ik heb nog steeds hulp nodig van een expert want ik kom er alleen in de projecten niet uit.*
d) *4 = goede kennis. Ik weet hoe het concept in elkaar steekt en ik heb soms een expert nodig voor enkele gedeeltes van het project, maar de opzet kan ik alleen.*
e) *5 = uitstekende kennis. Ik moet nog steeds bijleren maar ik weet wel hoe ik circulariteit kan integreren in een project en heb hier geen expert voor nodig.*

Q6. Waar ligt dit aan dat u zich in deze klasse indeelt? Welke kennis mist u op dit moment om het concept toe te kunnen passen?
Q7. Weet u waar uw informatie over het concept circulariteit (in de bouw) kan vinden?

Deel 3: Projectmanagers - werkwijze

Q8. Als we kijken naar projectmanagers die normaliter 3 speerpunten hebben: tijd, geld, kwaliteit. Hoe zou circulariteit hier volgens u bij passen? Moet dit als onderdeel worden gezien per speerpunt of als een apart speerpunt duurzaamheid?
Q9. De afgelopen tijd zijn er vaker nieuwe concepten of regels geïntroduceerd in de bouwsector. Denk aan cradle to cradle, BIM, BREEAM, energie/co2 neutraal bouwen, klimaatadaptatie etc. Hoe gaat u om met deze veranderingen of integratie van nieuwe concepten? En welke kennis heeft u nodig om het te integreren in projecten?
Q10. Bent u een initiatiefnemer in nieuwe concepten uitproberen of moet u eerst voorbeelden zien dat het lukt en hoe het uitgevoerd kan worden?

Deel 4: Projectmanagers - Het raamwerk voor BPM

Q11. Wat soort hulp zou u willen hebben om circulariteit meer te integreren in projecten? En in welke vorm?
Q12. Welke handvaten moet de hulp u geven?

Deel 5: Afronding

Q13. Is er nog iets onbesproken gebleven tijdens het interview maar wat wel van belang kan zijn voor mijn onderzoek?

Appendix G – Transcripts interview B

Transcript B8 is included below. All transcripts of interview B are presented in the related appendices book. This appendices book can be requested at the Construction Management & Engineering (CME) secretariat at the Technical University of Eindhoven. To reach the secretariat please contact i.m.dekkers@tue.nl**.**

Transcript interview B8

Geïnterviewde:	CPM 8
Interviewer:	Jeanine Többen
Datum:	16 oktober 2020
Manier van afname:	Online via Microsoft Teams
Specialisatie geïnterviewde:	Bouwprojectmanager, adviseur circulariteit
Duur:	24 minuten

Deel 1: Circulaire economie – introductie met circulariteit

Q1. In dit onderzoek wordt u gedefinieerd als bouwprojectmanager. Wat voor een soort projecten draait u? In de zorg of kantoorpanden en voor welk type opdrachtgevers?
A1. Ik draai projecten van VO tot oplevering. Soms doe ik projecten met contractmanagement. Het verschilt heel erg.

Q2. Hoe beschrijft u projectmanagement?
A2. Ik ben pas projectleider vanaf dit jaar. Je regelt een project voor de opdrachtgever. Het is echt een project dat je ervan maakt. Je hebt een start en een eindpunt. Het eindpunt kan nog wel eens veranderen. Dit is anders dan als je consultant bent dan zeg je dat je ongeveer daar heengaat, het eindpunt is dan vager. Een projectleider is meestal verantwoordelijk voor 1 project. Een projectmanager is meestal verantwoordelijk voor meerder projecten die tegelijkertijd lopen.

Q3. Bent u ooit al een keer in aanraking gekomen met het begrip circulariteit in uw projecten? En zo ja hoe heeft u dit toen aangepakt?
A3. Ja, ik ben wel vaker de vraag om circulariteit te integreren tegen gekomen in een project. Echter heb ik dan vaker een adviserende rol dan in plaats van de rol als projectmanager. Echter ben ik het ook een keer als projectmanager tegengekomen, toen kregen we het circulaire idee, geld technisch gezien, niet rond.

Deel 2: Bouwprojectmanagers en circulariteit in projecten

Q4. Aan welke termen denkt u, als u denkt aan circulariteit?
A4. Ik dan aan kosten, materialen en beheer en onderhoud. Daarnaast denk ik aan slopen, want je hebt iets namelijk grondstoffen en wat ga je met die grondstoffen doen: hergebruiken, recyclen of moet je het verbranden. Daarnaast denk ik ook altijd aan een nieuw gebouw; hoe duurzaam en hernieuwbaar is het om dit te bouwen.
Wat ik ook altijd een interessante vraag vind is; Hoe kun je een hernieuwbaar gebouw maken?
De woorden die we eraan geven aan een term zijn van belang. Misschien moeten we het niet meer beschrijven als hoe duurzaam, maar als hoe herbruikbaar is dit gebouw over 20 jaar nog. Dan ga je anders nadenken.

Q5. Als u zich mag indelen in een klasse van 1-5 in welke klasse bevindt u zich?

f) *1 = nauwelijks tot geen kennis. Ik zou niet weten hoe ik circulariteit moet integreren in mijn projecten*
g) *2 = matige kennis. Ik weet enkele aspecten van het concept circulariteit maar ik heb geen idee hoe ik dit moet integreren in mijn projecten of ik schakel een expert in voor dit gedeelte van het project.*
h) *3 = redelijke kennis. Ik weet verschillende aspecten van het concept maar ik heb nog steeds hulp nodig van een expert want ik kom er alleen in de projecten niet uit.*
i) *4 = goede kennis. Ik weet hoe het concept in elkaar steekt en ik heb soms een expert nodig voor enkele gedeeltes van het project, maar de opzet kan ik alleen.*
j) *5 = uitstekende kennis. Ik moet nog steeds bijleren maar ik weet wel hoe ik circulariteit kan integreren in een project en heb hier geen expert voor nodig.*

A5. Ik zou mijzelf indelen in klasse 4

Q6. Waar ligt dit aan dat u zich in deze klasse indeelt? Welke kennis mist u op dit moment om het concept toe te kunnen passen?
A6. Ik heb een hoop kennis over circulariteit. Het concept over een circulaire economie snap ik. Maar bijvoorbeeld voor het meetbaar maken, financiën en vragen over specifieke producten zoals circulair beton schakel ik iemand anders in. Ook al heb je er veel kennis over, het blijft een erg breed begrip. Ik zie in projecten dat je het niet alleen kan. Wel vind ik dat een projectmanager de vraag moet stellen zodat er processen op gang komen. Ik denk dan ook dat een projectmanager nooit de volledige kennis zal hebben over het concept circulariteit, maar hij of zij moet de juiste vragen kunnen stellen aan de andere betrokkenen.

Q7. Weet u waar uw informatie over het concept circulariteit (in de bouw) kan vinden?
A7. Tegenwoordig google je alles. Ik weet binnen het bedrijf ook waar ik de vraag kan wegzetten dus zo komen we er wel.

<u>Deel 3: Projectmanagers - werkwijze</u>
Q8. Als we kijken naar projectmanagers die normaliter 3 speerpunten hebben: tijd, geld, kwaliteit. Hoe zou circulariteit hier volgens u bij passen? Moet dit als onderdeel worden gezien per speerpunt of als een apart speerpunt duurzaamheid?
A8. Ik ben ook meer opgeleid met Grotik. Ik denk dat duurzaamheid/circulariteit een ontwerpcomponent is met gevolgen voor geld en tijd. Kopje duurzaamheid heeft wel zijn eigen invloeden.
Ik ben dan ook voorstander om duurzaamheid op de agenda te zetten, als reminder.
De enige kanttekening is dat Grotik een projestbeheerssysteem is en hoe stuur je op duurzaamheidsambities? Misschien is het wel een van de randvoorwaarden waar een project aan moet voldoen.

Q9. De afgelopen tijd zijn er vaker nieuwe concepten of regels geïntroduceerd in de bouwsector. Denk aan cradle to cradle, BIM, BREEAM, energie/co2 neutraal bouwen, klimaatadaptatie etc. Hoe gaat u om met deze veranderingen of integratie van nieuwe concepten? En welke kennis heeft u nodig om het te integreren in projecten?
A9. Ik vind dat een goede projectmanager de concepten afweegt en bespreekbaar maakt of er iets meegenomen moet worden in het project. Eigenlijk zou je een heel schema moeten kunnen doorlopen met heb je een dak, ja, kunnen we er iets mee wat betreft klimaatadaptatie. De kennis die je dan eigenlijk nodig hebt om een nieuw concept te integreren is een stappenplan dat je kan doorlopen op papier of in je hoofd. In dit stappenplan zou dan kennis van circulariteit moeten zitten.

Q10. Bent u een initiatiefnemer in nieuwe concepten uitproberen of moet u eerst voorbeelden zien dat het lukt en hoe het uitgevoerd kan worden?

A10. Ja ik hou er wel van om een project anders aan te vliegen. Hierin vind ik het vertrouwen heel erg belangrijk dat een klant in jouw heeft. Dat je iets kan voorleggen aan de klant want buiten zijn vraag ligt. Is het vertrouwen er dat je niet meteen afgebrand wordt? Zoja, dan kan je initiatiefnemen in nieuwe concepten.

Deel 4: Projectmanagers - Het raamwerk voor BPM

Q11. Wat soort hulp zou u willen hebben om circulariteit meer te integreren in projecten? En in welke vorm?

A11. De architect heeft naar mijn idee een belangrijke rol want die bepaalt hoe het vast zit, welke materialen er worden gekozen. Circulariteit zou in het ontwerpproces ook veel meer opgenomen kunnen worden. Dan moet de architect wel snappen wat het concept inhoud maar daar kan die projectmanager bij helpen door het onder de aandacht te brengen met de juiste keuzes aansturen.
Ik zou wel hulp willen hebben door in een overzicht per fase vragen te hebben met welke kritische vragen ik mij kan afvragen in die fase.
Hulp zou welkom zijn om bij de processen die een projectmanager doorloopt, te kijken hoe circulariteit hier aan toegevoegd kan worden.
Eventueel zal het ook helpen om circulariteit onder het projectmanagement schema te zetten.
Je bent een product aan het maken, het proces er naartoe verschilt niet zozeer in de bouw maar het product zelf elke keer wel. In de bouw optimaliseren we niet heel veel.
Ik heb het idee dat projectmanagers er niet van houden dat andere mensen zeggen hoe ze het moeten doen.
Als je circulariteit wil afvinken in een project moet je het tegenkomen op een lijstje en moet je eraan herinnert worden.
Aan de voorkant moet de projectmanager de tools hebben om de opdrachtgever te overtuigen om circulariteit toe te passen en daarnaast moet de projectmanager zelf de tools hebben om de ambities scherp te houden in de uitvoering.

Q12. Welke handvaten moet de hulp u geven?

A12. Hulp in de vorm dat een projectmanager bewust is in welke stap van het proces hij welke (kritische) vraag moet stellen om het concept onder de aandacht te brengen bij de andere betrokkenen.

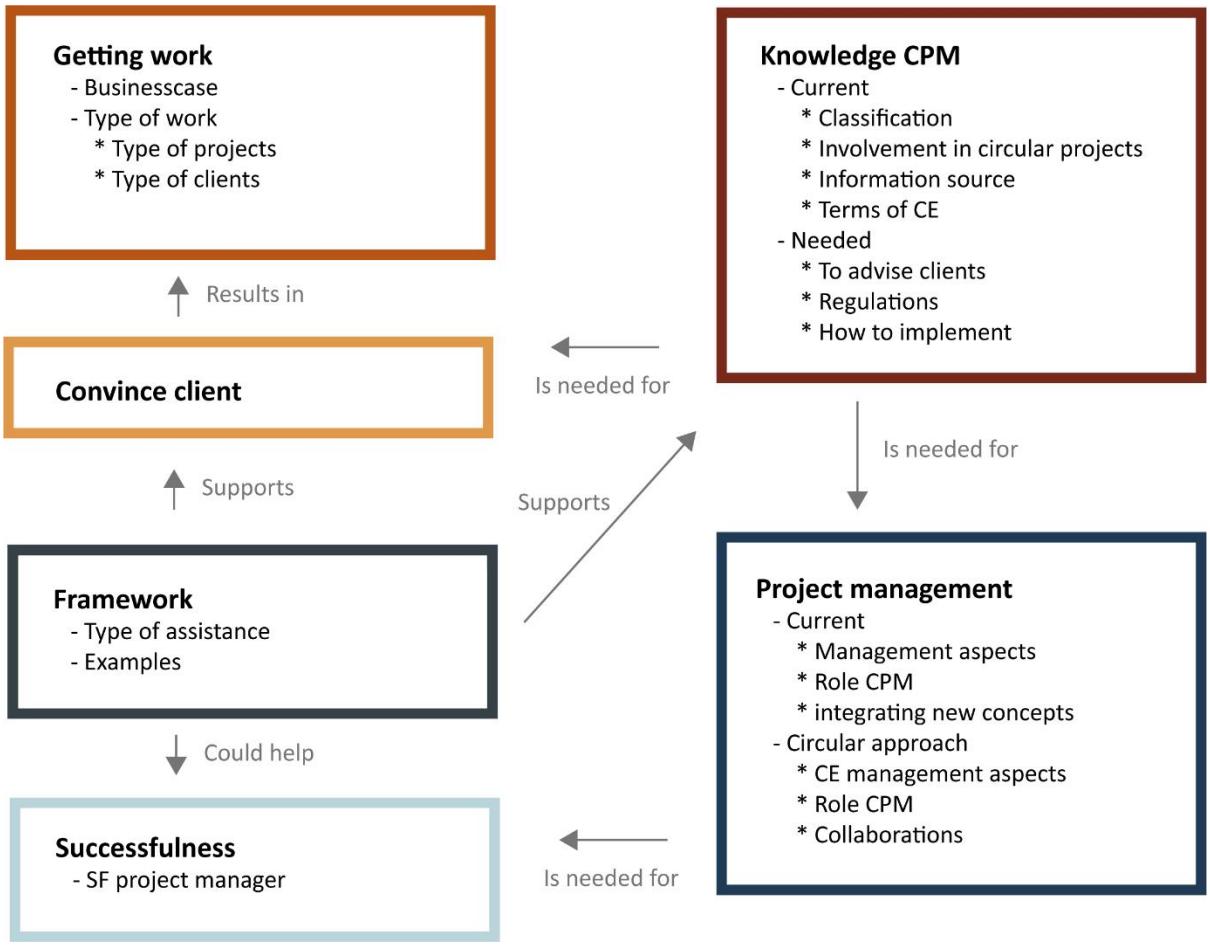
Deel 5: Afronding

Q13. Is er nog iets onbesproken gebleven tijdens het interview maar wat wel van belang kan zijn voor mijn onderzoek?

A13. De uitdaging is dat circulariteit niet het enige onderwerp is dat speelt, dat wil je nog even meegeven.

Appendix H – Overview results interview B

This overview provides an insight into the topics discussed with the respondents of interview B. The topics are all covered in the body of this report. The topics visualised correspond to the axial codes used with the coding techniques. The colours associated with the topics are related to the overview results of interview A in *Appendix E*.



Appendix I – Transcripts interview C

Transcript C5 is included below. All transcripts of interview C are presented in the related appendices book. This appendices book can be requested at the Construction Management & Engineering (CME) secretariat at the Technical University of Eindhoven. To reach the secretariat please contact i.m.dekkers@tue.nl**.**

Transcript interview C5

Case analyse:	Project C
Geïnterviewde:	projectmanager client– project C
Interviewer:	Jeanine Többen
Datum:	26 oktober 2020
Manier van afname:	Online via Microsoft Teams
Duur:	45 minuten
Opgenomen:	Ja

Algemeen:

Wat houdt het project in?

Het project wordt een bediencentrum voor bruggen. In 2015 besloten om over te gaan op afstandsbediening. Toen is er ook gezegd dan moet er een nieuw bediencentrum komen. Er is gekozen voor een centrale plek in de provincie. Daarnaast moest er ook een steunpunt komen. Dit is gecombineerd op 1 locatie. In 2018 is er door gedeputeerde staten besluitvorming geweest, toen werd een concreet project. Ik ben vervolgens gevraagd om het project te leiden.

Welke functie had je binnen het project?

Sinds 2012 bij de provincie. Al heel wat projecten gedaan. Sinds 2018 betrokken bij dit project. Vooral projecten voor provincie. Onderhoud en beheer van alle assets, dus ook gebouwen.

Project specifiek:

Was er al een ambitie op het gebied van circulariteit?

In 2017 heeft de provincie besluit genomen om in 2025 de meest circulaire regio te zijn en de meest aantrekkelijke regio te zijn voor circulaire initiatieven. Provincie moet hier dan ook het goede voorbeeld in zijn. Aan alle inkopen die we doen worden minimale circulaire eisen gesteld. Een vastgoed project moet circulair zijn omdat daarmee de ambitie uitgedragen kan worden.

Ik las dat jullie van het project een circulair icoon wilden maken. Hoe hebben jullie dit meegenomen in de uitvraag?

Het bestuur heeft aangegeven dat het een circulair icoon moest worden maar projectmanager en het team erom heen hebben zelf moeten opzetten wat dit betekent. Hulp gekregen van adviesbureau die samen met provincie, hoofdgebruikers en expert van buiten de organisatie de ambitie vertaald hebben in een ambitiedocument

Workshops en een methode gebruikt om de ambities in een document op te nemen met een aantal speerpunten.

Zeker van belang om een partij aan te laten schuiven die kennis heeft van circulariteit omdat wij niet weten wat gerealiseerd is en wat het hoogst haalbare is momenteel. Die kennis hebben we niet in huis. Er is een vereniging binnen de provincie die heeft geholpen om referentie projecten aan te dragen en ons te helpen.

Is er naast het ambitiedocument nog iets anders meegenomen in de uitvraag?

Er was een hele korte aanbestedingsprocedure door een strakke planning. De inschrijvende partij moest op basis van ambitiedocument en programma van eisen een plan van aanpak indienen, hoe ze het project wilden aanvliegen. Daarnaast moesten ze twee kansendossiers aanreiken; 1 op het gebied van energie en 1 op het gebied van circulariteit. Om de inschrijvende partij hierbij te helpen had de provincie zelf al kansen genoteerd met initiatieven uit de buurt om de creativiteit te bevorderen. Deze kansenkaarten waren als bijlage toegevoegd aan het programma van eisen. Een adviseursbureau op energie en duurzaamheid, heeft samen met de provincie creatieve sessies gehouden met allemaal experts zoals adviseur materialenpaspoort, sloopverenigingen, gemeente en circulaire organisatie van de provincie. Wat gebeurt er al om de locatie heen waarmee een koppeling gemaakt kan worden zodat de inschrijvende partij haar voordeel hiermee kan doen.

Hebben jullie bewust voor een bouwteam gekozen?
Ja, bewust gekozen voor een bouwteam gekozen. We hadden het ambitiedocument en daarna hebben we met z'n allen de aanbestedingsstrategie en contractvorm vastgesteld. Deze aanpak is getoetst door een marktconsultatie, dit werd bevestigd. Het doel van het Bouwteamfase was om een ontwerp te krijgen dat precies voldoet aan het programma van eisen en daar bovenop zoveel mogelijk van het ambitiedocument zou waarmaken zodat er een zo groot mogelijke plus op het programma van eisen werd gerealiseerd.
Wanneer het ontwerp voldeed aan de ontwerpkaders en binnen tijd en geld dan zou het vervolgd worden door een UAV-gc traject voor het ontwerpen, bouwen en onderhouden van het project. Er was een mogelijkheid om weer los te komen van het bouwteam, dit was gebaseerd op opschortende voorwaarden en het plafondbudget.

Zoals je net zei zijn er sessies met workshops geweest om de ambitie te formuleren. Stellen jullie altijd een ambitiedocument op?
Als provincie zijn we gewend om bij elk project een ambitiedocument op te stellen. Nu hebben we er veel meer tijd voor uit getrokken en een externe partij erbij betrokken om het samen te formuleren. Ook zeker aan te raden om experts erbij betrekken die weten wat de huidige mogelijkheden zijn in de markt. We hebben uitdagende eisen geformuleerd waarbij we ook terug hebben gekregen bij de marktconsultatie dat het wel erg ambitieus was. Voor een dergelijk project is het echt nodig om er tijd voor uit te trekken en niet 1 pagina voor op te nemen in je programma van eisen.

Aan hoeveel meer tijd moet je denken om dit traject te doorlopen?
Als je een beetje weet wat je wil kan je dit wel in 1à2 maanden vastleggen. Hiervoor is het wel belangrijk dat iedereen achter de keuze staat. Er moet draagvlak zijn bij het projectteam, ook wel de teamleider en alle gebruikers van het gebouw.

Kwaliteit is in programma van eisen en ambitie meegenomen, tijd is extra voor uitgesteld. Is er ook meer voor budget vrijgekomen?
We hebben een bouwkostenadviesbureau gevraagd. Een plafondbudget is vastgesteld, dit is meegegeven in de aanbesteding. Bouwkostenadviesbureau heeft het programma van eisen geraamd. Hier bovenop is nog een percentage bijgeplust voor circulariteit. 5-10%.

Ambitiedocument was een bijlage van het programma van eisen. Het programma van eisen was het basisniveau wat minimaal gerealiseerd moest worden. En in het bouwteamfase moest een zo groot mogelijk plus gerealiseerd moeten worden.
Gunningscriteria op proces hoe het plussen geïnventariseerd en concreet werden gemaakt. Niet beoordeelt op concrete maatregelen. Wel naar gekeken met de kansendossiers maar vooral gekeken naar het proces die ze voorstelden om het te bewerkstelligen. De inschrijver hoefde ook nog niet te komen met een ontwerp of een plan maar puur met een proces. Het is beoordeelt op een plan van aanpak.

Soms wordt er toch ook gevraagd om een ontwerp tijdens een bouwteamfase?
Ja dat kan maar wij wilden vanuit nul betrokken worden met de ontwerpende partij. Daarnaast wilden we allereerst het programma van eisen naar een hoger niveau tillen.

Een UAV-GC contract zou er daarna worden afgesloten. Is er ook al een budget meegegeven voor de beheerfase?
Nee, we hebben alleen een taakstellend budget meegegeven voor de investering, dus het bouwen van het gebouw zelf. Wel nagedacht over taakstellend budget voor onderhoud, lastig om hier een budget voor mee te geven. We hebben dit wel kwalitatief omschreven zoals we willen een onderhoudsarm gebouw. De uitwisseling tussen budgetten konden niet gedaan worden.

Budget is uiteindelijk iets opgeplust doordat er aanvullende scope was.

Hoe is er gecommuniceerd in het project?
Vanuit opdrachtgever is een projectmanager. Daarnaast is er een projectmanager vanuit opdrachtnemer. Contacten tussen projectmanagers. Gebruikerscontact met projectmanager klant. Er is een stuurgroep binnen de provincie waarin alle ambtelijke opdrachtgevers zitten (o.a. alle teamleiders van de gebruikers). Daarboven zitten nog bestuurlijke opdrachtgevers. Als provincie ook een projectteam. Daarnaast ook nog een projectteam met opdrachtgever en opdrachtnemer. Projectmanager opdrachtgever heeft mandaat en moet accorderen maar hier wordt uiteraard wel over gerapporteerd. Er is maandelijks opdrachtgevers overleg.

BIM werd genoemd in inschrijvingsleidraad. Is een digital twin noodzakelijk in een circulair project?
Voor een circulair project is het noodzakelijk om een digital twin te hebben. Dat je weet in de toekomst welke materialen er in je gebouw zitten, en per materiaal aangegeven wat de levensduur is en verwachte hergebruik van het materiaal. BIM model en materialenpaspoort staat in dit project los. Het kan wel geïntegreerd worden maar dit kost ook weer meer geld. Het is sowieso goed dat het ergens vaststaat en dat de beheerpartij ermee om kan gaan.
Eerst zal het beheer van het BIM model worden onderhouden door de opdrachtnemer die het de eerste jaren(10jaar) zelf zal doen. Daarna zal het overgedragen worden.
Beheerfase is 2x 5 jaar en dan neemt de provincie het over.

Is er met de gunningscriteria met fictieve korting gewerkt?
We hebben er wel over nagedacht om met een financiële prikkel te hanteren. De prikkel die wij voor ogen hadden was een PR-prikkel dat de opdrachtnemer een intrinsieke drive zou hebben in plaats van een financiële drive. Dus bewust gekozen voor geen fictieve korting.

Hoe hebben jullie circulariteit meetbaar gemaakt of geborgen tijdens het project?
Er is een document bijgehouden voor elk materiaal wat de samenstelling is van elk materiaal: biologisch, secundair en nieuw. Voor elk component maken ze dit inzichtelijk qua materialen. Voor het definitieve ontwerp was dit al gedaan en in de bouwfase wordt dit geüpdatet. Alle andere maatregelen worden genoteerd in een document. Qua maatregelen wordt hier dan mee bedoelt om zo circulair mogelijk te maken; energie, water en een bredere scope dan alleen het gebouw, kennisdeling dus openstellen voor publiek. Dus zachtere maatregelen die minder meetbaar zijn om de circulaire keuzes inzichtelijk te maken. Circulair in de breedste zin van het woord.

We hebben heel nauw de gebruikers betrokken voor energie. Ook een energie-netwerk aangelegd voor mochten er in de toekomst buren komen. Dus veel breder gedacht.

In het programma van eisen hebben jullie eisen gesteld op basis van monetaire waarde van materialen, waarom?
Als je op hoeveelheid kiest zit je al heel snel aan de 40% gestelde eis. Installaties is een groot deel van de monetaire waarde. Dus bouwkundig moet je dan al een heel groot deel secundair zijn. Ook opdrachtnemer uitdagen om creatief na te denken en om zoveel mogelijk secundair toe te passen.

100% in de toekomst her te gebruiken. Modulair is bij ons dat hele gebouw delen of elementen hergebruikt kan worden maar ook dat materialen makkelijk losgemaakt kan maken.

Circulair is ook heel erg wat de regio te bieden heeft en een (overheid)-opdrachtgever weet dit natuurlijk het beste. Als projectmanager van opdrachtgever ook heel erg kijken wat komt er vrij aan materialen en waar liggen kansen. Je moet een antenne als projectmanager uit hebben staan.

Heb je dit project anders gemanaged dan een traditioneel project?
Het management hoeft niet te veranderen maar er komt een doelstelling bij. Eventueel komt er gedurende het traject der mate grote kansen voorbij dat je je plannen nog moet wijzigen, flexibel zijn! Tijdens de UAV-GC waarbij het best gekaderd is moet er toch ruimte zijn. Consequenties op gebied van circulair moet inzichtelijk zijn zodat op basis hiervan achterhaalt kan worden wat het betekent voor de gestelde ambities.

In dit project geen goede PR gedaan. Hoe circulair ben je, er is nog steeds geen meetmethode.
Het is niet dat je 100% circulair kan zijn maar dat je vandaag weer iets leert, wat je morgen weer kan meenemen.

Samenvattend kunnen we stellen:
Het project is door middel van ambitiedocumenten, programma van eisen en kansenkaarten zijn de ambities opgeschreven hoe jullie circulariteit voor jullie zien. Door een bouwteam aan te gaan is het geprobeerd om pve naar een hoger niveau te tillen. Om dan vervolgens met dezelfde partij of een andere partij door te gaan in een UAV-gc traject. Waarbij ook de maintainfase is meegenomen om het project te realiseren. Daarnaast is er ook een digital twin gemaakt.

Uiteindelijk moet de mens het gaan doen, en dat is dan ook uiteindelijk de belangrijkste succesfactor. Het team en de samenwerking is hierin belangrijk. Hoe ziet het team de samenwerking voor zich.
Interview met projectleider en ontwerpleider maakte onderdeel uit van beoordeling, zodat je weet met wie je gaat samenwerken.

Heb je nog tips?
Hybride contractvorm dat is heel positief. Het ontwerp en vraagspecificatie stel je samen op.
Meerwaarde dat de opdrachtnemer ook zijn ei kwijt kan.
Vertrouwen hierin is super belangrijk. Papierwerk is nodig maar dat vertrouwen moet het uitgangspunt zijn.

Een veel intensievere samenwerking waarbij krachten gebundeld worden.

<u>Afsluiting:</u>
Ik wil je heel hartelijk danken voor de tijd en de bereidheid om mij te helpen met dit interview. Heb je nog iets toe te voegen dat nog niet is benoemd tijdens het interview maar nog wel van belang kan zijn voor het onderzoek en behorende bij de initiatie- en definitiefase?
Nee momenteel niet. Ik vind het goed dat je dit onderzoekt en ben benieuwd naar het resultaat.

Appendix J – Questions Interview D

English questions:

- Q1. What is your first reaction to the framework? Can you explain?
- Q2. Does the framework satisfy the design propositions?
- Q3. Is the framework applicable in a project and would you use it?
- Q4. Would you like to make adjustments to the framework?
- Q5. Are there challenges to implement the framework in a project?

Dutch questions:

- Q1. Wat is uw eerste reactie op het model? Kunt u dat uitleggen?
- Q2. Voldoet het model aan de ontwerpvoorstellen?
- Q3. Is het model toepasbaar in een project en zou u het gebruiken?
- Q4. Zou u aanpassingen willen maken aan het model?
- Q5. Zijn er uitdagingen om het model in een project te implementeren?

Appendix K – Transcripts interview D

Transcript D2 is included below. All transcripts of interview D are presented in the related appendices book. This appendices book can be requested at the Construction Management & Engineering (CME) secretariat at the Technical University of Eindhoven. To reach the secretariat please contact i.m.dekkers@tue.nl**.**

Transcript interview D2

Geïnterviewde:	Expert 2
Interviewer:	Jeanine Többen
Datum:	16 februari 2020
Interview techniek:	Online via Microsoft Teams
Specialisatie geïnterviewde:	bouwprojectmanager
Duur:	44 minuten

Deel 1: Uitleg totstandkoming model, bespreken van de validatie vragen en toelichting op de ontwerpvoorstellen.

Deel 2: Bespreken van het model
Expert: Aandachtspunt naar de toekomst is: hoe lang blijven de links naar websites nog bruikbaar.

Expert: heeft de keuze van een circulaire strategie ook te maken met de persoonlijke voorkeur van de klant of welke aspecten spelen daarbij een rol?
Interviewer: op dit moment is er nog meer onderzoek nodig naar de aspecten die een rol spelen bij het kiezen voor een circulaire strategie. Ik heb daar niet op gefocust maar de resultaten laat zien dat wel van belang is.

Expert: is de circulaire adviseur betrokken bij zowel definiëren, borgen en meetbaar maken?
Interviewer: Ja, uit onderzoek is gebleken dat de projectmanager tot zekere hoogte kennis moet hebben maar daarnaast zal iemand met meer inhoudelijk kennis moeten worden toegevoegd.
Expert: Wellicht is het goed om dit nog iets duidelijker te vermelden.

Expert: Een materialenpaspoort zal pas in de realisatiefase gemaakt worden. Wellicht dit aangeven in het framewerk. Dit is wel duidelijk voor een projectmanager maar nog niet voor een klant.
Interviewer: Dank voor de toevoeging. Daarnaast is deze informatie ook belangrijk om mee te nemen in je overwegingen in de beginfases omdat het wel gevolgen heeft voor planning en budget.

Deel 3: validatie door middel van opgestelde vragen
Q1. Wat is uw eerste reactie op het model? Kunt u dat uitleggen?
A1. Ik ben onder de indruk van het model. Ik vind het er fantastisch uitzien; heel overzichtelijk, duidelijke structuur met de opbouw en een fijne kleurstelling gebruikt.

Q2. Voldoet het model aan de ontwerpvoorstellen?
A2.
a) Het is een basismodel dat de stappen voor een circulaire aanpak en de consequenties voor het project inzichtelijk maakt.
Ja, het maakt alle stappen duidelijk inzichtelijk. Hier voldoet het model helemaal aan.

b) Het model is te gebruiken om aan een opdrachtgever uit te leggen; waarom een circulaire aanpak, hoe dit gerealiseerd kan worden en wat een circulaire aanpak betekent voor het project.

Ja hier voldoet het model aan. Het model biedt zeker handvaten om het gesprek aan te gaan als projectmanager zeker in samen spraak met een circulaire adviseur. In de basis voldoet het hieraan.

c) Het model kan zowel door de project manager gebruikt kan worden om de aanpak te bedenken van het project als interactief met de klant om een circulaire aanpak voor het project te bespreken.

Het model werkt van grof naar fijn, waardoor je het model kan gebruiken om het gesprek met de klant aan te kunnen gaan. Daarnaast geeft het ook de consequenties weer. Het model is nu voldoende om bewustwording te creëren bij de klant waar het om gaat en aan te geven hoe belangrijk een circulaire aanpak is. Daarnaast dient het ook voor gebruik door de projectmanagers.

d) Het model kan fungeren als checklist om te bepalen wat er in welke fase moet gebeuren en wat de aandachtspunten zijn.

Het geeft handvaten om door het project heen de belangrijkste dingen af te vinken. Daarnaast geeft het de rode draad weer van een circulaire aanpak.

Q3. Is het model toepasbaar in een project en zou u het gebruiken?

A3. Ja, ik zou het gebruiken. Het model is hartstikke overzichtelijk dus voor mij zou het bruikbaar zijn. Het zal aan de ene kant helpen voor de projectmanager om je in te lezen en aan de andere kant om er samen met de klant doorheen te lopen. Het is een interactief model dat ook achtergelaten kan worden bij de klanten.

Q4. Zou u aanpassingen willen maken aan het model?

A4. Een nederlandse versie van het model zou nog wel gewenst zijn.

Daarnaast de opmerkingen die zijn gegeven in deel 2, wellicht dat je hier nog iets mee kan ter verduidelijking.

Q5. Zijn er uitdagingen om het model in een project te implementeren?

A5. De uitdaging voor de implementatie is het budget en de angst voor een circulaire aanpak. Maar momenteel zie ik geen uitdagingen om het model te implementeren.

Wat ik hieruit haal is dat het uiteindelijk gaat om het gesprek voeren en alles wat daaruit gehaald kan worden is meegenomen. Het is uiteindelijk een kwestie van toepassen en ik ben ervan overtuigd dat je model gebruikt zal worden.

Ik wil u hartelijk danken voor het meewerken aan de validatie van het circulaire model voor de projectmanagers. Heeft u verder nog vragen?

Appendix L – Case analysis projects B - F

Project B

Project Generic

The project concerns the realisation of a new school where both education and entrepreneurs are located. The clients are three educational parties, a municipality and entrepreneurs. The new building is divided into building south and building north. The project is a traditional project.

Project Specific

Initiation and definition phase

Initiation phase

The initiative for a new school started in 2007 and lasted 10 years. Educational party 1 was interested in a new school and conducted a location survey as well as having a design made. After the municipality merged, Educational Party 2 joined Educational party 1 and together they decided to combine their six locations into one new location. An architect made a sketch design for the new location. However, the parties wanted to involve entrepreneurs which did not succeed. This was a challenge, despite working groups and information evenings. On the initiative of the municipality, Education Party 3 also joined the project initiators.

Definition phase

Project manager 1B started formulating the programme of requirements and sketch design phase. The clients were not satisfied with this party and switched to project manager 2B. Project manager 2B completed the programme of requirements by translating the ambitions of the clients and users into project objectives. The project has been divided in building North and building South. The north building has six months delay compared to the south building due to a delay in the decision-making process.

Progress of the project

The programme of requirements served as the basis for the design phase. This design phase was addressed by the same architect who had made a sketch design in the initiation phase. The programme of requirements was not converted into a request specification but into a final design. The final design serves as the basis for the contractor's tender. The final design for building south serves as the basis for building north.

Project management

It is managed according to the GROTIK aspects; money, risks, organisation, time, information and quality. After the initiation phase, project manager 1B is replaced by project manager 2B. In the definition phase there are two project managers; project manager 2B for construction-related aspects and project manager 3B for education and facility-related aspects.

Planning

The initiation phase had a duration of 10 years and the definition phase took 2 years.

Budget

The total budget for the project is 17 million. This consists of construction costs of 15 million and preparation costs of 2 million. Due to additional wishes and inflation, the budget has been increased slightly.

Procurement

For the selection of the architect, there has been no tendering. For the selection of the contractor, however, there was a call for tenders.

Form of contract

There is a UAC-ic contract with the contractor for the realisation and maintain phases.

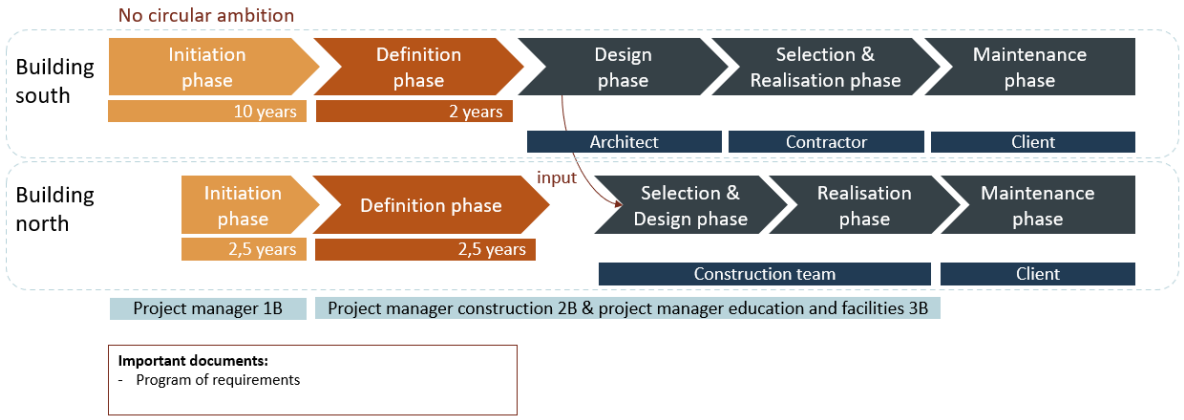


Figure L. 1 – Process project B = Figure 4.7

Role of the project manager

In this project, project manager construction 2B was asked to assist with the completion of the programme of requirements. Subsequently, the client commissioned for supervision until the final design and for supervision till the end of the execution phase.

Involved stakeholders

The initiation phase involved project manager 1B, an architect and the clients. In the definition phase, the construction project manager has been replaced and the team was expanded with consultants and project manager 3B for education and facility tasks.

Organisation chart

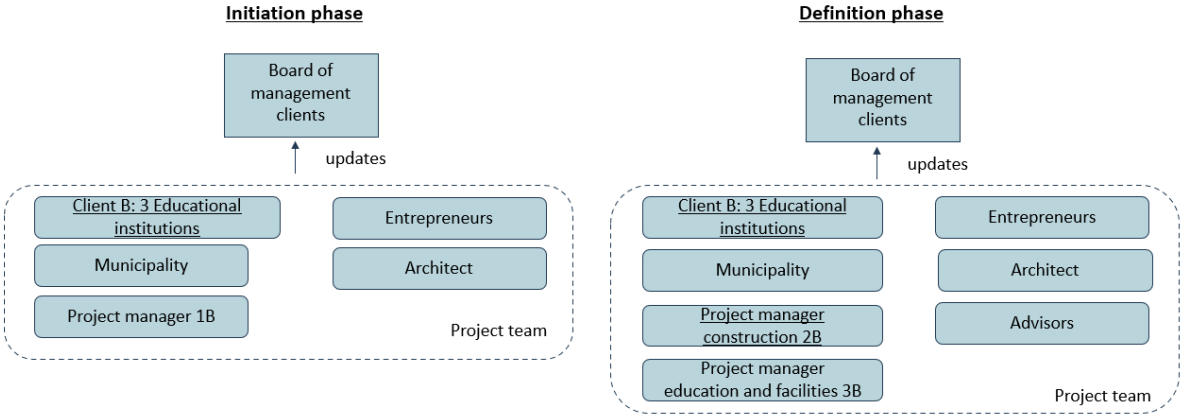


Figure L. 2 – Organisation chart project B = Figure 4.8

Circular ambition

In the definition phase, ambitions were formulated, including some sustainability ambitions such as an almost energy-neutral building. This ambition was also achieved. The clients focused on the perspective of the future with long term thinking. However, they also focused on budget, which resulted in the elimination of sustainable design solutions. There is still a lot of focus on money. Comparing this with the value of a circular economy, it is difficult to benefit at the moment from the residual value of materials that you will only get in the future. Flexibility has been taken as an approach for the building which resulted in clear pattern sizes and a flexible layout. The aim of the cooperation of the 3 Principals (government, entrepreneurs, education) was to keep the pupils on the island and

to reduce traffic (closing cycles). In educational terms, this means investing in sustainable relationships with pupils. Circularity is increasingly addressed in the curriculum and is reflected in the function of the building. However, circularity has not been considered in the construction phases of the school. Client B (*Appendix I*): 'At the beginning of the project, circularity was not yet applied and introduced. Ten years ago, we focused more at sustainability and how to organise sustainable education. It would certainly have been interesting if a project manager had informed us about circularity.'
Project management is always a game of time, money and quality, and in the end the project has to be continued. 'Perhaps we could have addressed sustainability and circularity on the agenda during the meetings, but we did not' (Client B, *Appendix I*).

Summary of project B

The project includes the realisation of a new school involving three types of clients. The project is divided into building south and building north. Building north is following building south. The construction project manager has been replaced between the initiation and definition phases. In the definition phase, a third project manager was appointed for the education and facilities aspects. The project does not have circular ambitions but does have sustainability ambitions in the form of energy neutrality. Even though circularity is not expressed in the construction, it is present in the vision and education of the users. The project is managed according to the Grotik aspects and the programme of requirements is an important document for the project.

Project C

Project Generic

The project will be a bridge operating centre at a central location in the province. The client is the province. Type of project is a (semi-)circular project.

Project Specific

Initiation and definition phase

Initiation phase

In 2015, it has been decided to operate the bridges remotely in the province and a new location was necessary. Meanwhile, in 2017, it was decided by the province to be the most circular region by 2025 and to be the most attractive region for circular initiatives. With this ambition, Project C became an example and had to be a circular icon. This ambition resulted in circular requirements demanded of all purchases made by the province. The project team had to define what a circular icon means for the construction project. They were assisted by a consultancy firm that, together with the province, main users and experts in the field of circularity, translated the ambition into a number of spearheads in an ambition document by means of workshops. Project manager client C (*Appendix I*) says: 'It is certainly important to hire a party who has knowledge of circularity if the organisation has not, since we did not know what has already been realised and what the highest achievable is in the market at the moment'. For every project of the province an ambition document is created. Within this project two months extra have been invested and external parties were involved for creating the ambition document. The ambition document mentions five categories: 'Energetic and healthy work environment', 'Realised without new raw materials', 'Flexible and adaptive', 'Self-sufficient using a local collective energy network' and 'Make optimal use of the watery environment'. All these categories are further specified in the ambition document. In addition, some models associated with a circular economy were included, such as the 6S model by Stewart Brand. A consultancy firm with knowledge of energy and sustainability has helped with reference projects and initiatives from the neighbourhood to set up opportunity cards for project C. These opportunity cards have been drawn up together with an advisor in the field of materials passports, a demolition association, municipality, province and a circular association within the province. The purpose of these opportunity cards is to provide market parties with opportunities of the neighbourhood and possible potentials to help them creating ideas. These opportunity cards functions as an appendix to the schedule of requirements in the definition phase.

Definition phase

The programme of requirements was compiled in the definition phase. This programme included requirements for a materials passport, an environmental impact factor of 2.74 and a requirement that at least 40% of the monetary value of the materials used should be recycled (secondary) material.
The programme of requirements, the opportunity maps, the ambition document and the approach to the proposed tendering strategy were tested and approved by means of a market consultation.
This was followed by a short tendering procedure, due to a tight schedule, to select a construction team. The construction team had to submit a plan of approach based on the ambition document and programme of requirements - how they wanted to approach the project. In addition, they had to submit two opportunity files: one in the field of energy and one in the field of circularity. The contract was awarded on the submitted plan of approach. The aim of integrating a construction team at an early stage was to obtain a design that met the programme of requirements and, on top of that, achieved as much as possible of the ambition document.
In the selection procedure, the contractor searched for reference projects and parties with whom they had worked before. In the end, a building team was formed comprising the architect, contractor and a consultancy firm.

Progress of the project
Once the programme of requirements had been completed and the project team's ambitions were clear, the construction team started designing. A traditional design phase took place with a sketch design, a preliminary design with material analysis and energy calculations, and a final design. During the design phase, certain requirements were revised or adapted because they turned out to be too ambitious. An example of revising requirements is the requirement to use secondary materials. The question was asked what secondary material is and whether this could be post-consumed materials (materials that have already been used) or pre-consumed materials (materials that are rejected at the time of production due to aesthetic reasons). During the procurement of the construction team, extra agreements, such as suspensive conditions and a maximum budget have been included to end the contract if requirements were not met. The contract between the construction team and the client have been continued with a UAC-ic contract for the design, construction and maintenance phases of the project. During the project, a digital twin of the project was created with a BIM model and a material passport. On this subject, project manager client C (*Appendix I*) says: 'For a circular project, it is necessary to have a digital twin. You need to know which materials will be present in your building in the future, what the lifespan of each material is and what the expected reuse of the material is.'
In order to monitor the requested percentage of reused materials, a document record the composition of each material: biological, secondary and new. This document is made during the final design and is updated during the construction and maintenance phase. All softer measures and choices made from a circular perspective but which cannot be measured are noted in another document. Firstly, the maintenance of the building and the BIM model will be retained by the construction team for 10 years, after which the province will take over.

Project management
Project manager client C (*Appendix I*) says: 'the management does not have to change, but certain objectives are added to the project. Opportunities may arise which needs flexibility in the project, even in a UAC-ic traject.' This project was managed primarily on the basis of time, money and quality. Whereby circularity set high requirements in terms of quality.

Planning
The initiation phase had a duration of 3 years. The definition phase took 1.5 years. Defining and recording the ambitions and drawing up the opportunity maps in the initiation phase took one to two months.

Budget
A building cost consultant estimated the programme of requirements for a budget. On top of this, a percentage of 5-10 percent was added for circularity. The target budget for the realisation phase was 10 million. The goal was to achieve the highest possible level of circularity for this amount.

Procurement
During the definition phase, procurement was used to select a construction team. No financial stimulation, such as a fictive discount, was included in the award criteria since the aim was to have an intrinsic drive for the construction team.

Form of contract
An UAC-ic contract was used. The client's project manager says: 'A hybrid form of contract worked very well in this project because the programme of requirements were drawn up together with the client and the contractor, with the added value to include the knowledge of the contractor. It is necessary to have a contract but trust should be the starting point between the parties'.

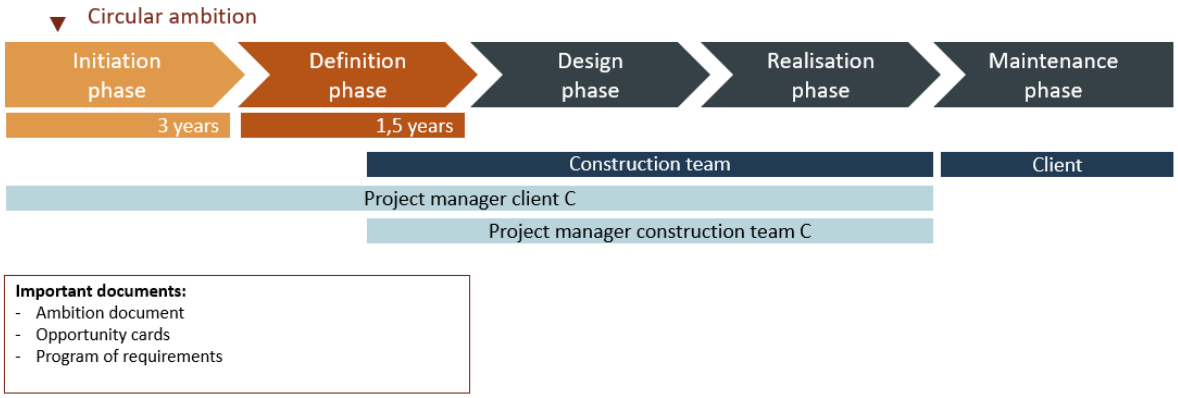


Figure L. 3 – Process project C = Figure 4.9

Role of the project manager

The client's project manager was responsible for incorporating the ambitions and wishes of the client into the project. In addition, there was a management role to involve all needed parties in the project team. From the definition phase onwards, there was also a project manager from the construction team who managed the construction team. Both project managers kept an overview and updated each other.

Involved stakeholders

In the initiation phase, project manager client, a circular advisor, a representative of the province, users and circular experts were involved. In the definition phase, a project manager from the contractor was also added to the above-mentioned project team, after the construction team had been formed.

Organisation chart

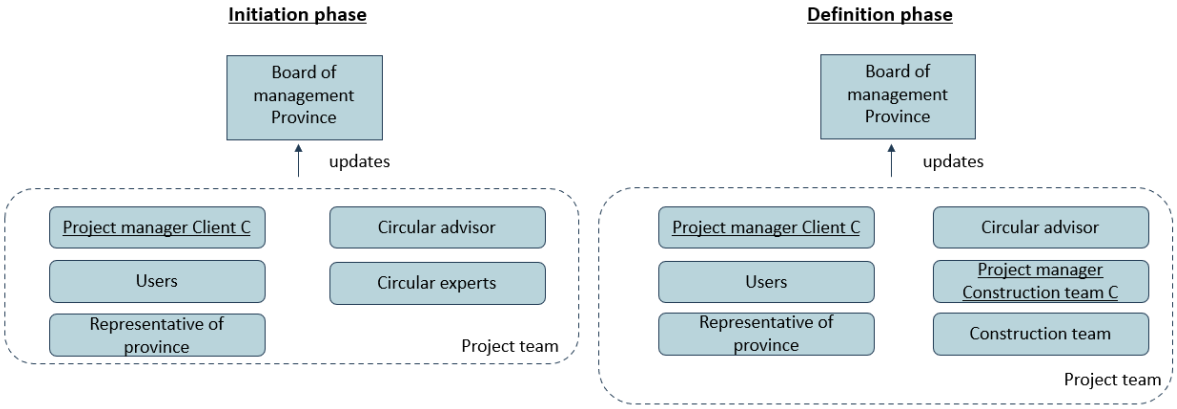


Figure L. 4 – Organisation chart project C = Figure 4.10

Circular ambition

A circular ambition was adopted in the initiation phase. By means of an ambition document, programme of requirements and opportunity maps, the ambitions and objectives were formulated, documented and used to tender. The main circular ambition was to use secondary materials with a focus on detachability. There was no clear tool yet for measuring circularity. In terms of a measuring tool, the construction team itself produced something by classifying materials according to new, biological and reuse. Re-using material requirements were based on the monetary value of the total materials to be used. The project is not 100% circular, but the motto was: you learn something today that you can apply tomorrow. Project manager client C (*Appendix I*) says: 'Ultimately, it's all about people, and that has been the most important success factor in this project. Therefore the team and

its cooperation are important. Furthermore, there has to be support for a circular approach from the project team, the team leaders and all the users of the building'.

Lessons learned
You have to keep your eyes and ears open for opportunities that come along, and you have to be lucky with the secondary materials you find. You run into a lot of barriers, which makes the process trial and error, so you have to be flexible in order to approach it differently', said project manager contractor team. In the initiation phase, the concept of circularity has to be defined in a project with the questions: what do you intend to achieve with circularity? and how will you include circularity in your project?

Summary of project C
The project concerns a new building to be constructed whereby circularity is an ambition from the start and the entire organisation support the approach. An external party helped to define the ambition and draw up the most important documents. A construction team selection took place in the definition phase based on soft selection criteria. Together with the construction team, the highest achievable programme of requirements was established. In this project 5-10% extra money was needed for circular building and 1 to 2 extra months for formulating the circular ambitions.

Project D

Project Generic

The project is the realisation of a new accident centre for railways. The client is a railway manager. Type of project is a (semi) circular project.

Project Specific

Initiation and definition phase

Initiation phase

The client has a general sustainability document that also covers circularity. All new construction projects, including this one, should have a circular approach. Within the organisation's real estate team, there are yet a few construction projects in which circularity has been implemented. The client intends to take social responsibility in the use of materials. The board of management decided that a new building was needed for this project. This project concerns a building that must function at all times due to its function. The project manager client therefore indicates that innovation within this project is very difficult. In the initiation phase, a start was made with the formation of the programme of requirements. It was decided to request the market to include circularity as they would know what is possible at the moment.

Definition phase

First of all, the project manager client contracted an architect and made a sketch design. Secondly, another party was contracted for the construction, installation mechanics and project management aspects. Together with the three parties (client's project manager, architect and the engineer/project manager) the objectives for the project were defined and the programme of requirements was finalised. The three parties jointly defined circularity. The architect made most material choices in the field of circularity.

Progress of the project

The design phase started with the same parties on the basis of a completed programme of requirements. Initially, costs were subordinate to circularity. Until the client was shocked by the costs and a comparison was made between a standard construction process in which circularity was not included and a process with circular principles. Ultimately, the circular option was chosen and the budget was distributed differently. The maintenance phase for the client

Project management

The client provided overall project management. The engineering firm was responsible for monitoring planning and budget from the definition phase onwards. The engineering firm and the architect had contracts with the client and had equal rights. Several stakeholders indicated that an independent circular advisor was desirable to give advice on circular solutions.

Planning

The initiation phase lasted six months and the definition phase had a duration of a year.

Budget

A comparison have been made between a standard construction method and building according to circular principles, it was concluded that the realisation with circular principles is about 15% more expensive. However, it was indicated that this is very difficult to estimate at the front end because, for example, there is no database with prices of reused materials available. 'If you only manage on the aspect money, you should not include a circular approach. Circular building is currently still more expensive than using new materials' stated Project manager construction 1D (*Appendix I*).

The extra budget required (15%) was labelled as additional work and came from another cost item, namely 'sustainability and circularity - budget', within the client's organisation. The residual value of the project was not taken into account. The total budget is approximately 1.2 million.

Procurement
The architect and the engineering firm were not contracted by means of a tender. There was a tender procedure for the contractor.

Form of contract
The contracted parties entered into a UAC-ic contract in the definition phase.

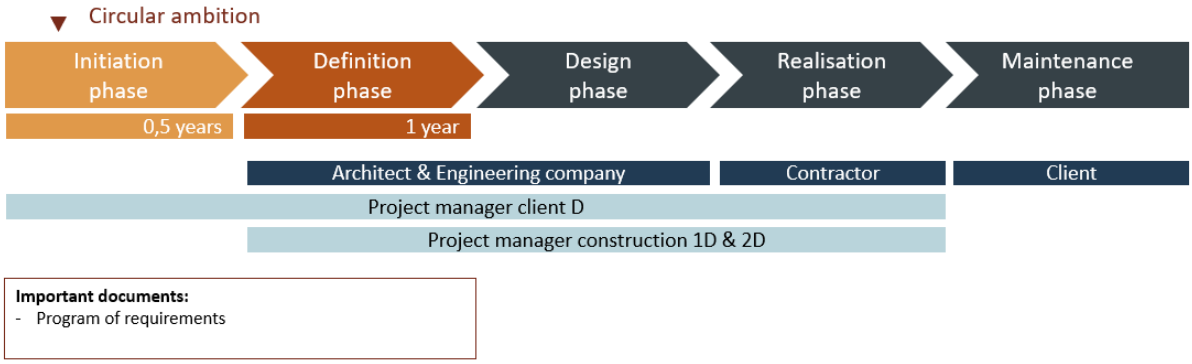


Figure L. 5 – Process project D = Figure 4.11

Role of the project manager
The role of the construction project managers was to relieve and support the client's project manager. Project manager client D says (*Appendix I*): 'In the future, a project like this should be less of a trial. Certainly if project managers and other parties have more knowledge'.

Involved stakeholders
In the initiation phase, there was a project manager client D who had contact with the users and set up the project. In the definition phase, an architect was connected for aesthetics and an engineering company for the construction, installation and building project management aspects.

Organisation chart

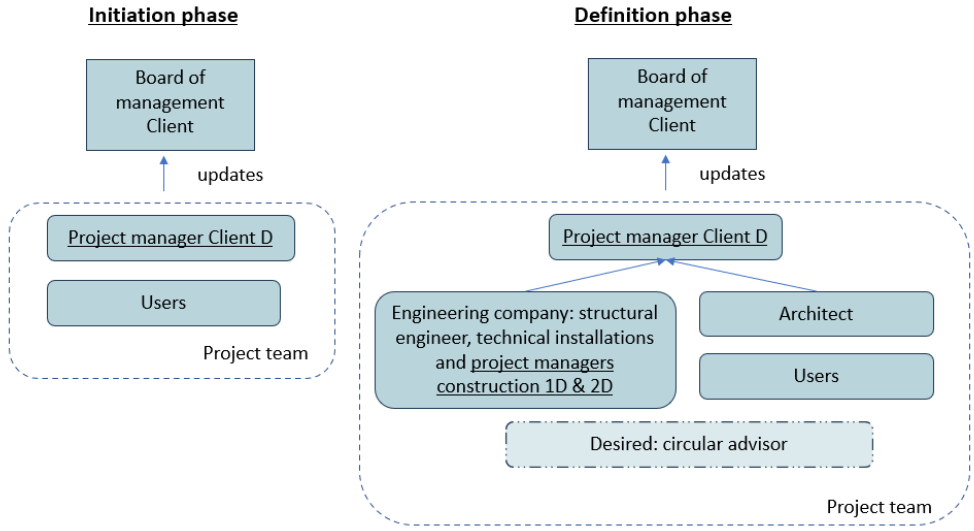


Figure L. 6 - Organisation chart project D = Figure 4.12

Circular ambition

At the start of this project, a circular ambition was expressed by the client. No ambition document was made for the project and no selection of parties was based on available circular knowledge.
As discussed above, circular construction is still more expensive than using new materials. Project manager construction 1D (*Appendix I*) said: 'using a circular approach gives the client a reputation, a faster construction time when using wooden materials and the residual value of the building is higher at the end of its lifetime.' In this project, money has been used from other financing budgets. Project manager construction 2D (*Appendix I*) stated that using money from other budgets is not always possible, certainly not with private clients.
Project manager construction 1D (*Appendix I*) said: 'Including the maintenance phase is part of a circular approach, but it was not applied in this project. If the maintenance phase was included, other choices would have been made regarding to materials in the design and realisation phases. However, this does mean that you will be asking a different type of contractor, one that has a maintenance branch. My experience is that clients do not want to be attached to parties for so many years'. In addition, a circular approach also entails barriers. For example, A guarantee certificate has to be obtained for reused materials with constructive purposes. In order to have project information, it is used to make a digital twin, according to project manager construction 2D (*Appendix I*). A digital twin was also made in this project.

Project manager construction 2D (*Appendix I*) stated that 'It must be clear what is meant by circularity. An ambition has to be defined early in a project and should not only be defined by the design team. Ideally, a circular advisor would have been added to the project team, who could oversee the various choices and give advice to the project team.' In addition, the project managers construction 1D and 2D indicated that time is needed in projects to reflect on the choices and to ask yourself whether the highest achievable is being realised.

Summary of project D

The project concerns a new building to be constructed. Project D has a circular ambition from the start but leaves the options and the definition for a circular approach to the market parties. In the initiation phase, the client performs the project management and, from the definition phase, this is assigned to the engineering firm. An architect is also contracted to the client. In this project, an independent expert in the field of circularity was desired. In addition, this project with circular aspects proved to be 15% more expensive than traditional construction.

Project E

Project Generic

The project includes the realisation of a new pavilion for the purpose of sharing knowledge about circularity, to accommodate meetings and a catering facility. The client is active in the financial sector. The project is part of the (semi-)circular projects.

Project Specific

Initiation and definition phase

Initiation phase

The client has owned the land since the last century. And since then, the architect has also been assigned to the plan. The pavilion was not an attractive investment from a real estate point of view, and was therefore temporarily postponed. After new plans of the municipality to improve the area around the project and make it more attractive, the initiative of the new pavilion continued. Two employees of the client were assigned to the project to devise a plan together with the same architect assigned to the project and some technical advisors. The project management was conducted by the architect and the two employees of the client. Several different plans and the need for meeting rooms led to the idea of a pavilion for receiving guests, organising events and having meetings.

Definition phase 1

In the definition phase, various project documents were drawn up, including the program of requirements and an ambition document. There was a sustainability ambition whereby the project would have to be BREEAM, WELL and LEED certified. In order to guarantee the sustainability ambitions, a sustainability advisor was engaged.

Definition phase 2

During an advanced design phase, the project was interrupted by the employees of the client's organisation who performed the project management. The original plans led to a standard new-build project with a few sustainable techniques, which was not what the client wanted. At that time, the basement floor of the project had already been poured in concrete. The client wanted a fully sustainable building, but did not know what this exactly meant and how this would be achieved. The project returned to the definition phase to agree on the level of circularity and reformulate the project objectives. The architect introduced a new plan in terms of the use of materials, the use of renewable materials and the inclusion of detachability. This radically different concept was appreciated by the client and the project was developed on this basis. The organisation of the sustainability advisor also helped with the central project management from the second definition phase onwards. In the second definition phase (and the phases that followed), various parties were dismissed because they did not support the choices or did not fully commit to a circular approach. The other parties that remained, provided feedback on the requirements set, discussed the consequences and provided opportunities for materials. Furthermore, the established requirements were revised, especially for the disciplines of installations and climate comfort. The requirements were described as ambitions, in order to examine together with the team how the ambitions could be achieved. The ambitions allowed the project team to discuss each choice with the various stakeholders and it stimulated generating ideas. The circular project manager E (*Appendix I*) adds: 'The market parties know very well what they can make and what effect it will have on the project. Formulating requirement and describing desired effects, will limit the options of the market parties. If a solution or idea of a market party is limited by a set requirement, then the team need to determine whether that requirement is very important. If the requirement is more important than the other ideas it is formulated well, if not, then the requirement have to be adjusted.'

Progress of the project
During the second definition phase, most of the design and realisation parties were already present. These parties were also attending the design phase.
Circularity is also implemented in the maintenance phase, since there is limited energy and waste may not be produced. However, no exploitation funds were made available in the definition phase for the maintenance phase. The project team set ambitions for the maintenance phase and each choice in the design and realisation phases were considered in terms of circularity and maintenance.

Project management
Within this project, sharing the interest of all parties was very important to understand certain choices and each other's perspectives. The majority of risks still remained with the client and the normal risks, which usually belong to the contractor, were also adopted by the client to encourage the circular approach. The project was managed on the aspects of money, time and quality. However, the project manager does indicate that a circular project involves new facets and additional tasks for the project manager. Hereby is meant for example new contract forms, additional stakeholders and digitalisation. Eventually, the ambition for a circular project is supported by the entire project team and organisation of the client.

Planning
The initiation phase had a duration of 12 years. The first definition phase took two years, followed by the design phase, which had also a duration of two years. After the first design phase, the project was temporarily paused for 3-4 months, after which the second definition phase took another six months.

Budget
The project cost 23 million and was about 25% more expensive than if it had been built traditionally. The project had to fulfil the ambitions and credibility of the client. As a result, new products were made and techniques were used that were not accustomed, making this project expensive. For the extra money needed, a request was made for learning funds. In addition, this project explored the financing option of product as a service. However, this option was difficult to apply because it was not yet available for all products and it was difficult to determine the residual value. The product as a service concept is used for the elevator facilities in the building.

Procurement
The award criteria for selecting a party was based on circularity, social involvement, financial considerations, sustainability and detachability. For each discipline, a party was chosen that qualified for the criteria.

Form of contract
The architect was involved as the in-house architect. The contractor had a traditional contract with an emphasis on circularity and had been there since the first track. Other parties had contracts in which circularity was prioritised.

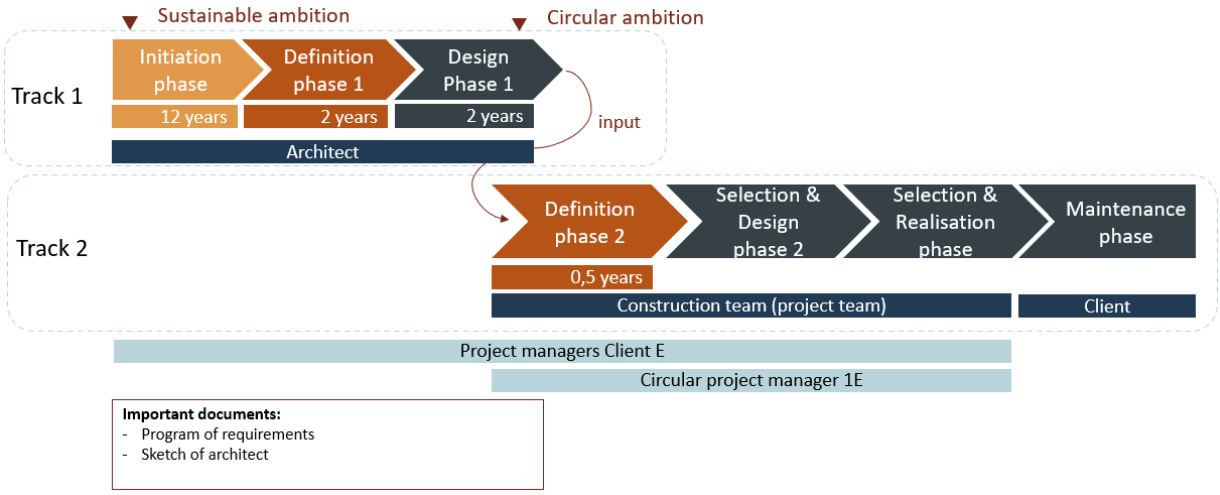


Figure L. 7 - Process project E = Figure 4.13

Role of the project manager

The role of the project managers in track 1 was to manage a project on time, quality and money with a focus on formulating the programme of requirements and integrating sustainability. In track 2, a circular project manager was appointed to identify and achieve the circular ambitions. Circular project manager A (*Appendix I*) indicates that there must be support from the client for a circular approach and that this can be created by the project manager or someone else from the project team. However, a project manager should always have the ambition to realise the highest achievable circularity within the client's conditions. In addition, a project manager will have to be critical towards a client; should ask what the requirements and constraints of the project are, ask why those requirements exist, and should realise and explain to the client that if the requirement is shifted, what the effect will be. The project manager should take the lead in the transition to circular projects.

Involved stakeholders

In track 1, four people from the client's real estate team were involved in the project team. The architect and other advisors were also present during the initiation phase. In the definition phase, the project team was supplemented with users and a sustainability advisor. During the definition phase of track 2, the contractor, suppliers and circular advisors joined the project team. A team member was also appointed to reflect the choices and the work results of the team. Furthermore, the reflection also consisted of asking questions concerning the achievements in terms of circularity and sustainability. The client provided several project managers for this project. In addition, an external party has been involved to help to achieve the maximum circular and sustainable project. In track 2, the circular project manager contributed with ideas about measuring circularity in the project, how parties would be challenged and reviewed the requirements of the project.

Organisation chart

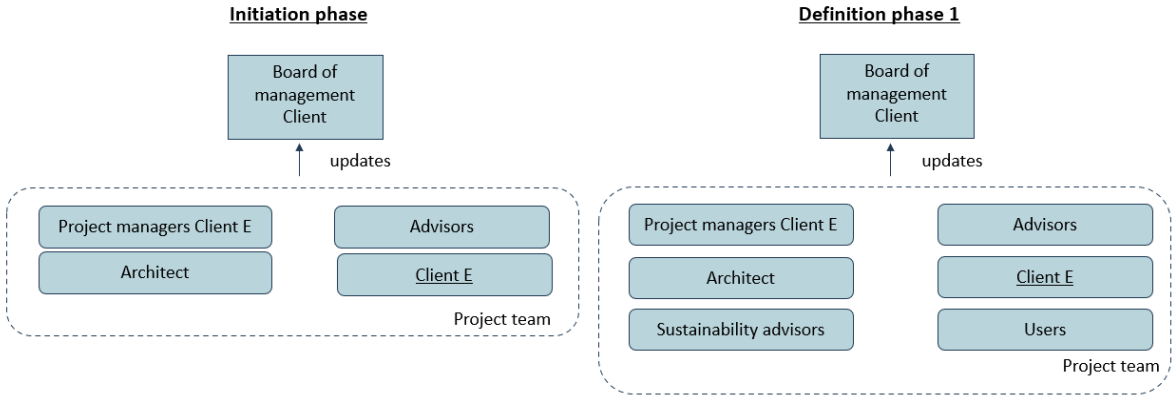


Figure L. 8 - Organisation chart 1 Project E = Figure 4.14

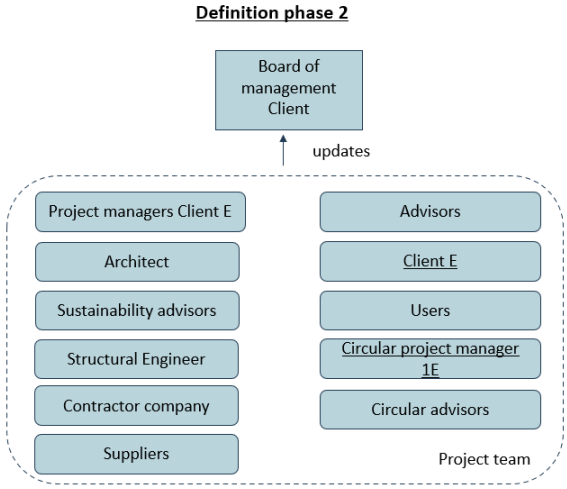


Figure L. 9 - Organisation chart 2 Project E = Figure 4.15

Circular ambition

The circular ambition was suggested by the architect after track 1 resulted in a relatively normal traditional new-build project with sustainability ambitions but, according to the client, not the kind of sustainability they had in mind. The client sees the urgency of the climate problem and wants to be an example to its clients where a building with standard sustainable solutions would not suffice. The project was awarded with a BREEAM outstanding certificate. The stakeholders involved were more familiar with sustainability in terms of energy and CO2 neutrality than circularity, as this was a new subject. As a result, the project became a quest to achieve the maximum feasible circular project. The motto of the project was 'right to copy', as everyone had the right to learn from it and to inspire others. Track 1 provided some preconditions for track 2 in terms of circularity, such as the concrete foundation and the basement of the building. This means that the building is not 100% circular, but the other materials used are demountable and remountable. The used materials has been recorded in a materials passport. During the project, use was made of the 10R model to measure circularity and weigh materials; other measuring methods were not yet in use. The first ladder of the 10R model was therefore very important, so that nothing was made that was not necessary. In addition, the focus was on BREEAM and a number of WELL's focus points were used. With each choice for a material, the questions were asked: using renewable materials, using dismountable connections and does a person feel comfortable with this material/building. The project team consisted of members who could think out of the box. At the time of developing and constructing the project, circularity was still a relatively unknown issue. Creativity and knowledge of the team was important. There was also a team member

who was responsible for the reflection of the team, asking critical questions and keeping the team focussed for a better circular result.

Summary of project E

The project concerns a new building to be constructed. During an advanced design phase, the project was interrupted because the client's sustainability ambitions were not being met. At that time, some parts of the building had already been realised. The project entered the definition phase again, in which the circular ambitions were formulated and the schedule of requirements was revised. A circular project manager was appointed to ensure the realisation of the circular ambitions. Various designing and executing parties were already present from traject 1 and they were also involved during traject 2. In addition, a team member was added who encouraged the team to reflect and the project team consisted of participants who could think out-of-the-box. The project was 25% more expensive than originally budgeted and was also delayed because phases had to be repeated.

Project F

Project Generic

The project involves the realisation of a new sheltered work place for 500 people, merging two old existing locations into one new location. The client is the municipality.

Project Specific

Initiation and definition phase

Initiation phase

The municipality determines that the buildings of the sheltered work places are outdated and no longer comply with laws and regulations. A project manager from the municipality is appointed (project manager client 1F). This project manager conducted a location study and draws up a global programme of requirements. The municipality determines that a new building should be built at a new location and the municipal council gives its approval, after which money is released for the project.

Definition phase

During the definition phase, the project manager client 1F is replaced by project manager client 2F. This second project manager updated the programme of requirements and linked it to a financial framework. Subsequently, a tender was published for a party that could help formulate the schedule of requirements, supervise the tendering procedure and supervise the realisationphase. This resulted in a project manager construction F. The project manager construction F helped to draw up a spatial plan, to conduct a volume study, developed a sketch and formulated the programme of requirements. At a late stage in the definition phase, a employee of the municipality informed the project team that circularity was a high priority issue for the municipality. Due to a lack of time, the decision was made to include this ambition in the selection specifications and to challenge the market to offer the best circular approach within the traditional budget. The ambition to create an energy-neutral building was present from the start of the project.

Progress of the project

After the definition phase, a selection phase started for a party that could design, realise and maintain the project. In the selection phase, two specifications document were shared: a document with product requirements and a document with process requirements. These requirements did not include any specific circular requirement but asked for a low GPR-score. A conscious decision was made to not involve the contractor in the definition phase.

Project management
The municipality provides the requirements in terms of budget and planning. The construction project manager manages the project in terms of time, quality and money.

Planning
The initiation phase had a duration of two years and the definition phase took one and a half years. During the definition phase, the project was halted for six months due to financing issues. From the start, there has been a time pressure on the project, since there is a political interest in moving the users as quickly and as well as possible.

Budget
The construction budget for the project is 30 million. 26.5 million has been reserved for the realisation of the project. The remaining costs are for the consultancy fees and the purchase of the land. A further 6 million has been reserved for the first 20 years of maintenance. It is not possible to include the maintenance budget in the realisation budget. No extra money was available for circularity at the end of the definition phase. In subsequent projects, this would have to be included earlier in the intial phases. Conversely, it has yet to be proven that circular construction is more expensive if this procurement strategy is used, said project manager construction F (*Appendix I*).

Procurement
First of all, a tender took place for a construction project manager. After the definition phase, a selection phase took place for a designing and contracting party. This was a European tender. During the selection of the designing and contracting party, a fictional discount was used. This is an incentive for the contractor to offer as much as possible within the budget of the project. In the tender specifications, circularity is mentioned separately in the sustainability section. When assessing sustainability, the following topics were mentioned: origin of raw materials, use of materials, inclusion of circularity in the management phase and the method of registering raw materials in a materials passport. The award criteria were determined together with a circular advisor.

Form of contract
A design, build and maintain contract has been chosen. This is a UAC-ic contract form. The maintenance was also tendered for a period of 20 years.

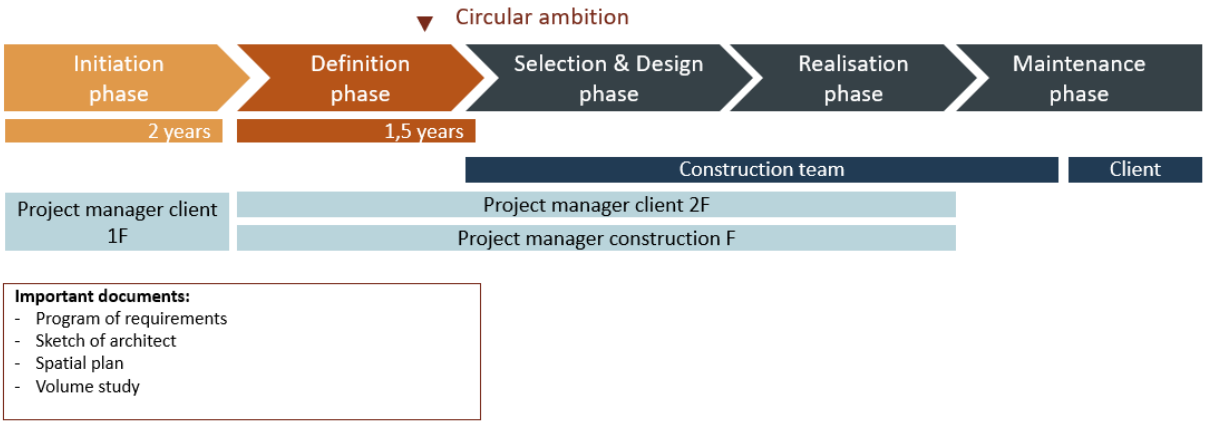


Figure L. 10 - Process project F = Figure 4.16

Role of the project manager
The role of the project manager construction F is to relieve the project manager client 2F of tasks and to advise proactively. In addition, the project manager construction F is responsible for the

programme of requirements, supervision of tenders and supervision of execution. The client project manager is responsible for communication between users, the municipality and the project team.

Involved stakeholders
The client's project manager, the municipality, consultants and managers of the users are involved in the initiation phase. In the definition phase, the client's project manager changes, a construction project manager is added and advisors from the company of the construction project manager were added.

Organisation chart

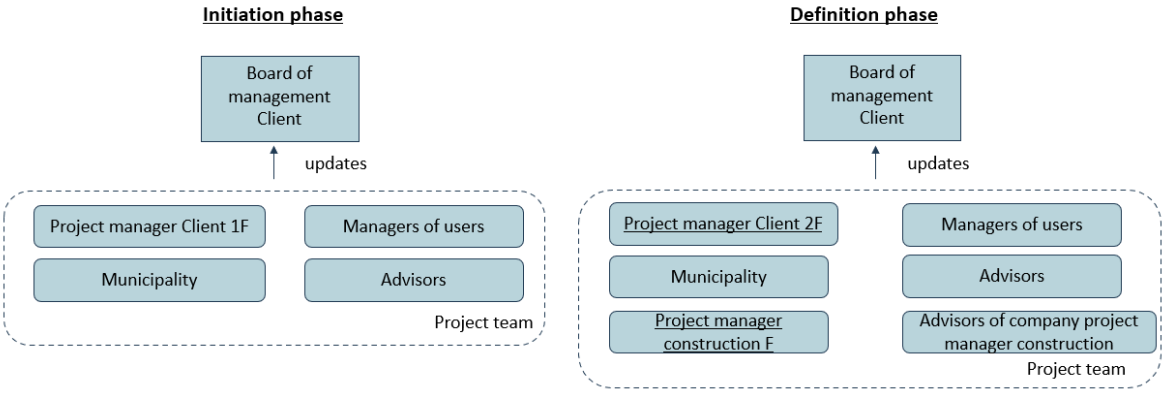


Figure L. 11 - Organisation chart project F = Figure 4.17

Circular ambition
At the end of the definition phase, a circular ambition was added to the project. Because of time constraints, no circular requirements were drawn up and it was up to the market parties to offer what was possible within the set budget. This choice was based on the fact that there was insufficient time to fully define circularity and the idea that the market knows better what is possible than the project team. Project manager client 2F (*Appendix I*) stated: 'If you don't know what you want, use the market. Furthermore, if there had been less pressure on the planning, the strategy would have been the same but the vision and ambition would have been described more clearly.'

Summary of project E
The project concerns a new building for the municipality. The project was started traditionally and a circular ambition emerged at the end of the definition phase. Due to time constraints, the ambition was not further elaborated in the programme of requirements. The market parties were challenged to achieve the highest possible circularity in the project within the set traditional budget constraints.

Appendix M - Input data for Fuzzy Delphi method and end result

The table below shows the input data for the Fuzzy Delphi method. The fifth and sixth column indicate where the success factor originates. Whereby L = literature and RR = research results. The last two columns indicate whether the success factor has been accepted in the assessment with the Fuzzy Delphi Method and the rank of the success factor.

No. SF	Main category	Sub-category	Success factor	L	RR	Result	Rank
1	Project preparation	Ambition	There is a circular ambition and vision from the client		X	accepted	1
2	Project preparation	Ambition	An ambition document has been drawn up for the project		X	accepted	12
3	Project preparation	Ambition	Circular ambitions are inventoried, formulated and translated into project objectives as soon as possible	X	X	accepted	3
4	Project preparation	Ambition	The client is made aware of his possible (circular) ambitions and the new developments in the market		X	rejected	35
5	Project preparation	Objectives	Circularity is an additional objective within the project		X	rejected	63
6	Project preparation	Objectives	Circular objectives are formulated in a way that is achievable and measurable	X	X	rejected	28
7	Project preparation	Approach project preparation	The concept of circularity is defined and documented in the project	X	X	rejected	51
8	Project preparation	Approach project preparation	Circular project requirements are formulated by the entire project team	X	X	rejected	32
9	Project preparation	Approach project preparation	Circular project requirements will be drawn up	X	X	accepted	6
10	Project preparation	Approach project preparation	Support for a circular approach from the client ensures a circular outcome at project level	X	X	accepted	17
11	Project preparation	Approach project preparation	Additional time will be reserved for setting ambitions, drawing up an ambition document and formulating objectives		X	accepted	14
12	Project preparation	role project manager	The project manager should initiate a conversation with the client about the circular ambitions and the possibility of integrating circularity in their projects		X	rejected	40
13	Project preparation	role project manager	The project manager should question the client whether the project can be connected to (other)		X	accepted	19

			existing circular/sustainability ambitions of the company				
14	Project preparation	role project manager	The project manager should be able to explain to the client what the consequences of a circular approach are in relation to the project		X	accepted	20
15	Project preparation	role project manager	The project manager has to create awareness and support from the client for a circular approach towards the project		X	rejected	33
16	Project management	Approach project management	The circular objective is outlined on the horizon and divided into small steps. After every step, it is evaluated and follow-up steps are considered		X	rejected	37
17	Project management	Approach project management	All phases in which the building is involved are included in the project; both the construction phases from initiation to realisation and the subsequent maintain and disassembly phases		X	accepted	21
18	Project management	Approach project management	A circular approach also includes a circular service; come up with a solution from the beginning, provide a solution and remain involved during the lifecycle so that solutions remain as optimal as possible		X	rejected	38
19	Project management	Approach project management	The project collects pre- and post-information on design and demolition process	X	X	rejected	58
20	Project management	Approach project management	Opportunity cards will be made about circular ideas and opportunities in the area that can be linked to the project		X	rejected	43
21	Project management	Approach project management	Sustainability/circularity is managed	X	X	rejected	30
22	Project management	Approach project management	A market consultation will be held to test the circular requirements and ambitions		X	rejected	62
23	Project management	Approach project management	Attention is paid to ensure that an interactive process can be created in the design and realisation phase	X	X	rejected	53
24	Project management	Approach project management	In a project the focus is on what is close to the scope and within reach of the project	X	X	rejected	44

25	Project management	Approach project management	Client must be challenged to innovate, this is not only the task for market parties/stakeholders in a circular approach		X	rejected	54
26	Project management	Procurement	In the project agreements are made (with new contract forms) so that materials do not end up as waste	X		accepted	15
27	Project management	Management	Project information is shared efficiently and transparently so that information does not get lost and the idea does not have to be reinvented	X		accepted	18
28	Project management	Management	The project / project team is flexible to review requirements in subsequent phases		X	rejected	47
29	Project management	Management	Clients take more risks to stimulate innovation and creativity	X	X	rejected	61
30	Project management	Management	Stakeholders are abandoning their standard approaches and routines and taking more risks	X	X	rejected	56
31	Project management	Management	Examples of other circular projects are used to inspire, to show that circularity can also be accessible and that not everything has to be applied at once		X	accepted	5
32	Project management	Management	There is knowledge of the existing legislation and regulations in the field of circularity and circular solutions are examined within these boundaries	X	X	rejected	55
33	Project management	Management	Time for reflection is included in the process to evaluate the project, to reflect on the team members, to inspire each other and to challenge each other whether the ideas can be made even more sustainable and efficient		X	accepted	27
34	Project management	Management	Projects are digitized by means of BIM, a digital twin or a materials passport		X	accepted	23
35	Project management	Project team	The project team uses non-hierarchical organisational structures	X		rejected	66
36	Project management	Project team	The project team includes people who can think out-of-the-box		X	accepted	11
37	Project management	Project team	Conditions to collaborate in a project are facilitated	X	X	accepted	26
38	Project management	Project team	The project team has knowledge of the concept of circularity		X	accepted	7

39	Project management	Project team	The project team understands each other and the members share the same circular goals, vision and philosophy	X	X	accepted	13
40	Project management	Project team	Trust is the basic principle between the client and the contracted party, but a contract remains necessary		X	rejected	60
41	Project management	Project team	All the interests of all parties are shared and there is an understanding of certain choices and points of view	X		rejected	48
42	Project management	Project team	All stakeholders involved in the project are motivated, both at company and personal level, to organise the project in a circular way	X	X	accepted	22
43	Project management	Project team	An external party joins the project team that has knowledge of circularity, can ensure the knowledge and can tell what is currently the highest achievable in the market		X	rejected	34
44	Project management	Project team	Increasing cooperation with new, multidisciplinary and international teams		X	rejected	64
45	Project management	Project team	There is a transparent cooperation with involved parties in order to promote the development of new concepts and sustainable collaborations	X	X	rejected	42
46	Project management	Project team	There is confidence in the market and opportunity for innovation in the process		X	rejected	45
47	Project management	Project team	In addition to the scope of the building, the project team is also investigating possibilities for connecting the project to circular ideas of the area		X	rejected	39
48	Project management	Project team	Client participates in the project team	X	X	rejected	49
49	Project management	Budget	On top of a traditional budget estimation, 10-15% is added for a circular approach		X	rejected	36
50	Project management	Budget	An inventory is made of additional financial resources at the client's organisation for sustainable/circular alternatives (such as tuition fees, sustainability budget)		X	accepted	24
51	Project management	Budget	The budget of the project is managed in a transparent way	X		rejected	59

52	Project management	Budget	The residual value of materials/the building is included in the budget if it can be deducted from the investment		X	rejected	31
53	Project management	Procurement	The market is involved in the process during initiation and/or definition phase	X	X	rejected	41
54	Project management	Procurement	A construction team will be integrated in the early phases of the project, based on trust, intended cooperation and suggested approach rather than money and quality	X	X	rejected	29
55	Project management	Procurement	Circularity must be clearly formulated in invitations to tender	X	X	accepted	8
56	Project management	Procurement	Tendering for market parties early in the project ((end of) definition phase)	X	X	rejected	57
57	Project management	Procurement	Select stakeholders with the entire project team	X		rejected	65
58	Project management	Procurement	The concept of circularity is included in selection criteria	X	X	accepted	9
59	Project management	Procurement	Selecting market parties on the basis of a competitive dialogue and assessing the proposed approach of them	X	X	rejected	50
60	Project management	Role project manager	Project manager has basic knowledge of the concept of circularity, understands the concept of a circular economy, is able to involve an advisor when necessary and can translate the knowledge into his own projects		X	accepted	4
61	Project management	Role project manager	Project manager knows that circularity can be a challenge for the client	X	X	accepted	25
62	Project management	Role project manager	Project manager has the courage to change, is curious about the concept of circularity, wants to try out new techniques and sees the urgency of a transition to a circular economy		X	accepted	10
63	Project management	Role project manager	Circularity is always an ambition of the project manager within the established requirements of the client		X	rejected	46
64	Project management	Role project manager	The project manager is critical towards the client and discusses the established requirements of		X	accepted	16

			the project and asks why these requirements exists				
65	Project management	Role project manager	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach		X	accepted	2
66	Project management	Role project manager	The project manager starts defining a process model for the project instead of drawing up a programme of requirements	X		rejected	52

Appendix N – Questionnaire Fuzzy Delphi method

Questionnaire of the Fuzzy Delphi method

Beste respondent,

Ik wil u alvast heel erg bedanken voor de tijd en moeite die u neemt om deze enquête in te vullen.

Deze enquête is onderdeel van mijn afstudeeronderzoek. Ik doe onderzoek naar hoe de vaardigheden van projectmanagers vergroot kan worden op het gebied van circulariteit en hoe circulariteit het beste geïntegreerd kan worden in bouwprojecten tijdens de initiatie- en definitiefase door de projectmanager.
Met verschillende methodes zoals het houden van interviews, projecten analyseren en een literatuurstudie heb ik succesfactoren geïdentificeerd. Een succesfactor omschrijf ik als een factor die positief bijdraagt aan het realiseren van circulaire projecten.

Het doel van deze enquête is om de gevonden succesfactoren te beoordelen.

De verzamelde gegevens worden anoniem geanalyseerd en alleen gebruikt voor onderzoeksdoeleinden. Bovendien is uw deelname volledig vrijwillig. Het invullen van de vragenlijst duurt 20-30 minuten.

Wanneer u nog vragen heeft of moeilijkheden ondervindt, kunt u contact opnemen via de mail of mij bereiken op 06-46498324

Alvast heel erg bedankt,

Met vriendelijke groet,
Jeanine Tobben

volgende pagina

9%

1. Zou u willen aangeven tot welke groep u behoort?

- [ ] Groep 1
- [ ] Groep 2

volgende pagina

18%

Uitleg over de enquête:

Uit de literatuur, afgenomen interviews en geanalyseerde cases heb ik 66 succesfactoren geïdentificeerd die positief bijdragen aan het realiseren van circulaire projecten in de initiatie- en definitiefase.

Deze succesfactoren wil ik laten beoordelen door u.
Ik wil u dan ook vragen om te bepalen per factor hoe succesvol u de factor acht op het gebied van circulariteit en/of de mogelijkheid om de factor te kunnen integreren in het project.
Het beoordelen is nodig om de projectmanagers een compacte lijst te geven met succesfactoren waarmee het meeste effect wordt bereikt om de transitie te kunnen maken naar circulaire projecten.

De factoren zijn opgedeeld in twee categorieën: project formuleren (deel 1) en projectmanagement (deel 2).
Per deel zijn er verschillende pagina's met factoren en in totaal zijn er 8 pagina's.

Het beoordelen van de succesfactoren gebeurt doordat u een keuze moet maken per factor hoe u de succesfactor identificeert. De keuze mogelijkheden zijn 'helemaal niet succesvol', 'niet succesvol', 'neutraal', 'succesvol' en 'erg succesvol'.

Ga bij twijfel uit van het eerste wat u te binnen schiet.

volgende pagina

27%

2. Deel 1.1: Project formulering - ambities/projectdoelstellingen

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
Er is een circulaire ambitie en visie vanuit de opdrachtgever	○	○	○	○	○
Er is een ambitiedocument opgesteld voor het project	○	○	○	○	○
Tijdig worden circulaire ambities geïnventariseerd, geformuleerd en vertaald in projectdoelstellingen.	○	○	○	○	○
De opdrachtgever wordt bewust gemaakt van zijn mogelijk (circulaire) ambities en van de nieuwe ontwikkelingen in de markt	○	○	○	○	○
Circulariteit is een aanvullende doelstelling binnen het project	○	○	○	○	○
Circulaire doelstellingen worden haalbaar geformuleerd zodat ze meetbaar zijn	○	○	○	○	○

volgende pagina

36%

3. Deel 1.2: Project formulering - aanpak/rol projectmanager

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
Het concept circulariteit wordt gedefinieerd en genoteerd in het project	○	○	○	○	○
Circulaire projecteisen worden geformuleerd met het hele projectteam	○	○	○	○	○
Er worden circulaire projecteisen opgesteld	○	○	○	○	○
Draagvlak voor een circulaire aanpak bij de opdrachtgever zorgt voor een circulaire uitkomst op project niveau	○	○	○	○	○
Er wordt meer tijd gereserveerd voor het vaststellen van ambities, opstellen van ambitiedocument en formuleren van doelstellingen	○	○	○	○	○
De projectmanager moet het gesprek met de klant aangaan over de circulaire ambities en de mogelijkheid om circulariteit te integreren in projecten	○	○	○	○	○
De projectmanager moet de opdrachtgever af laten vragen of het project kan aansluiten op (andere) bestaande circulaire/duurzaamheidsambities van het bedrijf	○	○	○	○	○
De projectmanager moet de opdrachtgever kunnen uitleggen wat de gevolgen van een circulaire aanpak is op het project	○	○	○	○	○
De projectmanager moet bewustzijn en draagvlak creëren bij de opdrachtgever voor een circulaire aanpak van het project	○	○	○	○	○

volgende pagina

45%

4. Deel 2.1: Projectmanagement - aanpak

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
Het circulaire doel wordt op de horizon geschetst en in kleine stappen opgedeeld. Na elke genomen stap wordt er geëvalueerd en vervolg stappen bedacht.	○	○	○	○	○
Alle fases waarbij het gebouw betrokken is worden meegenomen in het project; zowel de bouwfases van initiatie- tot realisatiefase en de vervolgfases beheer- en demontagefase	○	○	○	○	○
Bij een circulaire aanpak behoort ook een circulaire dienstverlening; aan de voorkant een oplossing bedenken, de oplossing aanreiken en gedurende de levensfases betrokken blijven zodat oplossingen zo optimaal mogelijk blijven	○	○	○	○	○
In het project wordt voor- en na-informatie verzameld over ontwerp- en slooptraject	○	○	○	○	○
Er worden kansenkaarten gemaakt over circulaire ideeen en mogelijkheden in de omgeving waarmee een koppeling gemaakt kan worden met het project.	○	○	○	○	○

Er wordt gemanaged op duurzaamheid/circulariteit.	○	○	○	○	○
Er wordt een marktconsultatie gehouden om de circulaire eisen en ambities te toetsen	○	○	○	○	○
Er wordt zorg gedragen dat er een interactief proces kan ontstaan in ontwerp- en realisatiefase	○	○	○	○	○
In een project wordt gefocust op wat dicht bij de scope en binnen handbereik van het project ligt	○	○	○	○	○
Opdrachtgever moet uitgedaagd worden om te innoveren, dit is niet alleen de taak voor marktpartijen bij een circulaire aanpak	○	○	○	○	○

volgende pagina

55%

5. Deel 2.2: Projectmanagement - management

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
In het project worden afspraken gemaakt (met nieuwe contractvormen) zodat materialen niet eindigen als afval	○	○	○	○	○
Projectinformatie wordt efficient en transparant gedeeld zodat informatie niet verloren gaat en het wiel niet opnieuw uitgevonden hoeft te worden	○	○	○	○	○
Het project/het projectteam is flexibel om eisen te kunnen herzien in vervolgfases	○	○	○	○	○
Opdrachtgevers nemen meer risico's om innovatie en creativiteit te stimuleren	○	○	○	○	○
Betrokken partijen laten hun standaard aanpak en routines los en nemen meer risico's	○	○	○	○	○
Voorbeelden van andere circulaire projecten worden gebruikt om te inspireren, te laten zien dat circulariteit ook laagdrempelig kan zijn en dat niet alles in één keer toegepast hoeft te worden	○	○	○	○	○
Er is kennis over de bestaande wet- en regelgeving op het gebied van ciruclariteit en er wordt gezocht naar circulaire oplossingen binnen deze gestelde kaders	○	○	○	○	○
Er wordt reflectietijd opgenomen in het proces om het project te evalueren, de teamleden te reflecteren, elkaar te inspireren en elkaar uit te dagen of de ideeën nog duurzamer en efficienter kunnen	○	○	○	○	○
Projecten worden gedigitaliseerd doormiddel van BIM, een digital twin of een materialenpaspoort	○	○	○	○	○

volgende pagina

64%

6. Deel 2.3: Projectmanagement - projectteam

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
In het projectteam wordt gebruik gemaakt van niet-hiërarchische organisatie structuren	○	○	○	○	○
Het projectteam bevat mensen die 'out of the box' kunnen denken	○	○	○	○	○
Condities om samen te werken in een project worden gefaciliteerd.	○	○	○	○	○
Het projectteam heeft kennis van het concept circulariteit	○	○	○	○	○
Het projectteam begrijpt elkaar en de leden hebben dezelfde circulaire doelen voor ogen, dezelfde visie en filosofie	○	○	○	○	○
Vertrouwen is het uitgangspunt tussen opdrachtgever en opdrachtnemer, maar een contract blijft nodig.	○	○	○	○	○
Alle belangen van alle partijen liggen op tafel en er is begrip voor bepaalde keuzes en standpunten	○	○	○	○	○
Alle betrokkenen van het project zijn gemotiveerd, zowel op bedrijfsniveau als persoonlijk niveau, om het project circulair in te richten	○	○	○	○	○

Een externe betrokkene sluit aan in het projectteam die kennis heeft van circulariteit, de kennis kan borgen en kan vertellen wat momenteel het hoogst haalbare is in de markt	○	○	○	○	○
Er wordt meer samengewerkt met nieuwe, multidisciplinaire en internationale teams	○	○	○	○	○
Er wordt transparant samengewerkt met betrokken partijen om de ontwikkeling van nieuwe concepten en duurzame samenwerkingen te bevorderen	○	○	○	○	○
Er is vertouwen in de markt en ruimte in het proces voor innovatie	○	○	○	○	○
Projectteam kijkt naast de scope van het gebouw ook naar mogelijkheden voor aansluiting op circulaire ideeën van het gebied	○	○	○	○	○
Opdrachtgever neemt plaats in het projectteam	○	○	○	○	○

volgende pagina

73%

7. Deel 2.4: Projectmanagement - budget

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
Bovenop een traditionele budgetraming wordt 10-15% toegevoegd voor een circulaire aanpak	○	○	○	○	○
Er wordt geïnventariseerd naar extra financiele middelen bij de opdrachtgever voor duurzame/circulaire alternatieven (zoals leergeld, duurzaamheidbudget)	○	○	○	○	○
Er wordt transparant gewerkt met het budget van het project	○	○	○	○	○
De restwaarde van materialen/het gebouw wordt meegenomen in het budget als dit afgetrokken kan worden van de investering	○	○	○	○	○

volgende pagina

82%

8. Deel 2.5: Projectmanagement - aanbesteding

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
De markt wordt betrokken in het proces tijdens initiatie en/of definitiefase	○	○	○	○	○
Er wordt een bouwteam geïntegreerd in de beginfase van het project, gebaseerd op vertrouwen, beoogde samenwerking en aanpak in plaats van geld en kwaliteit	○	○	○	○	○
Circulariteit moet duidelijk geformuleerd worden in uitvragen een aanbestedingen	○	○	○	○	○
Aanbesteding voor marktpartijen vroeg in het project ((einde)definitiefase) laten plaatsvinden	○	○	○	○	○
Selecteer betrokken partijen met het gehele projectteam	○	○	○	○	○
In selectiecriteria wordt het component circulariteit meegenomen	○	○	○	○	○
Marktpartijen selecteren aan de hand van een concurrentiegericht dialoog en beoordelen op de voorgestelde aanpak van marktpartijen	○	○	○	○	○

volgende pagina

91%

9. Deel 2.6: Projectmanagement - rol projectmanager

Succesfactoren dragen positief bij aan het realiseren van circulaire projecten en zouden toegepast moeten/kunnen worden in de initiatie- en definitiefase.

Beoordeel de volgende succesfactor

	1. Helemaal niet succesvol	2. Niet succesvol	3. Neutraal	4. Succesvol	5. Erg succesvol
Projectmanager heeft basiskennis over het concept circulariteit, snapt het concept van een circulaire economie, weet een adviseur te kunnen inschakelen wanneer dat nodig is en kan de kennis vertalen naar zijn eigen projecten	○	○	○	○	○
Projectmanager weet dat circulariteit mogelijk een uitdaging is voor de opdrachtgever	○	○	○	○	○
Projectmanager durft te veranderen, is nieuwsgierig naar het concept circulariteit, wil nieuwe technieken uitproberen en ziet de urgentie in van een transitie naar een circulaire economie	○	○	○	○	○
Circulariteit is altijd een ambitie van de projectmanager binnen de gestelde kaders van de opdrachtgever	○	○	○	○	○
De projectmanager is kritisch op de opdrachtgever en bespreekt de gestelde kaders van het project en vraagt waarom die kaders daar liggen	○	○	○	○	○
De projectmanager heeft intrinsieke motivatie en creëert enthousiasme waardoor de opdrachtgever overtuigt wordt voor een circulaire aanpak	○	○	○	○	○
Projectmanager start met het definiëren van een procesmodel voor het project in plaats van het opstellen van programma van eisen	○	○	○	○	○

volgende pagina

100%

Dit is de laatste pagina van deze enquête.
Ik wil u heel hartelijk danken voor het afronden en invullen van de vragenlijst.

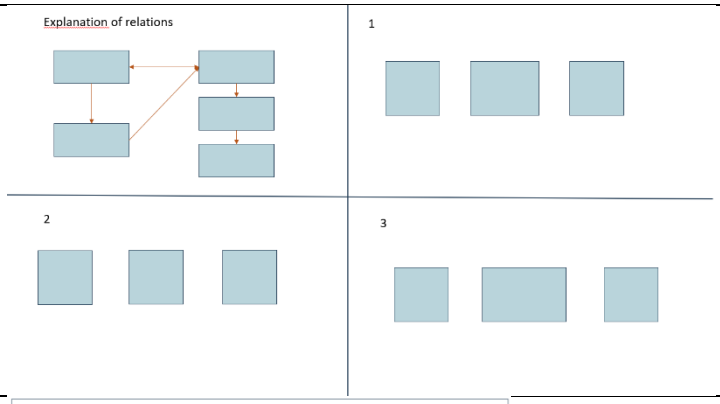
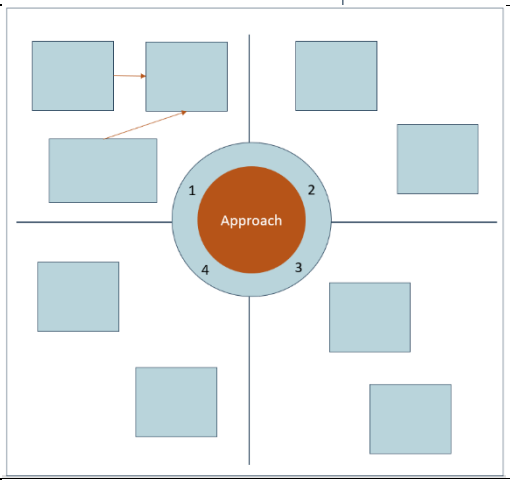
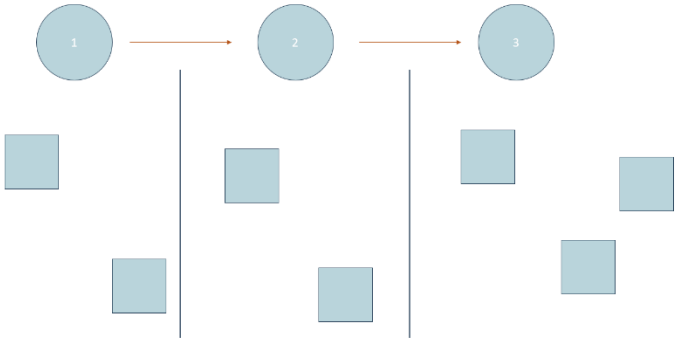
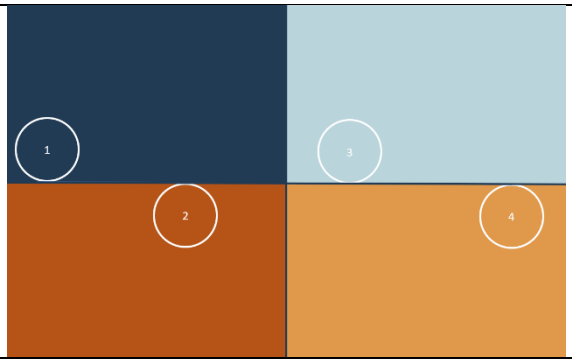
Als u vragen heeft omtrent dit onderzoek, kunt u contact opnemen via de mail: jeanine.tobben@sweco.nl

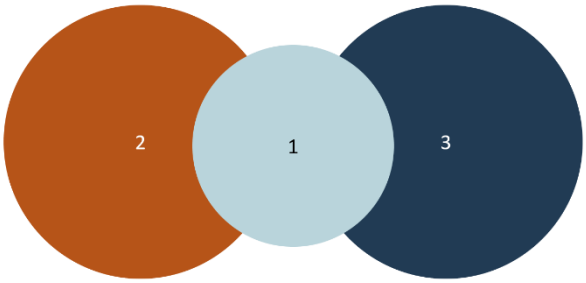
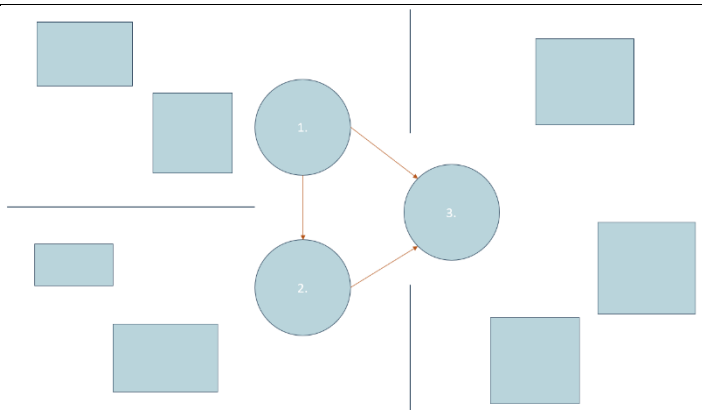
Appendix O – Calculation sheet Fuzzy Delphi method

No. SF	*All respondents*				*Group 1*	*Group 2*	*Group 3*	*Weighting*			
	aj	bj	cj	Sj	Sj	Sj	Sj	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0,250	0,870	1,000	**0,707**	**0,697**	**0,796**	**0,800**	0,752	0,779	0,780	0,7568
2	0,250	0,780	1,000	**0,677**	**0,674**	**0,769**	**0,667**	0,678	0,724	0,696	0,6961
3	0,250	0,850	1,000	**0,700**	**0,788**	**0,796**	**0,667**	0,733	0,759	0,724	0,7428
4	0,000	0,690	1,000	**0,563**	**0,561**	**0,667**	**0,533**	0,556	0,611	0,575	0,5810
5	0,000	0,560	1,000	**0,520**	**0,553**	**0,500**	**0,483**	0,517	0,505	0,501	0,5070
6	0,000	0,740	1,000	**0,580**	**0,598**	**0,583**	**0,617**	0,606	0,595	0,604	0,5935
7	0,000	0,630	1,000	**0,543**	**0,538**	**0,537**	**0,650**	0,590	0,568	0,599	0,5692
8	0,000	0,700	1,000	**0,567**	**0,591**	**0,648**	**0,517**	0,561	0,602	0,566	0,5794
9	0,250	0,800	1,000	**0,683**	**0,689**	**0,694**	**0,650**	0,672	0,681	0,669	0,6712
10	0,000	0,820	1,000	**0,607**	**0,591**	**0,778**	**0,800**	0,702	0,750	0,756	0,7157
11	0,250	0,740	1,000	**0,663**	**0,652**	**0,657**	**0,700**	0,674	0,668	0,680	0,6629
12	0,000	0,670	1,000	**0,557**	**0,621**	**0,657**	**0,567**	0,599	0,626	0,601	0,6089
13	0,250	0,660	1,000	**0,637**	**0,629**	**0,648**	**0,633**	0,632	0,641	0,637	0,6304
14	0,000	0,770	1,000	**0,590**	**0,682**	**0,676**	**0,567**	0,628	0,647	0,617	0,6351
15	0,000	0,700	1,000	**0,567**	**0,652**	**0,565**	**0,567**	0,606	0,581	0,582	0,5884
16	0,000	0,680	1,000	**0,560**	**0,659**	**0,546**	**0,550**	0,600	0,568	0,569	0,5793
17	0,000	0,760	1,000	**0,587**	**0,682**	**0,565**	**0,683**	0,674	0,618	0,651	0,6369
18	0,000	0,680	1,000	**0,560**	**0,659**	**0,546**	**0,550**	0,600	0,568	0,569	0,5793
19	0,000	0,600	1,000	**0,533**	**0,538**	**0,519**	**0,633**	0,580	0,553	0,585	0,5576
20	0,000	0,660	1,000	**0,553**	**0,652**	**0,648**	**0,500**	0,581	0,608	0,568	0,5939
21	0,000	0,720	1,000	**0,573**	**0,583**	**0,556**	**0,667**	0,620	0,591	0,621	0,5958
22	0,000	0,570	1,000	**0,523**	**0,508**	**0,528**	**0,633**	0,567	0,553	0,582	0,5507
23	0,000	0,620	1,000	**0,540**	**0,523**	**0,556**	**0,633**	0,576	0,571	0,592	0,5648
24	0,000	0,660	1,000	**0,553**	**0,530**	**0,667**	**0,550**	0,550	0,610	0,578	0,5765
25	0,000	0,620	1,000	**0,540**	**0,515**	**0,556**	**0,567**	0,542	0,551	0,554	0,5403
26	0,250	0,710	1,000	**0,653**	**0,652**	**0,648**	**0,750**	0,697	0,677	0,704	0,6764
27	0,000	0,770	1,000	**0,590**	**0,561**	**0,694**	**0,783**	0,674	0,694	0,719	0,6727
28	0,000	0,650	1,000	**0,550**	**0,545**	**0,537**	**0,667**	0,601	0,574	0,609	0,5772
29	0,000	0,580	1,000	**0,527**	**0,530**	**0,528**	**0,517**	0,524	0,525	0,522	0,5197
30	0,000	0,610	1,000	**0,537**	**0,530**	**0,556**	**0,517**	0,526	0,540	0,530	0,5288
31	0,250	0,820	1,000	**0,690**	**0,682**	**0,806**	**0,650**	0,677	0,741	0,698	0,7053
32	0,000	0,620	1,000	**0,540**	**0,523**	**0,565**	**0,617**	0,569	0,571	0,585	0,5624
33	0,000	0,690	1,000	**0,563**	**0,545**	**0,667**	**0,650**	0,603	0,640	0,636	0,6145
34	0,000	0,740	1,000	**0,580**	**0,561**	**0,676**	**0,683**	0,626	0,657	0,659	0,6336
35	0,000	0,490	1,000	**0,497**	**0,500**	**0,500**	**0,483**	0,492	0,495	0,491	0,4895
36	0,250	0,790	1,000	**0,680**	**0,682**	**0,676**	**0,767**	0,721	0,702	0,726	0,7011
37	0,000	0,700	1,000	**0,567**	**0,553**	**0,565**	**0,767**	0,653	0,618	0,673	0,6219
38	0,250	0,800	1,000	**0,683**	**0,773**	**0,685**	**0,750**	0,756	0,719	0,736	0,7286

39	0,250	0,750	1,000	**0,667**	**0,674**	**0,657**	**0,667**	0,669	0,663	0,666	0,6594
40	0,000	0,590	1,000	**0,530**	**0,538**	**0,528**	**0,517**	0,527	0,527	0,524	0,5222
41	0,000	0,650	1,000	**0,550**	**0,545**	**0,565**	**0,617**	0,580	0,575	0,590	0,5699
42	0,000	0,750	1,000	**0,583**	**0,689**	**0,556**	**0,750**	0,707	0,633	0,686	0,6583
43	0,000	0,700	1,000	**0,567**	**0,553**	**0,583**	**0,567**	0,562	0,573	0,569	0,5620
44	0,000	0,560	1,000	**0,520**	**0,530**	**0,519**	**0,500**	0,515	0,516	0,511	0,5111
45	0,000	0,660	1,000	**0,553**	**0,545**	**0,648**	**0,633**	0,594	0,625	0,621	0,6029
46	0,000	0,660	1,000	**0,553**	**0,568**	**0,537**	**0,633**	0,596	0,569	0,595	0,5737
47	0,000	0,680	1,000	**0,560**	**0,568**	**0,639**	**0,550**	0,565	0,602	0,578	0,5798
48	0,000	0,650	1,000	**0,550**	**0,545**	**0,574**	**0,517**	0,534	0,553	0,538	0,5399
49	0,000	0,690	1,000	**0,563**	**0,576**	**0,519**	**0,700**	0,629	0,578	0,628	0,5921
50	0,000	0,720	1,000	**0,573**	**0,659**	**0,574**	**0,650**	0,648	0,610	0,631	0,6214
51	0,000	0,600	1,000	**0,533**	**0,515**	**0,556**	**0,533**	0,527	0,542	0,536	0,5293
52	0,000	0,710	1,000	**0,570**	**0,682**	**0,574**	**0,500**	0,590	0,573	0,553	0,5794
53	0,000	0,670	1,000	**0,557**	**0,545**	**0,565**	**0,650**	0,595	0,585	0,608	0,5809
54	0,000	0,730	1,000	**0,577**	**0,583**	**0,574**	**0,650**	0,613	0,596	0,617	0,5964
55	0,250	0,800	1,000	**0,683**	**0,697**	**0,676**	**0,667**	0,681	0,677	0,675	0,6731
56	0,000	0,610	1,000	**0,537**	**0,621**	**0,537**	**0,617**	0,613	0,574	0,596	0,5857
57	0,000	0,530	1,000	**0,510**	**0,523**	**0,509**	**0,483**	0,504	0,505	0,498	0,5001
58	0,250	0,800	1,000	**0,683**	**0,682**	**0,685**	**0,683**	0,683	0,684	0,684	0,6766
59	0,000	0,650	1,000	**0,550**	**0,667**	**0,528**	**0,600**	0,625	0,573	0,592	0,5922
60	0,250	0,830	1,000	**0,693**	**0,788**	**0,778**	**0,667**	0,731	0,749	0,719	0,7367
61	0,000	0,720	1,000	**0,573**	**0,561**	**0,676**	**0,650**	0,611	0,648	0,641	0,6226
62	0,250	0,800	1,000	**0,683**	**0,780**	**0,685**	**0,650**	0,713	0,693	0,683	0,6981
63	0,000	0,660	1,000	**0,553**	**0,553**	**0,648**	**0,533**	0,551	0,600	0,568	0,5724
64	0,250	0,700	1,000	**0,650**	**0,652**	**0,648**	**0,650**	0,651	0,649	0,650	0,6434
65	0,250	0,860	1,000	**0,703**	**0,697**	**0,704**	**0,800**	0,745	0,729	0,755	0,7262
66	0,000	0,630	1,000	**0,543**	**0,629**	**0,537**	**0,633**	0,624	0,580	0,606	0,5937

Appendix P – 6 layout sketches for the framework

Nr.	Sketch	Explanation	Comment
1		The explanation of relations and the 3 different steps are presented on 4 different papers. These can be placed together as a puzzle.	As much attention to the explanation of the relationship as to the results of this research
2		The circular idea has been incorporated into the design in the form of a circle.	As much attention to the explanation of the relationship as to the results of this research
3		The relationship between the steps and how the framework works is shown above the information. This resulted in three parts instead with content. This is a linear representation.	The relationship between the different steps is not linear. Step 1 also affects step 3. This is not properly represented here.
4		This is another sketch with a linear visualisation. The explanation gets an own sheet.	Again, as much attention to the explanation of the relationship as to the results of this research

5		The idea of using circles have been shaped in a different way	A waste of space outside the circles where information could also have been posted.
6		The relation between the steps are presented in the middel. It becomes clear that 1 is needed for 2 and 3, and that information is exchanged. It is possible to cut this representation into 3 sheets (2 landscape and 1 portrait) or the whole on 1 sheet.	However, a lot of attention is still paid to general knowledge while this is not what the research is mainly about.

Appendix Q – Success factors concisely

No.	Description	Success factor	Concise for model
1	Ambition	There is a circular ambition and vision from the client	Client has a circular ambition and vision
2	Ambition	An ambition document has been drawn up for the project	Draw up an ambition document
3	Ambition	Circular ambitions are inventoried, formulated and translated into project objectives as soon as possible	Identify and formulate circular ambitions and translate them into project objectives
9	Approach	Circular project requirements will be drawn up	Draw up circular project objectives
10	Approach	Support for a circular approach from the client ensures a circular outcome at project level	Client (including organisation) supports circular approach
11	Approach	Additional time will be reserved for setting ambitions, drawing up an ambition document and formulating objectives	Reserving time for setting ambitions, drafting an ambition document and formulating objectives
13	Role project manager	The project manager should question the client whether the project can be connected to (other) existing circular/sustainability ambitions of the company	Project manager questions the client for possible connections to (other) circular/sustainability ambitions (of the company)
14	Role project manager	The project manager should be able to explain to the client what the consequences of a circular approach are in relation to the project	Project manager explains the consequences of a circular approach for the project to the client

Nr.	Description	Success factor	Concise for model
17	Approach	All phases in which the building is involved are included in the project; both the construction phases from initiation to realisation and the subsequent maintain and disassembly phases	All phases in which the building is involved are included in the project (including management and dismantling phases)
26	Management	In the project agreements are made (with new contract forms) so that materials do not end up as waste	Agreements (and contract forms) ensure that material does not end up as waste
27	Management	Project information is shared efficiently and transparently so that information does not get lost and the idea does not have to be reinvented	By sharing project information efficiently and transparently, information (for follow-up projects) will not be lost
31	Management	Examples of other circular projects are used to inspire, to show that circularity can also be accessible and that not everything has to be applied at once	Circular example projects are used to inspire, demonstrate that circularity can be easily accessible and that not everything has to be applied at once

33	Management	Time for reflection is included in the process to evaluate the project, to reflect on the team members, to inspire each other and to challenge each other whether the ideas can be made even more sustainable and efficient	Reflection time is included in the process to evaluate, to reflect the team members, to inspire and to challenge each other for a different approach
34	Management	Projects are digitized by means of BIM, a digital twin or a materials passport	Project is digitalised (through BIM or material passport)
36	Project team	The project team includes people who can think out-of-the-box	Project team includes members who can think out-of-the-box
37	Project team	Conditions to collaborate in a project are facilitated	Facilitating conditions for cooperation
38	Project team	The project team has knowledge of the concept of circularity	The project team has knowledge of the concept of circularity
39	Project team	The project team understands each other and the members share the same circular goals, vision and philosophy	Project team understands each other and have the same circular goals, vision and philosophy in mind
42	Project team	All stakeholders involved in the project are motivated, both at company and personal level, to organise the project in a circular way	All stakeholders in the project are motivated to adopt a circular approach, both at company and personal level
50	Budget	An inventory is made of additional financial resources at the client's organisation for sustainable/circular alternatives (such as tuition fees, sustainability budget)	Inventory of additional financial resources for a circular approach in the clients' organisation (such as learning money or sustainability budget)
55	Procurement	Circularity must be clearly formulated in invitations to tender	Circularity is clearly formulated in tenders and procurements
58	Procurement	The concept of circularity is included in selection criteria	Circularity is included in selection criteria
60	Role project manager	Project manager has basic knowledge of the concept of circularity, understands the concept of a circular economy, is able to involve an advisor when necessary and can translate the knowledge into his own projects	Project manager has basic knowledge of the concept of circular construction, can translate it into a project and engages a consultant when necessary
61	Role project manager	Project manager knows that circularity can be a challenge for the client	Project manager is aware that circularity can be a challenge for the client
62	Role project manager	Project manager has the courage to change, is curious about the concept of circularity, wants to try out new techniques and sees the urgency of a transition to a circular economy	Project manager dares to change, is curious about the concept of circularity, wants to experiment with new techniques and sees the urgency of a transition to a circular economy
64	Role project manager	The project manager is critical towards the client and discusses the established requirements of the project and asks why these requirements exists	The project manager is critical towards the client, discusses the constraints of the project and asks why the constraints exist

65	Role project manager	The project manager has intrinsic motivation and creates enthusiasm which convinces the client for a circular approach	The project manager is intrinsically motivated and enthusiastic, convincing the client to take a circular approach

Appendix R – Validation document

1

2


Ontwerp eisen voor het framewerk
1. Basis model om de stappen inzichtelijk te maken van een circulaire aanpak en de consequenties voor het project
2. Model te gebruiken om uit te leggen aan opdrachtgever waarom een circulaire aanpak, hoe dit gerealiseerd kan worden en wat een circulaire aanpak betekent voor het project
3. Een model dat zowel door de project manager gebruikt kan worden om de aanpak te bedenken van het project als interactief met de klant om een circulaire aanpak voor het project te bespreken.
4. Checklist wat er in welke fase moet gebeuren en wat aandachtspunten zijn

3


Validatie vragen
Q1. Wat is uw eerste reactie op het model? Kunt u dat uitleggen?
Q2. Voldoet het model aan de ontwerpvoorstellen?
- Basismodel stappen inzichtelijk maken
- Model dat waarom, hoe, wat vragen beantwoord
- Voor projectmanager als interactief met klant
- checklist
Q3. Is het model toepasbaar in een project en zou u het gebruiken?
Q4. Zou u aanpassingen willen maken aan het model?
Q5. Zijn er uitdagingen om het model in een project te implementeren?

4