



# From Circular Ambitions to Circular Projects

A Systems Thinking Approach

Written by  
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# From Circular Ambitions to Circular Projects

A Systems Thinking Approach

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# PREFACE

Before you lies my master thesis – From Circular Ambitions to Circular Projects – A Systems Thinking Approach. It is the result from research into the topic of improving the incorporation of circularity in initiation and definition phase of building projects. This report is the final product for my graduation process for the master Construction Management and Engineering at the Faculty of Civil Engineering and Geosciences at Delft University of Technology.

This study presents several intervention strategies that can be used by project managers to steer towards a better incorporation of client's circular ambitions in the initiation and definition phase. Systems Thinking is used as a methodology and provided valuable insights and a tool for discussion in practice.

In 2017 I started my journey at the TU Delft as a first-year Architecture student. Over the course of the bachelor program a variety of perspectives on the construction sector were offered. My interests changed overtime. However, sustainability, and circularity as a part thereof, have always been of interest to me. In line with this, I followed the minor program Sustainable Development at the Leiden University. This trend continued during my master where I took several elective courses related to sustainability and/or circularity at both the TU Delft and Eindhoven University of Technology. It is therefore only logical that the subject of my master's thesis would relate to sustainability or circularity in the construction sector.

The topic further formed when I started as a graduation intern at Sweco Nederland B.V.. I want to express my gratitude. First to my company supervisor, Jeanine Többen, who was always able to place everything into perspective. Thank you for guiding me in this process and referring me to the right people, so I did not have to struggle with data collection. My sincere thanks to my team manager, Christiaan Voorend, for your never-ending enthusiasm and general interest. And of course, the rest of the team, it meant a lot that you made me feel welcome and I appreciate your involvement.

To continue, I want to express my sincere appreciation to my TU Delft graduation committee. A special thanks to my first supervisor, Quirien Reijtenbagh, who guided me from the early beginning. Thank you for helping me find the right topic and challenging me in the phases thereafter to achieve the best result possible. Leon Hombergen, I would like to thank you for your specific feedback that was always valuable, clear and substantiated. Ad Straub, thank you for your reassuring energy during the progress meeting and the constructive feedback.

I want to thank my family and friends for being there for me during this process and providing the necessary distraction. A heartfelt thank you to my partner, Claudan, who patiently sat with me in times of stress. You helped me overcome the hurdles that I made impossible to overcome myself.

Ending on a personal note, I want to dedicate this thesis to my late grandmother who passed away shortly before my green light. She has been my biggest role model and supporter, always wanting her grandchildren to have a good life, to be happy and healthy. My heart aches realizing I cannot share this moment with you, but I believe you will be there during the rest of this journey.

For you reader, I hope you enjoy reading this thesis.

Faïsha Werners  
June 2024

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# ABSTRACT

Circular procurement has been found unsuccessful in two-thirds of the cases. Literature indicates that Systems Thinking (ST) is required to boost the transition to a circular building sector. This study focuses on the Initiation and Definition (I&D) phase of building projects. Currently several barriers impede the incorporation of circular ambitions in this phase, the study aims to develop a set of intervention strategies that can be used by Project managers (PMS) to overcome the barriers. ST is used and its contribution is evaluated. The research question address is

“How can systems thinking contribute to the development of intervention strategies for the incorporation of circular ambitions in the initiation and definition phase of a building project?”

This is a Research through Design study, in which a Causal Loop Diagram (CLD) reflecting the process of incorporating circular ambition in the I&D phase is developed as an artifact. This CLD is used to gain insights in the dynamics in this process and to formulate intervention strategies.

The study begins with a search into the current barrier to circularity in the I&D phase making use of semi-structured interviews. It commences with the development of the CLD and formulation of intervention strategies in three sessions with a focus group. These results are discussed in semi-structured interviews with practitioners who were not involved in the focus group.

A total of twenty-six barriers were identified. The most cited barriers are the expected higher investment required for circular approaches; current financial models that are not organized for circularity and predetermined budgets that do not consider circularity. In the developed CLD six (6) themes were identified: certainty, knowledge, innovation, budget, materials, and courage. Based on this model eight intervention strategies were formulated.

Five (5) out of the eight (8) intervention strategies are related to knowledge and knowledge sharing, indicating the importance thereof. Although the initial hypothesis suggested that through ST different intervention strategies would be formulated compared to event-based thinking, the findings showed limited differences between the two. However, ST proved valuable in improving the understanding of the dynamics and challenges in incorporating circularity by making mental models explicit and facilitating communication. Key insights highlighted the central role of ‘experience’ in improving the incorporation of circularity in the I&D phase. ST can also be used as a discussion tool among practitioners. It will help to explore circularity and surface underlying problems that impede the uptake of circularity.

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# EXECUTIVE SUMMARY

Every year the demand for ecological resources and services exceeds what the earth can regenerate in a year. The Circular Economy (CE) is seen as a solution to release some of the stress caused by the human population. This is recognized by the Dutch government, who set the ambitious goal to be fully circular by 2050 (Rijksoverheid, 2016). One of the most polluting and resource demanding sectors is the construction industry, therefore it is appointed as one of the priority sectors in the transition. Procurement practices can be used as a powerful tool to boost the circular transition and especially the initiation and definition (I&D) phase of a project have a large impact on the final product. However, circular procurement has been found unsuccessful in a significant share of the cases (Zijp et al., 2022). To deal with the current barriers impeding the uptake of circular procurement, a deeper understanding of the dynamics in the process of incorporating circularity in the I&D phase is needed (Kristensen et al., 2021; Qazi & Appolloni, 2022; Rejeb et al., 2023; Sönnichsen & Clement, 2020). A shift to Systems Thinking (ST) is required to boost the transition (Campbell-Johnston et al., 2019; Kristensen et al., 2021).

In literature various advantages of ST were found. It makes mental models explicit and thereby improves the understanding of the system (Maani & Cavana, 2000; Schwaninger, 2009), it assists users to act in a way that is in the long-term best interest to of the system (Sterman, 2000) and, it helps to explore potential intervention strategies (Schwaninger, 2009; Sterman, 2000). Based on these advantages the research stated with the following hypotheses:

*“Through ST different interventions will be suggested and preferred compared to those formulated with event-based thinking.”*

The main- and sub-research questions that were answered in this research are:

*“How can Systems Thinking contribute to the development of intervention strategies for the incorporation of circular ambitions in the initiation and definition phase of a building project?”*

**SQ1:** *“What is the process for incorporating circular ambitions in the I&D phase of a building project and what are the barriers in doing so?”*

**SQ2:** *“What is ST and how can it be used to provide insight in the dynamics of the process of incorporating circular ambitions in the I&D phase of a building project?”*

**SQ3:** *“What is a CLD that reflects the process of incorporating circular ambitions in the I&D phase of a building project?”*

**SQ4:** *“What intervention strategies for the incorporation of circular ambitions in I&D phase of a building project can be developed based on the CLD reflecting the process?”*

The goal of this research is to examine the contribution of ST in the development of intervention strategies that contribute to the better incorporation of circular ambitions in the I&D phase of a building project. This was split up into two research objectives:

- 1. Develop a set of intervention strategies that can be used by PMs in the I&D phase of a building project that contribute to the better incorporation of circular ambitions.*
- 2. Determine the contribution of ST in the development of intervention strategies in the I&D phase of a building project*

## Research methods

The approach in this study can be described as Research through Design (RtD), in which the developed Causal Loop Diagram (CLD) functions as the artefact. A CLD is an important tool in the Systems Thinking and Modelling (ST&M) methodology that is used in this research.

The research started with a literature study to gain a deeper understanding of the important concepts relevant in the study: ST, barriers to circularity in the construction industry and project development. A structured literature search was carried out to identify the current barriers impeding the incorporation of circularity in the I&D phase of building projects. This resulted in five relevant articles, but no data specific to the I&D phase was found. Therefore, a total of eight semi-structure interviews with field experts followed. The CLD was developed in three focus group sessions with five participants. During these sessions different creative brainstorming techniques were used to achieve the final diagram. Based on the diagram intervention strategies were developed with the focus group.

A second set of semi-structured interviews was conducted for validation and triangulation of the findings from the focus group. The CLD was presented to experts outside of the focus group to determine transferability of the model outside of the group. During these interviews the participants were also asked to propose intervention strategies and indicate the strategies they deemed most useful before introducing the ST methodology. These results were compared to the findings from the focus group. The developed intervention strategies were compared with the identified barriers.

## Results

Through the first set of semi-structured interviews a total of twenty-six different barriers were identified that can be categorized in seven barrier groups: economic, technological, organizational, social, cultural, regulatory, and technical. The most cited barriers in the interviews are the expected higher investment required for circular approaches; current financial models that are not organized for circularity; predetermined budgets that do not consider circularity; the limited availability of second-hand materials; the limited time and capacity of PMs; insufficient knowledge about circularity and; the complexity around planning and storage of second hand materials.

The CLD reflecting the process of incorporating circular ambitions in the I&D phased of building projects that was developed can be found in Figure I. In the CLD the following six (6) themes were identified: certainty, knowledge, innovation, budget, materials, and courage. In total nine (9) reinforcing and two (2) undetermined loops were found in the system. Based on the CLD the following leverage points were detected: experience; degree of management vision; organization circularity ambition; insight; knowledge; commitment management; ambition project team; knowledge sharing; sustainability standards; budget available for circular solutions; enthusiasm and certainty.

The CLD and the leverage points were used to formulate intervention strategies during the focus group and semi-structured interviews. These strategies are: 1) continuous education of PMs to ensure up-to-date knowledge and awareness of circular approaches and materials; 2) consult an external source of knowledge and experience on the use of circular approaches and materials; 3) promote client awareness on the necessity of circular approaches and materials through inspiration and education; 4) alleviate uncertainties regarding budget and quality of reused and bio-based materials; 5) Well-considered budget creation by scope revision and reallocation of funds; 6) ensure a company culture that encourages the use of circular approaches; 7) external factors such as changes in law and regulation regarding circularity in the construction sector or setbacks and; 8) developments in client managements vision and commitment regarding the circular transition.

## Discussion

The most interesting finding in this study is the importance of education and knowledge sharing the overcome the current problems. Five (5) out of the eight (8) intervention strategies are related to this. In literature the importance of knowledge sharing, and education is also found, especially to tackle social and cultural barriers (Ababio & Lu, 2023; Osei-Tutu et al., 2023; Wuni, 2022). This research contributes to the academic literature by showing that knowledge and education can also be deployed to overcome economic barriers.

Economic barriers were the most cited barrier group by practitioners. This is in line with current literature where the expected higher upfront costs and higher costs in general were the often-cited barriers (Charef et al., 2021; Osei-Tutu et al., 2023; Wuni, 2022). However, in practice, circularity does not always lead to a cost increase. Practitioners often lack comprehensive knowledge of circularity. This might lead to certain biases, which are influenced by own experience. This highlights the importance of knowledge and knowledge sharing as drivers for circularity in the I&D phase.

Based on the advantages of ST this study started with a hypothesis as introduced above. The hypothesis did not proof to be true. Intervention strategies formulated after ST did not differ significantly from those formulated before ST. However, the ST method did confirm it's advantages. First, mental models were made tangible, this made it possible to convey them clearly during the validation interviews. Second, through the developed CLD multiple insights were gained. The most interesting insight is the key role of 'experience' in the model. This

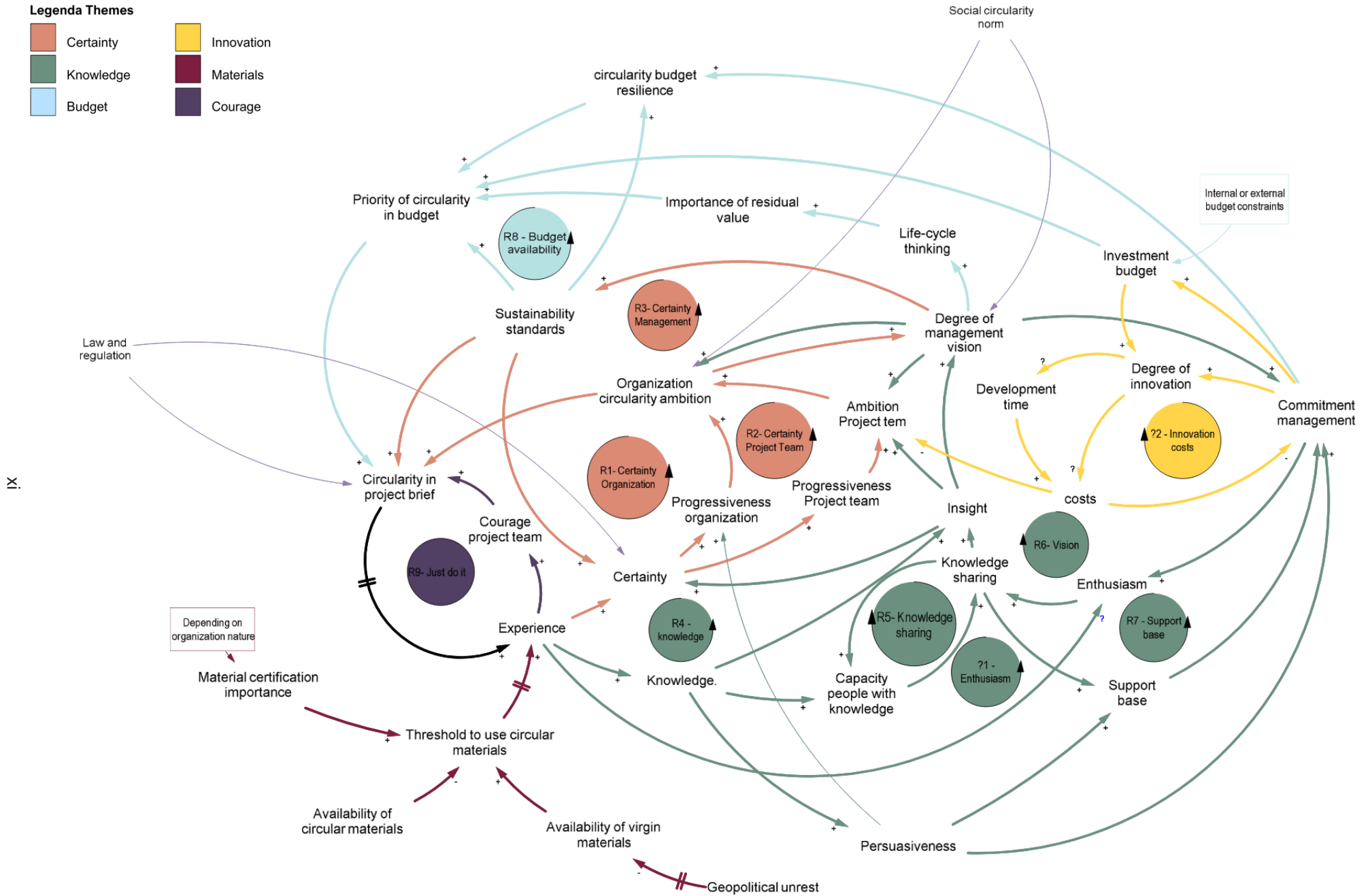


Figure 1. Causal diagram reflecting the process of incorporating circularity in the I&D phase of a building project, from a project managers point of view. Own image

variable has a central role in the CLD, and many loops emerge from experience. Third, the proposed intervention strategies were run through the model and their expected influence on the variables was visualized. This improved insight and provided a basis for discussion.

This research contributes to both practical and scientific understanding of circularity in the building sector. On a scientific level, it contributes by identifying barriers to circularity in the I&D phase, an area that was underexplored. The potential of ST to improve the uptake of circularity in the early project stages is explored. At a practical level, offers intervention strategies to improve the uptake of circularity. Highlighting the role of knowledge and knowledge sharing. Additionally, the method can be used as a discussion tool among practitioners to enhance professional maturity and offer new perspectives.

## **Conclusion**

This research aimed to develop intervention strategies for PMs to better incorporate circular ambitions in the I&D phase of building projects and to evaluate the contribution ST in this process. Eight intervention strategies were formulated, seven of which remained relevant after applying the ST methodology. Although the initial hypothesis suggested that through ST different intervention strategies would be formulated compared to event-based thinking, the findings showed limited differences between the two. However, ST proved valuable in improving the understanding of the dynamics and challenges in incorporating circularity by making mental models explicit and facilitating communication. Key insights highlighted the central role of 'experience' in improving the incorporation of circularity in the I&D phase. ST can also be used as a discussion tool among practitioners. It will help to explore circularity and surface underlying problems that impede the uptake of circularity.



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# LIST OF ABBREVIATIONS

BoT	Behaviour over Time
CE	Circular Economy
CLD	Causal Loop Diagram
EMF	Ellen McArthur Foundation
I&D	Initiation and definition
PM	Project Manager
RtD	Research through Design
SD	System Dynamics
ST	Systems Thinking
ST&M	Systems Thinking and Modelling

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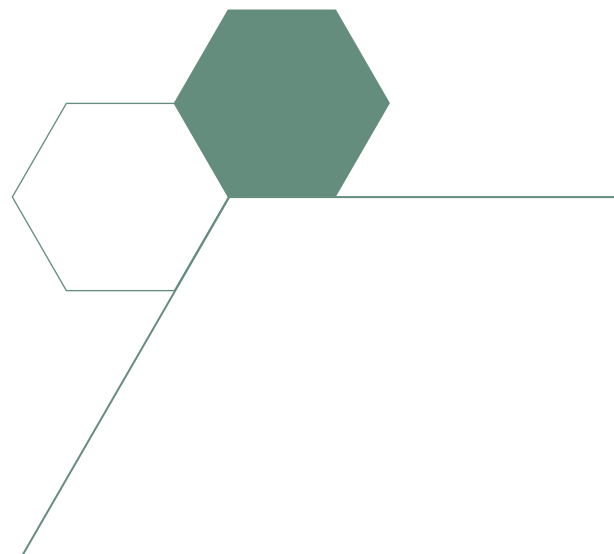
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# CHAPTER 1

# INTRODUCTION



# Introduction

Year after year the human population causes more stress on our planet. This becomes clearly visible when looking at the earth overshoot day, which fell on the 2nd of August in 2023. This marks the date in the year when the demand for ecological resources and services exceeds what the earth can regenerate in one year. Every year this date is moving forward, increasing the stress on our planet (Earth overshoot day, n.d.).

The Circular Economy (CE) is seen as a possible solution to release this stress (van Oppen et al., 2018). CE aims at replacing the current, linear economy, with a take-make-dispose character. In a CE the value of products, materials and resources is maintained as long as possible (Alhola et al., 2019). There are three basic principles of CE: waste and pollution are eliminated, products and materials are circulated, and nature is regenerated (EMF, 2017). Strategies in CE are amongst others: refuse, reduce, reuse, repair, recycle and recover (Het groene brein, n.d.).

In 2016 the Dutch government introduced the program 'a circular economy in the Netherlands by 2050'. This program presents the ambitious goal for the Netherlands to be fully circular by 2050. In 2030 the use of abiotic primary resources should be halved (Rijksoverheid, 2016). As part of a program that monitors this transition, the planbureau voor de leefomgeving (PBL) publishes the ICER (Integrated Circular Economy Report, or in Dutch Integrale Circulaire Economie Rapportage) every other year. The latest ICER, published in 2023, draws some harsh conclusions. The main message: with the current trends and policies the intermediate goal of 2030 will not be achieved and a fully circular economy by 2050 seems increasingly more distant (PBL, 2023). The construction industry is a big polluter and consumes large amounts of resources at the same time (Anastasiades et al., 2020; Ellen MacArthur Foundation, n.d.). Therefore, the Dutch program includes the construction industry as one of the priority sectors to focus on in the transition (Rijksoverheid, 2016).

## 1.1. Procurement as a tool for the circular transition

Public procurement is seen as a strategic and powerful instrument in addressing some of today's major challenges. It can be used as a tool to promote more socially and ecologically sound production and consumption (Adamo et al., 2023). In 2019, Dutch public authorities spent around €85 billion on public procurement. This comes down to roughly 11% of the Dutch Gross Domestic Product (GDP) (Zijp et al., 2022). When considering the EU, public authorities spend around a total of €2.000 billion on procurement of services, works and supplies. This accounts for approximately 14% of the EU GDP (European Commission, 2017). Public procurement with circular ambitions can therefore be an important driver in reaching national and international sustainability and circularity ambitions (Campbell-Johnston

et al., 2019). This type of procurement can be referred to as Circular Public Procurement (CPP). Which is defined by the European Commission as "a purchasing process that aims to contribute to closed energy and material loops within supply chains, whilst minimizing, and in the best case avoiding, negative environmental impacts and waste creation across their whole life cycle" (Adamo et al., 2023, p.2).

The procurement process can be divided in three phases: preparation of the tender, the tender procedure and execution of the contract. In the first phase, the purchasing need is defined (PianOo, n.d.-b). This can also be referred to as the initiation and definition (I&D) phase of a project (BNA & NLIingenieurs, 2014). In this phase, the client's wishes and ambitions are translated into requirements and specifications (PianOo, n.d.-d). In the project brief these elements are combined and this is the final product of this phase. Systemically integrating circularity in these phases will result in the execution of more circular projects as the project brief (the project brief, or in Dutch Programma van Eisen, PvE) largely determined the outcome. Detailed and well thought out specifications will result in a project that is in line with the desired outcome (Bruggeman, 2018; PianOo, n.d.-d).

Ambitions are a driving force in the transition to a circular economy. Despite the high ambitions set by the Dutch government, the adoption of circular practices in the construction industry is slow. In practice it has been found that CPP is unsuccessful in two thirds of the cases (Zijp et al., 2022). This is often due to the tender lacking circular ambition. The translation from high level circular ambitions to actions on a project level has been found challenging (Loewe & Rippin, 2015; Veen, 2022; Personal communication, October 11, 2023). Additionally, the CPP body of knowledge is limited as the concept is relatively new (Alhola et al., 2019; Sönnichsen & Clement, 2020). There is a need for a deeper understanding of the dynamics in the process of incorporating circularity in the I&D phase (Kristensen et al., 2021; Qazi & Appolloni, 2022; Rejeb et al., 2023; Sönnichsen & Clement, 2020).

## 1.2. The potential of Systems Thinking for CE in the construction industry

A shift to Systems Thinking (ST) is required for the transition to CE in the construction industry (Campbell-Johnston et al., 2019; Kristensen et al., 2021). Kim defines ST as "a way of seeing and talking about reality that helps us better understand and work with systems to influence the quality of our lives" (Kim, 1999, p. 2). The approach can help tackle difficult and interdependent problems occurring in the world of today (Metabolic, n.d.). ST is both a theory and a worldview, its core idea is that the answer to problems can be found within the system itself. Through the mapping of systems insights in the internal dynamics and complexities

Table 1.1. Advantages of Systems Thinking based on literature

Advantages of Systems Thinking	Source
Makes mental models explicit, thereby improving the understanding of the system's dynamic behavior and presenting it in an understandable way	Maani & Cavana (2000); Schwaninger (2009)
Assist users to act in the way that is in the long-term best interest of the system	Sterman (2000)
Helps to explore potential interventions and their impact	Sterman (2000); Schwaninger (2009)

will be gained. The root causes of problematic structures will be uncovered (Meadows, 2008). In Table 1.1 three benefits of ST are set out. ST helps users act in a way that is in the long-term best interest of the system as a whole and supports by exploring the potential impact of the interventions (Schwaninger, 2009; Sterman, 2000). Based on these advantages the following is hypothesized:

*“Through ST different interventions will be suggested and preferred compared to those formulated with event-based thinking.”*

A Causal Loop Diagram (CLD) is an important tool in ST, in such a diagram the system is visualized. ST does not aim at solving the problem but nudges the system in the right direction through the introduction of intervention strategies. These are actions that exert a positive long-lasting influence on the system to change it fundamentally (Maani & Cavana, 2000).

### 1.3. Research questions and objective

The adoption of circular principles in the construction industry is slow. To overcome the challenges a deeper understanding of the dynamics impeding the uptake of circularity is needed. It is expected that ST will contribute to uncover the systems structure and the root of the problems. This translated to the following research question:

*“How can Systems Thinking contribute to the development of intervention strategies for the incorporation of circular ambitions in the initiation and definition phase of a building project?”*

This question has been unraveled in four sub-questions. These sub-questions are stones towards the main questions. The following sub-questions were formulated:

SQ1: *“What is the process for incorporating circular ambitions in the I&D phase of a building project and what are the barriers in doing so?”*

SQ2: *“What is ST and how can it be used to provide insight in the dynamics of the process of incorporating circular ambitions in the I&D phase of a building project?”*

SQ3: *“What is a CLD that reflects the process of incorporating circular ambitions in the I&D phase of a building project?”*

SQ4: *“What intervention strategies for the incorporation of circular ambitions in I&D phase of a building project can be*

*developed based on the CLD reflecting the process?”*

The goal of this research is to examine the contribution of ST in the development of intervention strategies that contribute to the better incorporation of circular ambitions in the I&D phase of a building project. The research is focused on the dynamics in the I&D phase, and the role PMs play in this process. PMs are often hired by a client for their expertise. In this function they play a key role in the translation process. The above is summarized into two research objectives:

*1. Develop a set of intervention strategies that can be used by PMs in the I&D phase of a building project that contribute to the better incorporation of circular ambitions.*

*2. Determine the contribution of ST in the development of intervention strategies in the I&D phase of a building project*

### 1.4. Introduction of the case company

This graduation research is conducted at Sweco, an architectural and engineering consultancy firm operating in multiple northern European countries. Europe-wide they have approximately 22.000 employees that operate in three segments: water, energy and industry, transportation infrastructure, and buildings and urban areas. This graduation research is conducted in the Dutch department, in the segment buildings and urban areas.

Sweco has high ambitions in terms of sustainability, they aim to be one hundred percent carbon-neutral and circular by 2035. This is fifteen years before the goal set by the Dutch government. They want to operate at the centre of the green transition. Actions are taken with regards to their own operation. However, they realize most impact can be made through the large number of client projects they carry out every year. Two strategic approaches are formulated to reach these goals in client projects; carry out projects that contribute to sustainable development and increase sustainability performance in client projects.

One of the services offered by Sweco in the buildings and urban areas segment is project management. This is the service area of interest in this research. Sweco's projects managers (PMs) support clients with the translation from a vision to a tangible implementation of it. This study is conducted in a team of twenty PMs, each operating in their own projects. They are deployed at different stages of a project and in multiple sectors. Public and semi-public

clients cover a large share of the works. The companies' resources, knowledge and experience in the Dutch building industry will be used to gather data for this study.

## 1.6. Reading guide

The structure of this thesis is visualized in Figure 1.1.. The thesis is organized in six chapters; 1) introduction; 2) framework; 3) methodology; 4) results; 5) discussion and 6) conclusion.

In the current chapter the research topic is introduced, and the research objective and questions are presented. Chapter two provides a wider background to the research problem; the concept of circularity in the construction sector is introduced, the project development process is elaborated upon, the current barriers to circularity in the

construction industry are introduced and the theory behind ST is further explained.

In chapter three the methods used in this research are explained. The use of the ST methodology is elaborated upon, and the research approaches used are presented. The results chapter presents all the results from the empirical research. Barriers impeding circularity in the I&D phase of building project specifically are explained. The developed CLD is presented and explained, and the intervention strategies identified are displayed. A critical discussion of the research findings follows in chapter five, where the limitations of the research and recommendations of future research are also provided. Finally, in chapter six, first the sub-questions are answered followed by answering the main research question and a reflection on the research objectives.

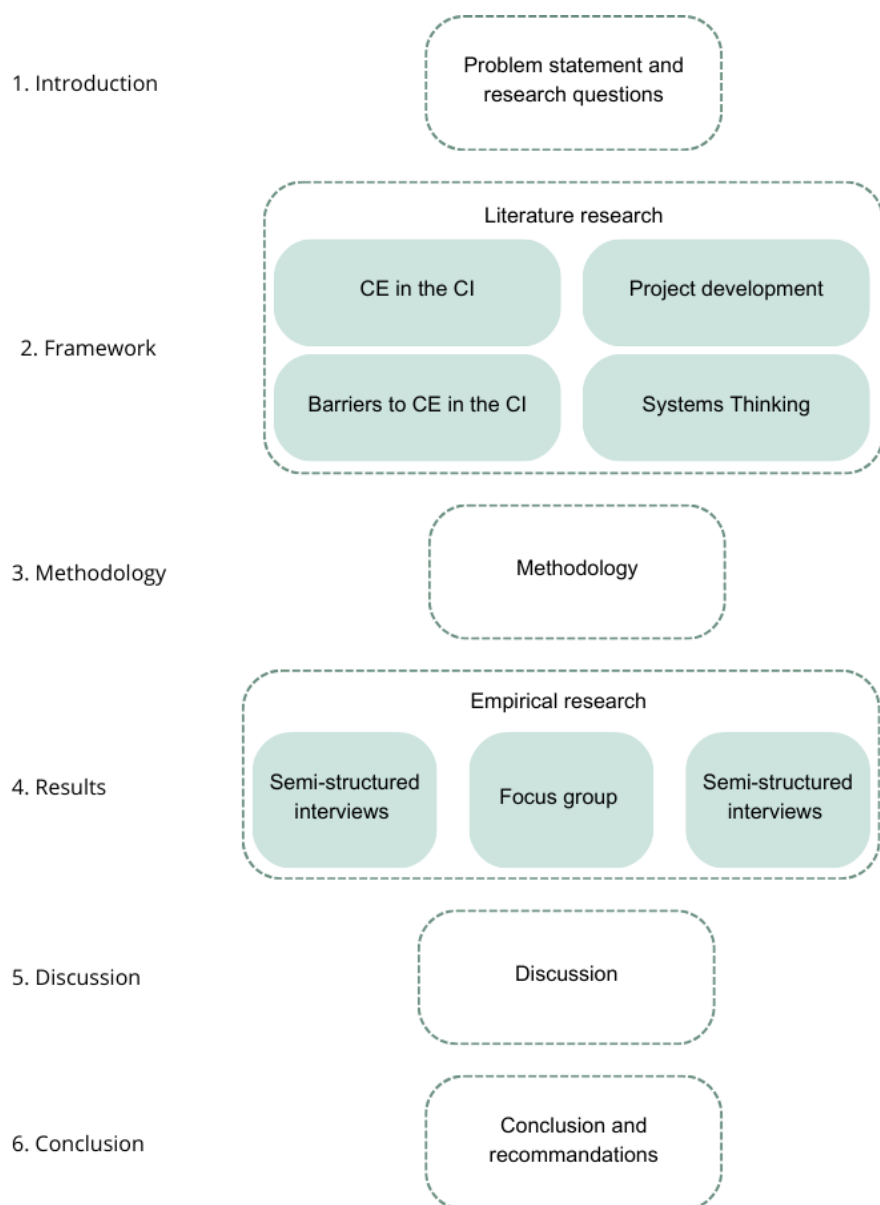
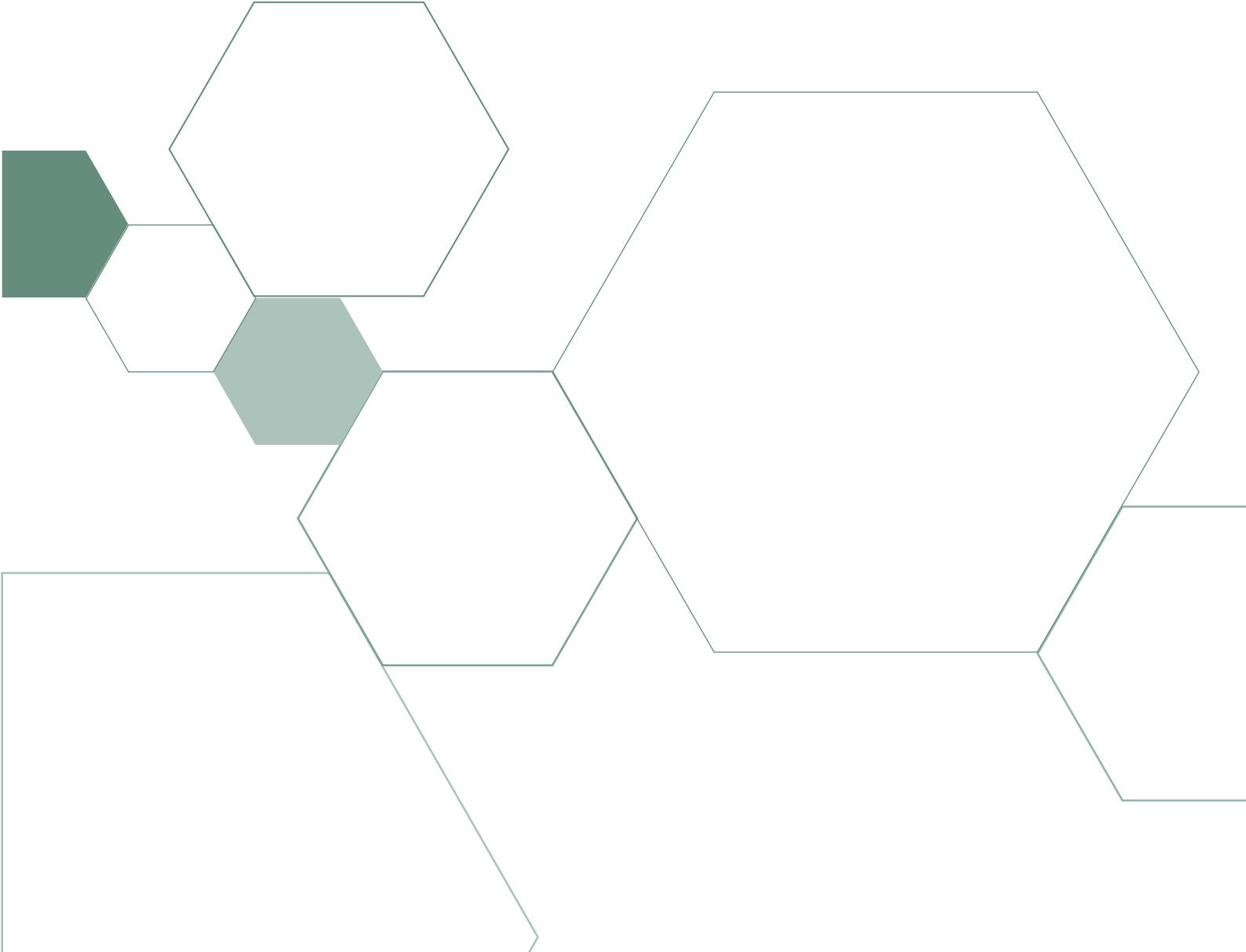


Figure 1.1. Thesis structure and research strategies. Source: Own Image

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# CHAPTER 2

# FRAMEWORK



# Framework

This chapter provides the background to important topics in this thesis. First the concept of CE and its relation to the construction industry is explained. This is followed by an elaboration of the stages of a building project. In 2.3. the barriers to circularity in the construction sector are introduced and the chapter is concluded with an explanation of the theoretical behind ST.

## 2.1. Circularity in the Construction Industry

In recent years, CE has become a popular topic of discussion in both literature and practice (Anastasiades et al., 2020; Kirchherr et al., 2017). The concept emerged as a response to the negative impact of the current economic systems. CE can be seen as a part of sustainability. it was first brought up to reduce the depletion of resources (Klein et al., 2020).

Figure 2.1 shows a representation of the current economic system. In this model growth and wealth are driven by the rapid use of raw materials. At the end of life, elements and materials usually become obsolete (van Oppen et al., 2018; Zu Castell-Rüdenhausen et al., 2021).

CE aims to increase the effective use of raw materials and limit the use of materials to reduce environmental pressure and geographical dependencies (Van Berkel & Schoenaker, 2020). A representation of CE is displayed in Figure 2.2. The Ellen MacArthur Foundation (EMF), one of global leading platforms on the topic, state that the CE is based on three principles: eliminate waste and pollutions, circulate products and materials and the regeneration of nature (EMF, 2017)

Despite the popularity of the topic, no consensus has yet been reached on the exact definition of CE (Anastasiades et al., 2020). Kirchherr et al. analysed one hundred fourteen (114) definitions of the concept and concluded the following: “[CE is] an economic system that replaces the ‘end-of-life’ concept with *reducina*, alternatively

*reusing, recycling and recovering materials in production/ distribution and consumption processes”* (Kirchherr et al., 2017).

### 2.1.1. Principles of the Circular Economy

The basic principles of CE can be explained by the butterfly diagram visualized in Figure 2.3. This model shows the cycling of biodegradable materials on the left side. This includes food but also potential building materials such as cotton or wood. In this cycle the processes related to returning nutrients to the soil are described.

In the technical cycle on the right is shown how products and materials can be kept in cycling at their highest value level. In general, the smaller loops are preferred over the bigger loops. This part of the model shows resemblance with the ‘R-ladder’, this is an often referred to concept for CE. Different versions of the ‘R-ladder’ exist, ranging from 3R to 9R. The Dutch government refers to a 6R-framework, including the strategies Refuse & Rethink, Reduce, Reuse, Repair, Recycle, and Recover (Rijksdienst voor Ondernemend Nederland, 2020). In this order, the first strategies are preferred over the latter. In conclusion CE principles include following the steps of the R-ladder (technical cycle) or applying bio-based materials (biological cycle).

### 2.1.2. Circularity in the context of the Construction Industry

The construction sector worldwide is performing poorly on topics such as waste generation, pollution and resource depletion (Ossio et al., 2023). This was also acknowledged by the Dutch government, who appointed the construction sector as one of their focus sectors in the transition agenda (Coenen et al., 2022). CE in the construction sector can also be referred to as Circular Construction (CC). In general CC is about applying the principles of CE in the construction sector. In the transition agenda the following definition is used:

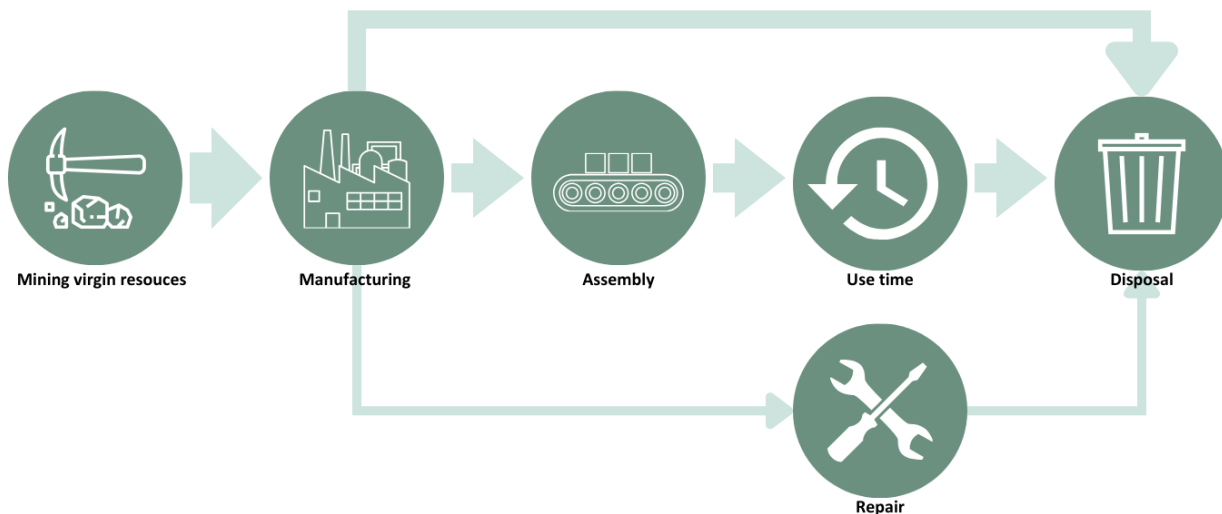


Figure 2.1. Material flows in the take-make-dispose economy. Arrow size represents the amount of material in the flow. Source: Anastasiades et al., 2020



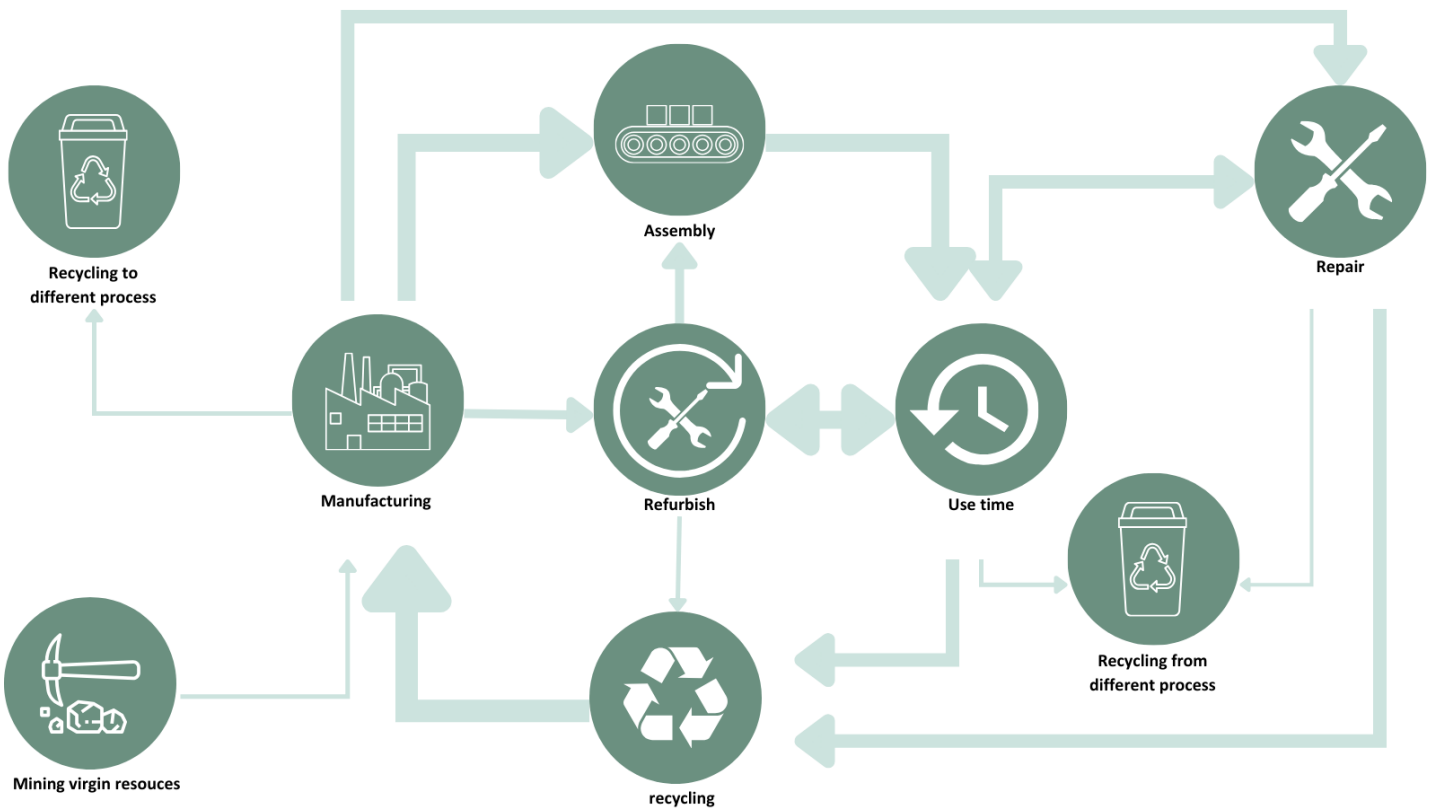


Figure 2.2. Material flow in the circular economy. Arrow size represents amount of material in the concerning flow. Source: Anastasiades et al., 2020

“... the development, use and reuse of buildings, areas and infrastructure without unnecessarily exhausting natural resources, polluting the living environment, and effecting ecosystems. Construction in a way that is economically sound and contributes to the well-being of humans and animals. Here and there, now and later.” - (Gruis et al., 2018, p. 10)

In a circular design, lifespan extension of the building, future reuse of materials and environmental burden of new

materials are considered (PianOo, n.d.-a). Platform CB’23 provides a description of a circular building. They state that a circular building is designed making use of circular design principles and is realized with circular products, elements and materials (Platform CB’23, 2019). Considering the above the following definition is used:

“a project is circular if during definition and design, circular strategies or bio-based materials are considered and used”

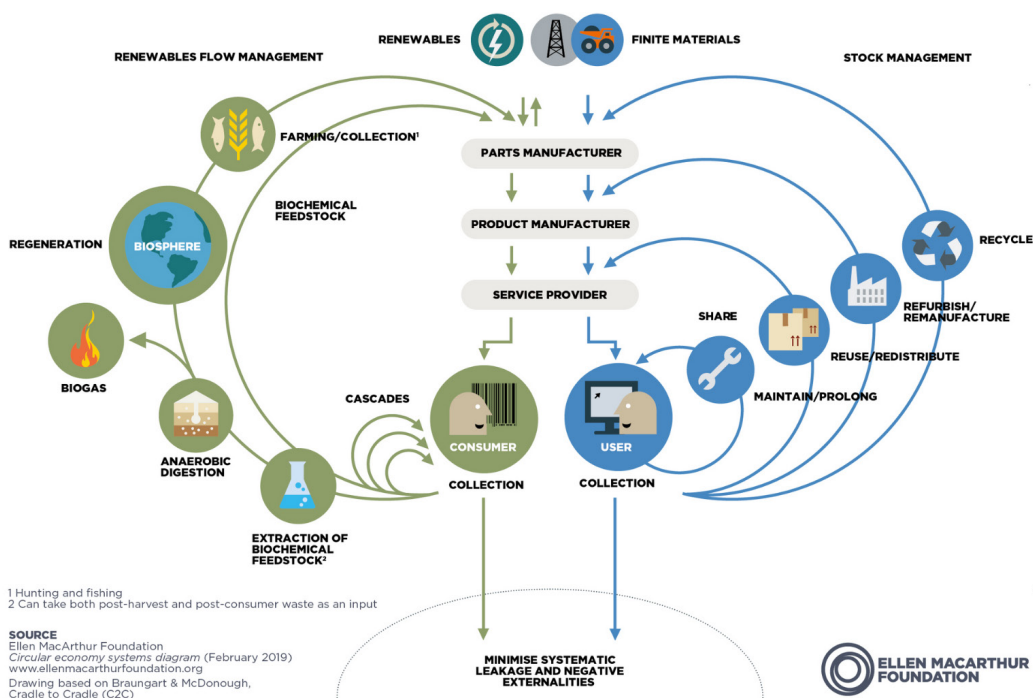


Figure 2.3. Butterfly diagram. Source: EMF, 2022

## 2.2. Phases of the Project Life-Cycle

Every building and construction project generally progresses through the same phases. This can be referred to as the life cycle development sequence of a project (Dawson, 2007; Morris, 2004). The exact phases of the life cycle differ per author. For instance, Weiss and Wysocki (1992) distinguish five different phases; definition, planning, organization, control and close (Dawson, 2007). In the Netherlands, a standard contract exists between client and contractor for the traditional building process. This contract is referred to as The New Rules 2011 (TNR; De Nieuwe Regels in Dutch). In this document the phases of a project are defined, including the corresponding tasks (BNA & NLingenieurs, 2014; Ubink, 2018). In figure 2.4. the phases as used in TNR are presented. In the following sections these phases are shortly explained.

### Initiation and definition

Every project starts with an I&D phase, according to TNR the deliverable of these phases is a project brief (in Dutch Programma van Eisen). This document includes functional and spatial requirements and specifications, wishes, ambitions and expectations (BNA & NLingenieurs, 2014; Habekotté, 2022). Specifications are a part of the project brief and can be described in two ways: functional or technical. Technical specifications provide an exact description of the works, service or product. Functional specifications give a description of the intended result. This leaves more space for market parties to propose creative solutions (PianOo, n.d.-d). Van Oppen et al. (2018) also advise to use functional specifications to increase the level of circularity. In traditional contracts the specifications are usually technical. Thus, in general it can be stated that tradition project delivery models do not fit circular project development.

The project brief largely determines the project outcome, based on this document the design is made and it is the basis for tenderers to develop their bid (Bruggeman, 2018; PianOo, n.d.-d). The I&D phase is exploratory by nature. When a consultant is hired, the project goals are formulated in consultation with the client and potential users. Gathered data is translated into clear and tangible criteria (Klarenbeek, 2021). Decisions made in the early stages of a project have a great influence on the results, initial performance and long-term effects (Klarenbeek, 2021; Kohler et al., 2013; Versteeg Conlledo, 2019). Therefore, the incorporation of circularity in the project brief and requirements is important and will secure the minimal desired level of circularity in the project.

### Design

Based on the project brief, the architect will make a physical representation of the building. The design flows through multiple phases, increasing in level of detail. The following design phases are distinguished: Sketch design, pre-design,



Figure 2.4. Phases of the project management life-cycle. Source: BNA & NLingenieurs 2014, own image

definitive design technical design and implementation design (BNA & NLingenieurs, 2014).

### Execution

In this phase, supervision of the contract and execution takes place. An advisor is often asked to do this on behalf of the client (BNA & NLingenieurs, 2014). This phase concludes with the project being delivered and handed over to the client (Habekotté, 2022; O'Callaghan, 2007). If circular principles are embedded in the design these will become visible during this phase. Changes, including suggestion for circular alternatives, can still be made. However, this will lead to increased costs. The further the project life cycle progresses, the more expensive modifications become (Klarenbeek, 2021; PMBOK Guide, 2021).

### Exploitation

During the exploitation of the building, the building is used, managed and maintained by its users. This usually is the longest phase of a project lifecycle (Habekotté, 2022; Klarenbeek, 2021).

### End-of-life

This is an often-forgotten phase in the project life cycle. The end-of-life phase present itself when the building does no longer meet the functional, spatial, legal, or other requirements and it is not feasible to renovate. The building will be decommissioned and can be demolished or demounted (Habekotté, 2022). In CE it will function as a material bank for new construction projects.

## 2.3. Barriers impeding Circularity in the Construction Industry

In this section barriers to circularity in the construction industry are introduced. Multiple studies were found regarding the barriers to circularity in the construction industry in general. However, elaborate data on the barriers specific to the I&D phase was difficult to find. Klarenbeek (2021) found several barriers which they categorized in three barrier groups: 1) unclear responsibility for CE, 2) segmentation of the construction sector, and 3) insufficient integrated knowledge on CE. These barrier groups were reflected against the life-cycle phases. Their research showed that all barriers occur in the I&D phase.

A general search into the barriers to CC resulted in the following eight main barrier categories: economic, technological, environmental, organizational, social, cultural, regulatory and technical. A short description of each of these categories is provided in Table 2.1. These barrier categories are retrieved through the analysis of multiple articles that considered the barriers to circularity in construction. In each of these articles different overlapping barrier categories were identified. Barriers in the categories were combined or split up depending on the author. The eight barrier categories used in this thesis are further explained in the sections below.

Barriers can be divided in these categories, yet this does not imply the categories stand on their own. An interesting observation is made by Wuni (2022) who indicates the interdependence of the barrier categories. Barriers are a part of a complex system, and their relations explain the slow adoption of circular approaches in the construction industry.

### 2.3.1. Economic barriers

Economic barriers are concerned with budget constraints, funding challenges, financial disincentives and material

costs (Wuni, 2022). Barriers related to market supply and demand also fall under this category (Osei-Tutu et al., 2023). Key barriers include higher upfront investment costs, budget or funding constraints, lack of short-term financial benefits, relatively higher costs of reclaimed materials, lack of market pressure, immaturity of the market and limited availability of reused materials (Osei-Tutu et al., 2023; Wuni, 2022). This barrier category was found in all considered studies.

The expected higher upfront cost is the most cited barrier in this group (Charef et al., 2021; Osei-Tutu et al., 2023; Wuni, 2022). Some of the causes for these increased upfront costs are the long and costly certification procedures, harvesting of second-hand materials in advance and the extra time and research needed to deviate from the norm (Ababio & Lu, 2023; Charef et al., 2021).

Higher costs in general are an often-cited barrier, the association that circular building will be more expensive causes clients to avoid this, especially with the sometimes tight and predetermined budgets (Ababio & Lu, 2023; Osei-Tutu et al., 2023). Furthermore, the (financial) incentive to choose the circular option is low due to the relatively low price of virgin materials. In addition, reclaimed materials have a low market value due to people's perception of it being 'inferior' (Osei-Tutu et al., 2023). This results in low market supply and demand (Charef et al., 2021). Other barriers are the lack of financial and reporting tools (Ababio & Lu, 2023) and the short-term vision on economic benefits (Charef et al., 2021).

### 2.3.2. Technological barriers

Barriers in this category are related to tools, procedures and access to technologies (Charef et al., 2021; Wuni, 2022). Availability of appropriate technology is fundamental for the transition to a circular construction industry and a lack thereof is an important threshold (Ababio & Lu, 2023). The most mentioned barriers include the lack of technology

Table 2.1. Barrier categories and description. Source: Ababio & Lu (2023); Charef et al. (2021); Osei-Tutu et al. (2023); Wuni (2022)

Category	Description
<b>Economic</b>	Barriers relates to budget constraints, funding challenges, financial disincentives, material costs and market supply and demand
<b>Technological</b>	Barriers related to tools, procedures and the availability and acces of proper technology
<b>Environmental</b>	Barriers related to environmental impact and the corresponding assessment methods
<b>Organisational</b>	Barriers related to organisations internal structures policies and rules, coordination of activities and involvement of stakeholders.
<b>Social</b>	Barriers related to human behavior, emerging from social issues, psychological and cultural opinions and personal characteristics
<b>Cultural</b>	Barriers related to ideas, cultural believes and the attitudes
<b>Regulatory</b>	Barriers related to government steering mechanisms
<b>Technical</b>	Barriers related to the depth of technological expertise

readiness, proven technology and materials, immature recycling market and technology, lack of performance guarantees on reused materials and a lack of digital tools that enable CE practices (Charef et al., 2021; Osei-Tutu et al., 2023; Wuni, 2022).

The unavailability of tools is specifically mentioned to be a barrier in the project planning phase, this includes I&D (Ababio & Lu, 2023). Digital technologies are often not mature yet and it is argued that these challenges are related to the complexity of the construction sector which can also be seen as a barrier on its own (Ababio & Lu, 2023; Wuni, 2022). Most alternative materials are still in their research and development phase and are not yet proven (Wuni, 2022). In addition, the lack of performance guarantees and standards for reused materials and the process related are a barrier. Current regulations are strict, increasing the threshold to apply reused materials (Ababio & Lu, 2023; Osei-Tutu et al., 2023). Investments in CE technologies for the construction sector are falling behind due to the immaturity of the concept. This leads to the limited availability of fitting tools and technologies (Wuni, 2022).

### 2.3.3. Environmental barriers

Environmental barriers are related to environmental impact and assessment methods. The most mentioned barriers are the lack of awareness about the impact of construction waste, the lack of incentives in assessment methods and, impact of emissions of transport and use of raw materials (Osei-Tutu et al., 2023).

Environmental barriers are often experienced in the end-of-life phase of a project (Charef et al., 2021; Osei-Tutu et al., 2023), they are therefore not expected to occur in this study.

### 2.3.4. Organizational barriers

Organizational barriers are related to the internal structure of an organization, the policies and rules, coordination of activities and the influence and involvement of stakeholders (Wuni, 2022). Some of the most mentioned barriers in this group are the lack of management and organization support, lack of cooperation and information sharing between stakeholders and an increased organizational process, planning and increased workload due to CE practices (Charef et al., 2021; Wuni, 2022).

A lack of management support results in CE not being a priority in the company leading to a slow adoption of the concept (Charef et al., 2021; Wuni, 2022). Often the burden of planning and administration is too high (Wuni, 2022). The lack of budgetary allocation for circularity is also mentioned as a barrier, this is relevant to the I&D phase as budgets are determined before this phase and these constraints thus form a barrier (Charef et al., 2021). The lack of communication between different disciplines and

stakeholders is also mentioned as a barrier. This can be appointed to the fragmented nature of the construction sector and its supply chain (Ababio & Lu, 2023; Charef et al., 2021; Wuni, 2022).

### 2.3.5. Social barriers

Social barriers include barriers emerging from social issues, psychological and cultural opinions and personal characteristics such as knowledge, skills and attitude (Ababio & Lu, 2023; Charef et al., 2021; Osei-Tutu et al., 2023). Human behaviour is the central factor in these barriers. Key barriers in this group are the lack of awareness, knowledge and expertise related to CE, lack of education and training on CE, lack of human resources, lack of acceptance of reclaimed materials and lack of interest and client demand (Ababio & Lu, 2023; Charef et al., 2021; Osei-Tutu et al., 2023; Wuni, 2022).

Knowledge and awareness of the CE concept and the related processes is limited in general; this results in limited implementation of CE (Wuni, 2022). Furthermore, reused materials are perceived as inferior or less aesthetically desirable. Causing a further delay to the uptake of CE because of the perception and preference of materials (Osei-Tutu et al., 2023).

### 2.3.6. Cultural barriers

Cultural barriers are related to ideas, cultural beliefs and the attitude of players in the construction sector (Charef et al., 2021; Wuni, 2022). Key barriers in this category are the conservative nature of the sector, resistance to change, lack of concern for recycled, reused or bio-based materials and the perception of reused materials as inferior (Osei-Tutu et al., 2023; Wuni, 2022). This last barrier also emerged under the social barrier category, indicating the interdependence between the categories.

The cultural beliefs are deeply rooted in the sector and are a barrier to the uptake of new technologies. This is also related to the conservative and risk avoiding nature of the sector (Ababio & Lu, 2023). Traditional methods are preferred due to the increased risks and uncertainties associated with circular products and strategies (Charef et al., 2021; Wuni, 2022). The limited number of successful projects is not beneficial for the uptake of CE and makes it difficult to translate CE theory to practice (Wuni, 2022). Furthermore, reused or recycled materials are often perceived with scepticism regarding the quality, leading to a preference for new materials (Osei-Tutu et al., 2023).

### 2.3.7. Regulatory barriers

Regulatory barriers are related to government steering mechanisms that push the construction industry towards more circular practices (Wuni, 2022). Barrier under this category include the lack of governmental pressure, lack of (financial) support mechanisms or tax incentives and

a lack of regulatory frameworks and legislation for CE implementation in the construction industry (Wuni, 2022).

Regulations can also be too strict for allowing innovations (Charef et al., 2021). The lack of financial support is also cited as a barrier, due to the higher investment costs CE practices are less attractive. Without some sort of financial support, traditional construction methods are often preferred (Wuni, 2022). Another barrier is the inconsistency of policy on a local and regional level. This results in construction companies dealing with different policies concerning circularity in every project, hindering maturation of their processes and knowledge (Ababio & Lu, 2023).

### 2.3.8. Technical barriers

Technical barriers are related to the depth of technological expertise needed for CE implementation in the construction sector (Wuni, 2022). Key barriers include the lack of technical knowledge, technical complexity of the transition in construction projects and limited design codes and standards for waste management (Osei-Tutu et al., 2023; Wuni, 2022).

For a full CE implementation in the construction industry, the whole supply chain must be reconfigured. Processes will have to be reinvented and new working relations need to be built. In addition to the new deconstruction methods, materials will have to be stored somewhere. Possibly for longer periods of time, this results in barriers related to the limited availability of storage space (Osei-Tutu et al., 2023).

## 2.4. Introduction of Systems Thinking

Systems Thinking (ST) approaches that we know today, find their origin in the first half of the twentieth century. Multiple schools emerged, but the most important characteristic of ST is their shared worldview. In addition to theory, ST provides a way of thinking and dealing with the world around us (Schwaninger, 2009). ST helps its users to see the world as an intricate network, an action never stands on its own, and all elements are interlinked (Maani & Cavana, 2000; Sterman, 2000).

### 2.4.1. Systems Dynamics

Systems Dynamics (SD) currently is the largest 'school' of ST (Schwaninger, 2009), and is used in this research. It is important to know what a system is before diving deeper into SD theory.

Many definitions can be found in literature, but Meadows' definition of a system in her book *'Thinking in Systems'* has been an important source of inspiration for most (Raghunathan, 2021). Meadows defines a system as *"a set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as*

*its function or purpose"*(Raghunathan, 2021, p. 24). In their paper Arnold & Wade propose a definition of SD by its objective, derived from a review of SD literature. They concluded the following definition: *"[SD] is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects"* (Arnold & Wade, 2015, p. 8). Both definitions articulate the three important aspects of a system: its elements, the interconnections and its purpose.

### 2.4.2. Difference between event-based thinking and Systems Thinking

The central aim of SD is to move away from the event-oriented worldview and provide a holistic view of human systems. An event-oriented worldview will lead to event-oriented solutions, which may not always consider their (negative) long-term effects (Sterman, 2000). In Table 2.2 the differences between event-based thinking and ST are summarized.

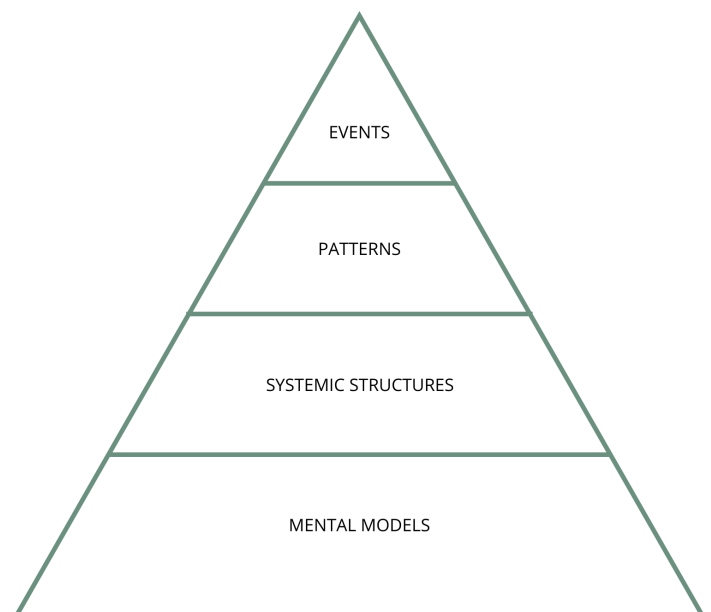
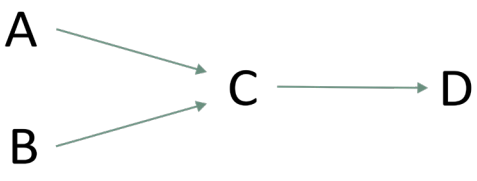
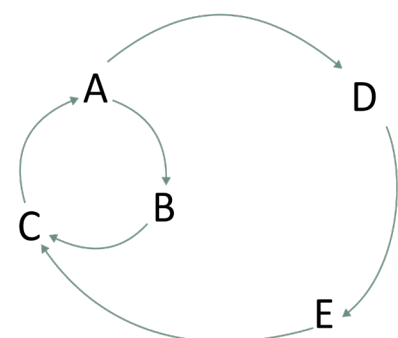


Figure 2.5. Four levels of thinking. Source: Maani & Cavana, 2000, own image

The four levels of thinking (Figure 2.5) are often cited in SD literature. At the top of the pyramid, the event level is found. This is the most visible level of thinking; it presents what we know and experience on a day-to-day basis. At the second level, patterns of these events are recognized. On the level of systemic structures, the effect of these patterns and trends on each other is found. The last level, mental models, is much deeper and present an individuals or groups underlying, values, believes and assumptions (Maani & Cavana, 2000).

Mental models are described by theorists as: *"a collection of routines or standard operating procedures, scripts for selecting possible actions, cognitive maps of a domain, typologies for categorizing experience, logical structures for the interpretation of language, or attributions about individuals we encounter in daily life"* (Sterman, 2000, p.

Table 2.2. Characteristics of event-based thinking and systems thinking. Source: Maani & Cavana (2000); Sterman (2000)

Event-based thinking	Systems thinking
	
Linear causality	Intricate network with elements and interconnections that form feedback loops
Problems are blamed on clearly defined causes	Structure explains behavior of the system
Basic world view	Holistic world view
Events	Mental models
Problems are clearly defined	Problems are wicked with many dependencies
Event-oriented solutions aimed at fixing problems	Interventions that push systems towards desired state

16). SD deals with these mental models, it also uncovers hidden complexity and the systems characteristics. Through ST and SD, the move is made from event level thinking to this deeper level of mental models. The goal is to determine lasting intervention for complex problems (Maani & Cavana, 2000; Pidd, 1996; Sterman, 2000). People naturally think in an event-based manner. However, if people have a deeper understanding about the dynamics of the system, they are more likely to make decisions that are in favour of the whole system in the long-term (Sterman, 2000).

SD does not aim at ‘fixing’ a problem but identifies leverage points. A leverage point is a place in a system where a small adjustment or intervention can exert a long-lasting effect of the system. Causing the system to change towards the desired state (Meadows, 2008; Raghunathan, 2021). ‘Fixing’ a problem would suggest there to be an optimal solution and this would ignore the complexity of the system. Based on these leverage points intervention strategies can be formulated. These strategies or actions do not aim at solving the problem directly but are rather a way of exerting long lasting influence on the system to change it fundamentally (Maani & Cavana, 2000).

### 2.4.3. What is a Causal Loop Diagram

Causal loop diagrams (CLD) are an often-used tool in SD. They provide a simplified representation of the system and exist out of variables and relations. CLDs clarify mental models present in an individuals or groups mind. They help identify drivers of the systems behaviour and provide a simplified representation of reality. This makes it relatively simple to communicate CLDs to others (Sterman, 2000; Zhou, 2012). In Figure 2.6 a simplified version of a CLD for population is shown. In this figure the following variables

can be identified: births, population and deaths. Variables are elements, actions or circumstances that can influence and are influenced by other variables (Maani & Cavana, 2000). Most important is that variables can increase or decrease over time. The relations in a CLD are indicated with the arrows. A further explanation of the systems thinking language can be found in Appendix A.

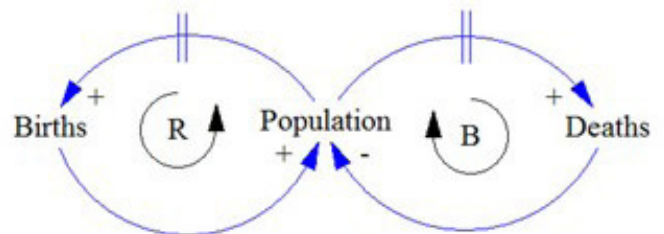
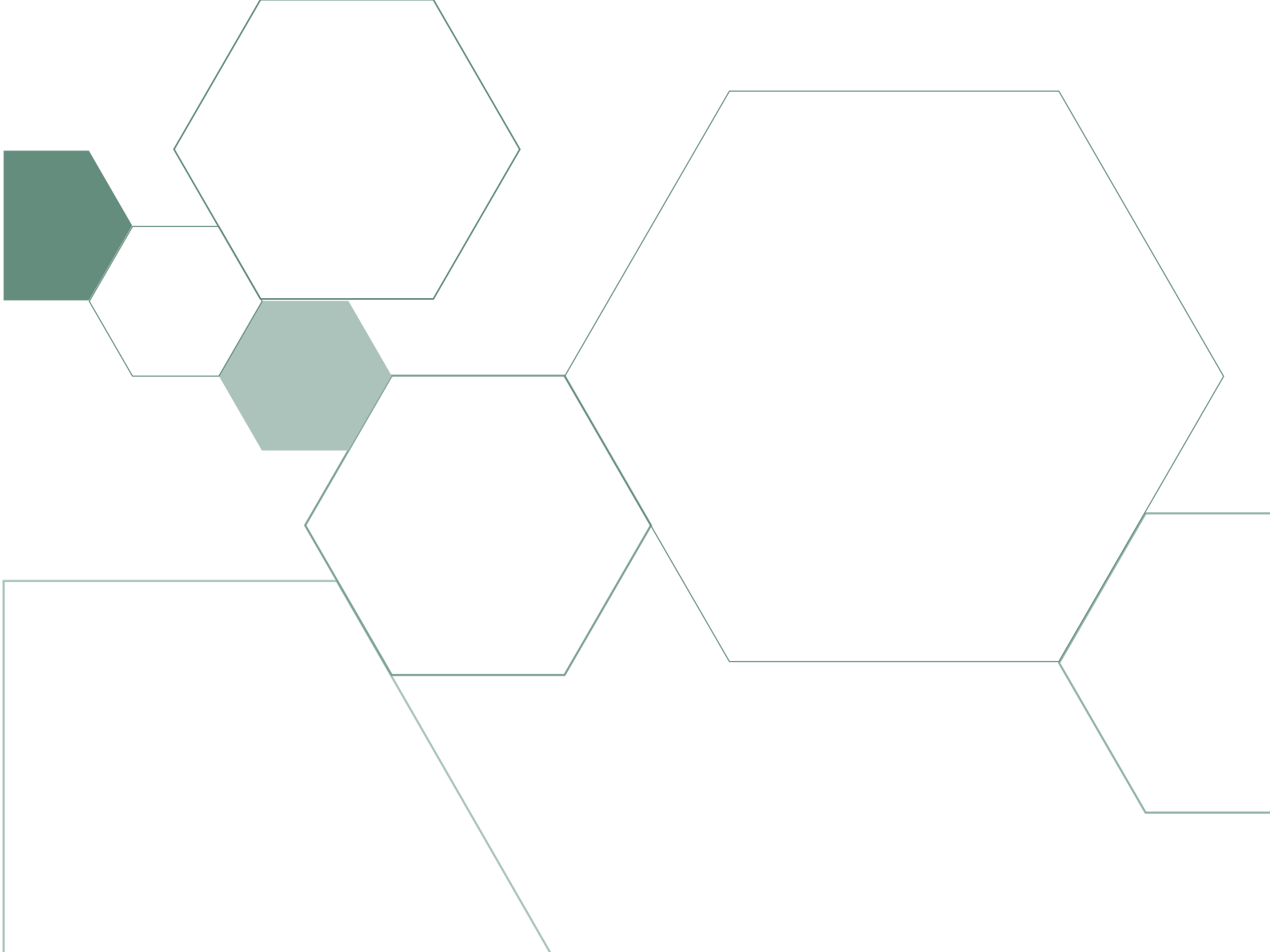


Figure 2.6. Simplified CLD with reinforcing and balancing loop that impact population. Source: Zhou, 2012

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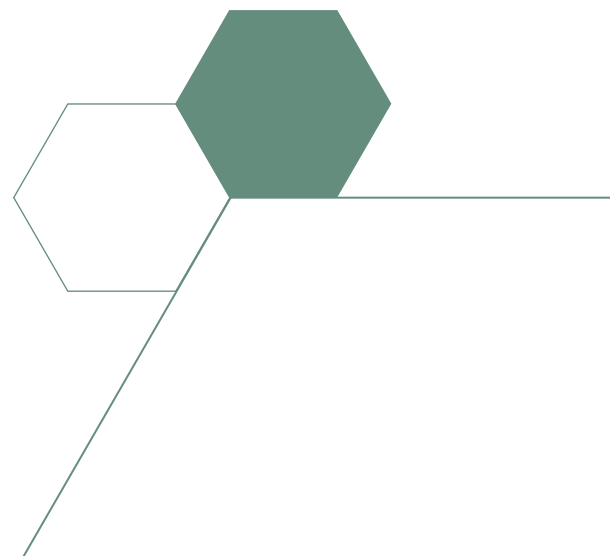
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# CHAPTER 3

# METHODOLOGY



# Methodology

The research aims at developing a set of intervention strategies that can be deployed by PMs in the I&D phase of a building project, through ST. A practice-oriented problem is addressed. The approach of this study can be described as research through design (RtD). In RtD, the generation of knowledge and understanding are results from the development of an artifact (Godin & Zahedi, 2014). An artifact can be described as an object that is created during the process of designing something (Stappers & Giaccardi, 2014). Some examples are a sketch, diagrams of 3D prototypes. Multiple design activities can be deployed, depending on the skills of the designer and researcher (Stappers & Giaccardi, 2014). Developing an artifact is an iterative process, in the case of this research the artifact that is developed is a CLD. As introduced in chapter 2.4.3., a CLD is an important tool in ST and in this research, it serves as a medium for knowledge generation.

This chapter starts with the introduction of the used ST methodology and explains how this methodology is used. It continues with an elaboration of the data gathering methods used in this research. In section 3.3. data triangulation and validation are explained.

## 3.1. The Systems Thinking and Modelling Methodology

The Systems Thinking and Modelling (ST&M) methodology developed by Maani & Cavana (2000) is used as the guiding methodology in this research. ST&M methodology is divided into five phases that each consists out of several steps, an overview of all steps and phases can be found in Appendix B. The literature stresses that neither all phases are required for every research, nor all steps of a phase. As this is qualitative research, only steps from phases one and two will be used. These steps are presented in Table 3.1.

## 3.2. Data Collection

The data gathering methods used in this research include literature study, semi-structured interviews and focus groups. In the following sections, these methods and how

they are used to gather the data are explained. In Figure 3.1 an overview of the data gathering methods and their relation to each other is presented. First, the literature study is explained, this is followed by an elaboration on the semi-structured interviews to explore the barriers, the focus groups and data triangulation.

### 3.2.1. Literature study

Through a literature review the following topics are researched: ST, barriers to circularity in the construction industry, and project development. This is also indicated in Figure 3.1..

The literature study can be split up into unstructured and structured research. Information about ST, circularity in the construction industry and project development is collected using an unstructured method. To identify barriers to the incorporation of circularity in the sector a structured approach is used.

The aim of the unstructured literature search was to gain a better understanding of the relevant processes for incorporating circular ambitions in the I&D phase of a building project. The concept of circularity in the construction industry is explained and the relevant stages of a construction projects are introduced. A combination of scientific and grey literature was used. Grey literature includes government reports and web-based information (e.g. from PianOo.nl).

The barriers to circularity in the construction industry are retrieved through a structured literature search. Elsevier’s database, Scopus, was used, because it is seen as a dominant database for the collection of construction journal articles and is used globally (Osei-Tutu et al., 2023; Wuni, 2022). Ninety-one (91) results were found using the following search string:

TITLE-ABS-KEY (“construction industry” AND “circular economy” AND barriers)

Table 3.1. Steps used from the Systems Thinking and modelling process. Source: Maani & Cavana, 2000. Modifications by author

Phases	Steps
<b>1. Problems structuring</b>	<ol style="list-style-type: none"> <li>1. Identify problems or issues of concern</li> <li>2. Collect preliminary information and data</li> </ol>
<b>2. Causal loop modelling</b>	<ol style="list-style-type: none"> <li>1. Identify main variables</li> <li>3. Develop Causal Loop Diagram</li> <li>4. Analyze loop behavior over time</li> <li>6. Identify key leverage points</li> <li>7. Develop intervention strategies</li> </ol>
<b>5. Implementation and organisational learning</b>	<ol style="list-style-type: none"> <li>1. Prepare a report and presentation</li> <li>2. Communicate results and insights</li> </ol>

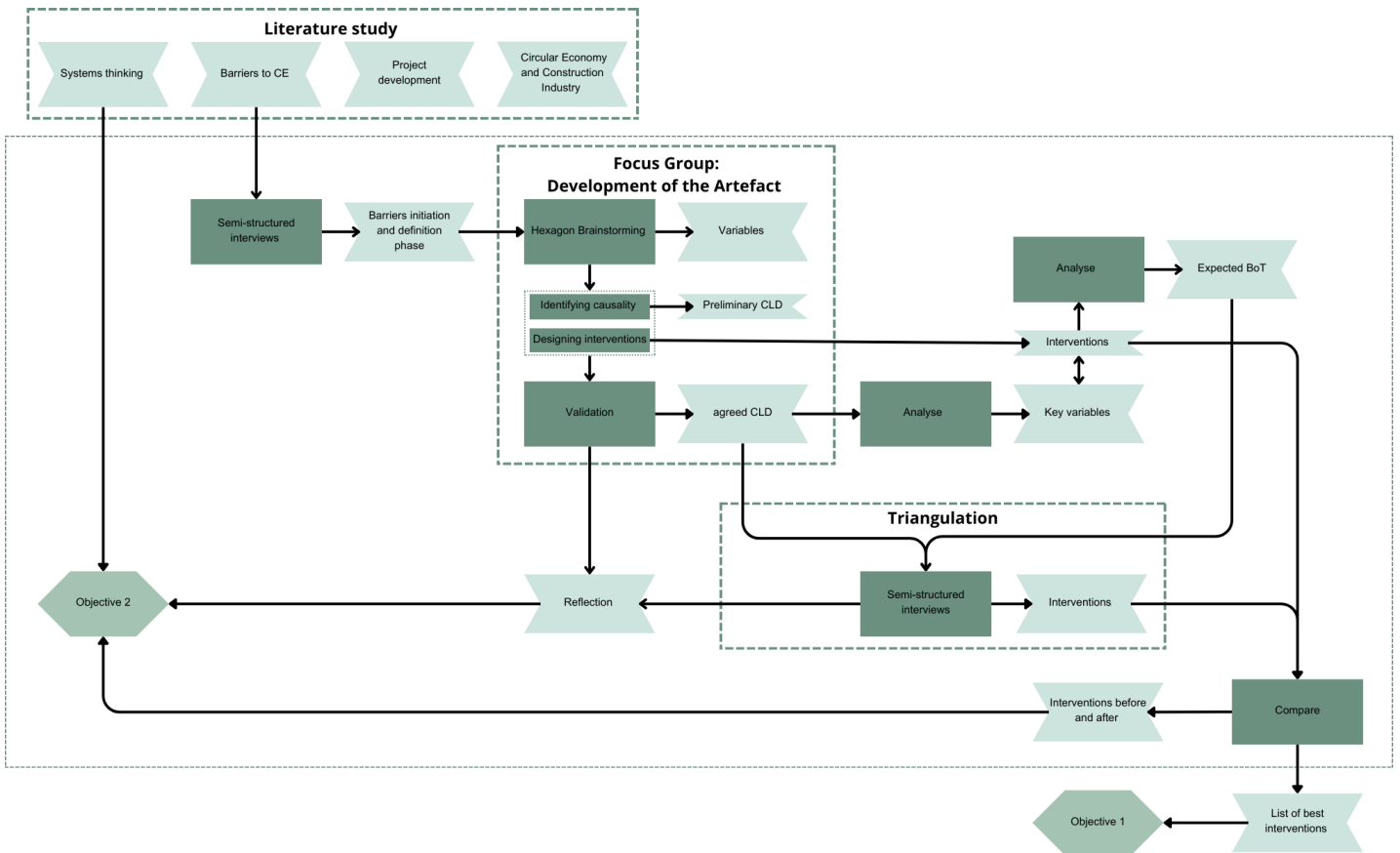


Figure 3.1. Schematic presentation of data gathering and analysis. Source: own image

This set of results was filtered to only include review articles, leaving eight-teen (18) results. Only English articles are considered, this did not exclude any of the documents. The titles and abstracts of these articles were scanned. The scope of this research is limited to the Dutch context, documents with a geographical scope outside of the European Union were therefore excluded. Furthermore, articles with a focus on one specific material or approach to CE were left out of the selection. This resulted in a total of five articles that were used in this research.

### 3.2.2. Semi-structured interviews

To retrieve specific data on the barriers to circularity in the I&D phase, in-depth one-on-one interviews with a semi-structured nature were conducted. This information was not available in current literature. The interviews were held face-to-face or via Microsoft Teams, depending on the availability and location of the participant. The benefit of a semi-structured interview is the possibility to ask additional questions when interesting, new topics occur (Baarda et al., 2018). This would not be the case with fully structured interviews. At the same time this structure provides a guideline to address all topics. The interview guides were created based on the literature on barriers to circularity in the construction industry in general and can be found in Appendix C1.

The interviews were recorded, and a full transcript was made making use of the transcribe tool in Microsoft Word Online or Microsoft Teams. This transcript was

thoroughly reviewed and corrected by the researcher. The recording was deleted, and the transcript was shared with the participant. The transcripts were coded and made anonymous to ensure interviewees privacy. At the start of each interview the research in general was introduced, followed by a description of the goals and topic of the interview itself.

### Data analysis

ATLAS.ti data analysis software was used to perform an analysis of the transcripts in a structured and systematic manner to collect useful data. Information from the transcripts is evaluated, coded and structured through this program. Saldaña (n.d., p.4) describes a code as “a researcher-generated construct that symbolizes and thus attributes interpreted meaning to each individual data for later purposes of pattern detection, categorization, theory building, and other analytical processes.”

In this study, coding was conducted using a combination of inductive and deductive coding approaches. With deductive coding pre-determined codes are used when analysing the data. During inductive coding, codes emerge whilst reading the transcript. The deductive codes are developed based on the literature review, it is possible that the coding scheme retrieved does not capture all codes or codes might be formulated that are not used. Inductive coding gives the opportunity to fill this gap. The final list of codes and subcodes can be found in Appendix C2. The process of reading and coding the transcripts was done twice to ensure no important information was left out during the

first coding round.

### Interview participants

In total eight interviews were conducted; participants were selected based on their function and experience. Amongst the participants were two senior PMs employed by the case company, two PMs employed by an external project management firm, two PMs employed by clients and two circularity experts employed by the case company. In Table 3.2 an overview of the participants, their function and experience can be found.

### 3.2.3. Focus group

A second data gathering method is through three focus group session with the same participant combination. Two of the sessions took ninety minutes and the last sessions took an hour, the dates of the focus group sessions can be found in Table 3.3.. One of the benefits of group sessions is the potential for discussion between participants. Participants are pulled out of their individual trains of thought. By responding to each other different information comes up (Baarda et al., 2018; Verschuren & Doorewaard, 2007). The identification of variables is the first step of the second phase of the ST&M methodology. These variables are formulated and linked during the focus group sessions. The result of the focus group is a workable and agreed upon CLD, together with a list of intervention strategies.

Table 3.2. Description participants semi-structured interviews barriers

Group	Code	Description of role	Experience [year]	Date of interview
<b>Project manager</b>	PM1-B	Employed at case company, mostly public or semi-public projects	>30	November 8, 2023
	PM2-B	Employed at case company, mostly public or semi-public projects. Lot of experience with circular projects	>40	November 15, 2023
	PM4-B	Employed at small (team of 20) construction management and consultancy firm in the Neherlands. Combination of public clients, housing associations and businesses.	15	November 30, 2023
	PM5-B	Employed at small (team of 20) construction management and consultancy firm in the Netherlands. Combination of public clients, housing associations and businesses.	10	January 8, 2024
	<b>Client</b>	PM3-B	Employed as PM at the housing department of a nationally operating public party. In possession of >500 properties and a combined floor area of 1,8 million m <sup>2</sup> .	>10
	PM6-B	Employed as PM at the housing department of a nationally operating public party. In possession of >500 properties and a combined floor area of 1,8 million m <sup>2</sup> .	>20	January 9, 2024
<b>Sustainability</b>	CEex1	Employed at case company, seconded to a local authority. Working for 2 years on a circularity tool for said local authority.	<5	December 1, 2023
	CEex2	Employed at case company, advises in sustainable buildings with a special focus on BREEAM certification. Advises mainly on non-residential construction.	>10	December 4, 2023

In the following sections first the focus group composition is presented. This is followed by the data analysis method and an elaboration on the steps in each of the group sessions.

### Focus group participants

A group of five employees of the case company took place in the focus group. Focus group participants were invited based on their experience with project management and diverging experience with circularity in their projects. A total of eight participants were asked and a few of them had to cancel due to their work schedules. In Table 3.4 participants experience is indicated with the number of years they work. The group consisted of PMs, all involved in the planning stages of the project but with experience throughout the project life cycle.

Table 3.3. Date and time focus group session

Session #	Time [minutes]	Date
Focus group 1 (FG1)	90	January 24, 2024
Focus group 2 (FG2)	90	February 7, 2024
Focus group 3 (FG3)	60	February 28, 2024

### Data analysis

Data analysis for all group sessions proceeded in a similar

Table 3.4. Coding and experience focus group participants

Code	Experience [year]
PM1-F	<10
PM2-F	>5
PM3-F	>30
PM4-F	>30
PM5-F	>30

manner with the combination of transcripts and pictures. The focus groups were recorded, and a full transcription was made making use of the transcribe tool in Microsoft Word Online. This transcript was thoroughly reviewed and corrected by the researcher. The transcripts were made anonymous to ensure participants privacy. During the group session pictures were made of the results generated. The input was used to develop the CLD in the modelling software VENSIM.

Making use of ATLAS.ti data analysis software the transcripts were analysed. Coding was conducted using a combination of inductive and deductive coding approaches. Coding schemes for each session can be found in Appendix D1.

### Session one: Hexagon mapping

The first focus group session aimed to identify variables influencing circularity in the I&D phase using hexagon brainstorming. This is a creative brainstorming technique in which hexagons play a central role. It was developed by two 'creativity and organizational development consultants'; Antony Hodgson and Gary Chicoine-Piper. This technique can be used to surface underlying assumptions and mental models in a group setting (kreutzer, 1997). The creative thinking process is supported by making use of movable hexagon shaped post-its. Due to their shape hexagons can easily be linked and clustered and thought are separated from their original owner.

A three-step technique was used to identify variables (Adams & Cavana, 2009; Maani & Cavana, 2000; Woog et al., 2006):

1. Identifying issues
2. Identifying clusters
3. Identifying variables

A PowerPoint presentation and guide were developed based on these three steps to help the researcher stay on track during the focus group (Appendix D2). In the guide the information and questions provided by the researcher are fully written out. Time for discussion was built in during the session. The guide served as a means of making sure all information was shared and all steps were taken.

## Data analysis

During this first step problems, uncertainties, opportunities, opinions, ideas and questions are generated around a central question (Cavana et al., 1999). The participants mental models and concerns are surfaced (kreutzer, 1997). This step captures the 'event-level of the world. Participants were asked to write down problems and thought around a central question individually. This was summarized in a maximum of six words and was written down on **yellow** hexagons.

The hexagons were pasted on a wall in random order, after which the participants were asked to respond. Some new problems and thought were written down and added. This discussion continued until no new thoughts came up. On **orange** hexagon post-its barriers resulting from the interviews were added.

The group was asked to propose intervention strategies after the previous discussion was concluded. These interventions identified are seen as 'event-based' interventions because they were proposed before knowing the dynamics in the system. These interventions were written down on **white** hexagons and pasted on another wall.

### Identifying clusters

In this step the problems and thoughts collected on the yellow and orange hexagons were clustered. The focus group was split up. One half was asked to cluster the related hexagons together, the other half had to respond to the suggestion the first group made. After consensus was reached, each cluster was named (kreutzer, 1997).

### Identifying variables

Variables were formulated based on the clusters defined in the previous step. These were written down on a **blue** hexagon post-its. The group was split up in smaller sections to execute this step. The variables were pasted on the wall next to their cluster.

Table 3.5. Hexagon brainstorming colour coding

Color	Meaning
Yellow	Problems, uncertainties, opportunities, opinions, ideas, questions
Orange	Problems and barriers from interviews
Blue	Variables

### Session two: Relations and interventions

The goal of the second session was to discuss and agree upon variable names, develop a CLD and formulate intervention strategies based on that.

The session started with a review of the variables formulated by the participants in the previous session. After validation the group was asked to indicate relations between the variables. This resulted in a preliminary CLD.

Based on this CLD intervention strategies were proposed. In the following paragraphs the steps in this session will be explained in further detail. Slides and a focus group guide were prepared, the focus group guide is available in Appendix D2.

### Validating variables

The variables resulting from the first session are discussed so they meet the formulation requirements for variables. All variables were discussed, and extra attention was given to variables that had to be reformulated. This discussion and validation were conducted around a discussion table. The researcher acted as a facilitator, asked questions and made sure all participants were heard.

### Linking variables

In this step, the focus group was asked to indicate the relations between variables making use of painter's tape and markers. The variables as decided upon in the previous step were written down on blue hexagon shaped post-its and were pasted on a wall. The tape was used to create a line between the variables. With a marker the direction with and the polarity of the link with a plus (+) or minus (-) sign were added (see Figure 3.2). These lines could easily be added and removed by all the participants. This method was preferred over a digital method, because it ensured the equal participation of all participants in drawing lines and relocating variables. This interactive linking of variables, resulted in a preliminary CLD.



Figure 3.2. Small section of CLD developed by Focus group showing how relations were indicated. Source: own image

### Developing interventions

In this step intervention strategies were formulated based on the feedback loops that emerged in the CLD. First, the focus group was asked to identify variables with the most impact. Second, the problematic structures were identified. Third, for each indicated key variable a discussion took place to formulate intervention strategies to break or add a link or to shorten a delay. The suggested interventions were written down on yellow hexagon and added to the wall.

### Session three: Validation

The researcher further developed the CLD using the input

of both group sessions and the pictures. Some assumptions were made based on literature or the thesis limitations. For clarification of certain points, additional one-on-one conversations were held with the participants.

To reflect on the model, in a third, sixty (60) minute session, the CLD was presented and discussed. The focus group guide used during this session can be found in Appendix D2. This session completely took place around a discussion table. The CLD was first presented as a whole and later divided in smaller sections. Based on the conclusions of this discussion some final changes were made to the model.

The second session was used to reflect on the ST method and its use in the study. This was done through a central discussion. This was suitable in this case because the focus group participants were already familiar with each other. They are colleagues and have been working together for a longer time.

### 3.2.4. CLD analysis

the 'loops' tool in VENSIM® was used to analyse the CLD and determine the systems leverage points. Data on all variables was retrieved. The number of loops each variable is part of is gathered. Furthermore, the number of loops with less than eight variables is extracted. Loops of eight variables or less are relatively short, indicating that a change in one variable in the loop will result in an effect on the other variables relatively quick. The variables that are part of more than ten loops of less than eight variables are considered leverage points. The expected effect of the proposed interventions on these variables is drawn out in behaviour over time diagrams.

## 3.3. Data reliability, validation and triangulation

Data reliability is ensured by audiotaping and transcribing the interviews and focus group sessions. The transcripts of the interviews were shared with the participants to give them the opportunity to make changes or add clarifications. The participants of the focus group were also given the opportunity to read through the transcript. The consecutive steps of the focus groups ensured time and space to reflect on previous steps and clarify when needed. Supervisors were consulted during the development of the interview guide and focus group planning. Their comments helped in strengthening data collection.

During a third session with the focus group, the model was validated. This was to ensure the CLD developed was agreed upon by the focus group.

To triangulate and verify the findings, four one-on-one semi-structured interviews were conducted with field experts. They were not involved during the other stages of the study. The aim of these interviews was to determine

the generalizability of the model beyond the focus group and validate the results. An interview guide was prepared (Appendix E) and the following steps were taken. The current problems related to the incorporation of circularity in the initiation and definition phase were introduced. The interviewees were then asked about the intervention strategies they would propose to overcome these. This was followed by an introduction of the interventions proposed by the focus group. Based on the full set of intervention strategies the interviewees indicated what they considered to be the most effective interventions.

The CLD and expected effect of the interventions was walked through together with the interviewees and they were asked if they considered the CLD to be correct and complete. A short reflection of the process followed. The results of these interviews are used to draw the final conclusions and are added in the discussion section.

### *Interview participants*

A total of four semi-structured interviews were conducted for data validation and triangulation. The participants of these interviews were selected based on their function and diverging experience with circular projects. All four participants were employed at the case company. In Table 3.6 their work experience in years is indicated. The group consisted of PMs, all primarily involved in the planning stages of projects.

*Table 3.6. Discription participants validation interviews*

<b>Code</b>	<b>Experience [year]</b>	<b>Date of interview</b>
PM7-F	<10	March 19, 2024
PM8-F	>30	March 20, 2024
PM9-F	>30	March 26, 2024
PM10-F	>20	March 28, 2024

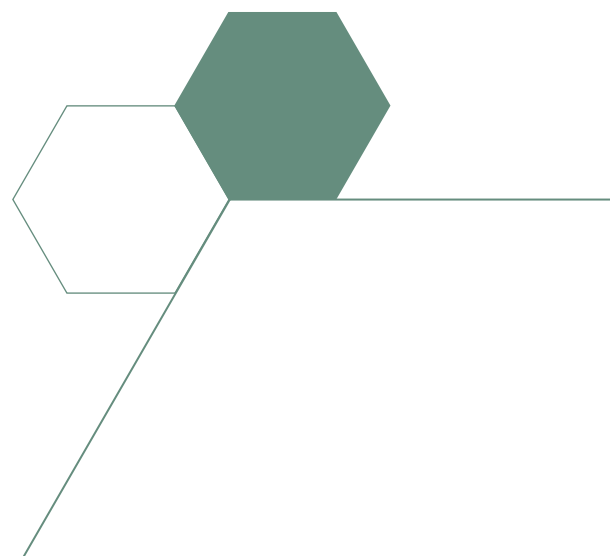
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# CHAPTER 4

# RESULTS



# Results and analysis

In this chapter the results from the empirical research are discussed. In section 4.1. barriers impeding the uptake of circularity in the I&D phase of building projects, as found through the interviews are discussed. This is followed by the presentation of a CLD reflecting the process of incorporating circular ambitions in the I&D phase of building projects. The results of the intermediate steps to arrive at the CLD are highlighted. This section concludes by identifying key leverage points and explaining the intervention strategies. In the last part of this chapter, the intervention strategies proposed by the focus group and in the one-on-one interviews are introduced and linked to the leverage points.

## 4.1. Barriers impeding circularity in the initiation and definition phase of building projects

Through eight (8) interviews with field practitioners, twenty-six (26) barriers impeding the uptake of circularity in the I&D phase were identified. No environmental barriers were identified, this is as expected since environmental barriers

occur in the end-of-life phase of projects (Charef et al., 2021; Osei-Tutu et al., 2023). Environmental barriers are therefore not further considered in this research. Barriers from all other identified barrier categories (economic, social, technological, organizational, cultural, technical and regulatory) were found. An overview of the identified barriers for each category is displayed in Table 4.1.. Paragraph 4.1.1. until 4.1.7. will further elaborate on the identified barriers.

### 4.1.1. Economic barriers

Economic barriers were the most cited by the interviewees. Barriers in this category were mentioned by all the interviewees and were often brought up multiple times. Most of these barriers are concerned with either budget constraints or costs increases due to the introduction of circular measures.

In this category, the necessary higher investments (B1) is the most mentioned barrier. Four interviewees stated that circular principles and measures require a higher

Table 4.1. Barriers to the Initiation and Definition phase of a building project.

Category	Barriers	# mentioned
<b>Economic</b>	B1 Higher investment	10
	B2 Financial models are not organised for circularity	5
	B3 Budgets are predetermined without considering extra budget for circularity	5
	B4 Second hand materials are not available	4
	B5 Requires an upfront investment	2
	B6 External factors cause increasing prices	1
<b>Social</b>	B7 Limited time and capacity of PM or project group	4
	B8 Insufficient knowledge about circularity	4
	B9 Novelty of reuse	2
	B10 Poor expectation of esthetics	2
	B11 Perception of high costs	1
<b>Technological</b>	B12 Quality guarantees for reuse	3
	B13 Performance guarantees bio-based	2
	B14 Reused materials are not conform current norms and standards	2
	B15 No existing, widely used, market place for reused materials	1
	B16 Not one agreed upon consensus about what is (most) circular	1
	B17 Certificates such as BREEAM are time consuming	1
	<b>Organisational</b>	B18 Low commitment management
B19 Diverging interests within organisation		3
B20 Different ideas about circularity within management layers		1
<b>Cultural</b>	B21 Current market is not designed for circularity	3
	B22 Stakeholders perceive circularity as difficult	1
<b>Technical</b>	B23 Planning and storage is complex	4
<b>Regulatory</b>	B24 Inter-organisational tension	2
	B25 Uncertainty about circularity by policy makers	1
	B26 Applying for subsidies is time consuming	1

investment in general. Others specified that the increased costs were due to the reuse of materials, the higher costs of renovation in comparison with building new or the higher costs of circular deconstruction.

CeEx1 provided some nuance on this topic. They stated *"I always find that financial barrier a bit tricky, because I have been working at the municipality of [CITY] for two years now and we do quite a lot of circular things. We have never experienced that it [the costs] really goes massively out of step, and often you even see that circular projects turn out to be cheaper."* When asked how they would explain increased costs were still a reoccurring barrier, they mentioned three things. First, sometimes it is reality and the costs do increase. Second, people with limited knowledge about circularity truly believe it to be true. And lastly, it might be an easy excuse to not deal with it. *"If you find something difficult, complicated, you're already up to here in your project. You have to consider so many things, I understand that too. Then there's also someone who comes along and says you have to do circularity... Sometimes it might also be a bit of an excuse."*

Other barriers, such as the current insufficient financial models (B2) and predetermined budgets not considering circular measures (B3), are related to budget constraints. The first barrier was mentioned by five different interviewees and the latter by four of them. Budgets are determined before the definition phase, if in the previous phases circularity is not considered it is difficult to still include it in the project. PM6-B said: *"if we get a project assignment, with the project calculation, so let's say, in the business case, without additional circularity costs, then it is very difficult to incorporate that afterwards."* Furthermore, budget calculations are often based on pre-existing cost figures that do not yet consider circularity, this results in tight budgets if you do want to make a project circular. PM3-B stated: *"it was based on old cost figures in which this [circularity] was not considered yet. But the budget is determined in the definition phase and that is what you will have to work with"*.

The mismatch between available second-hand materials and the market demand is another barrier in this category. This mismatch can emerge from material availability in general, but it is also mentioned that the available materials do not one-on-one fit a new situation. PM2-B said: *"And it is mainly a search for the product that is fitting. Then you also have to modify it so that it becomes suitable for the project. The effort is sometimes more than when you just order new"*.

#### 4.1.2. Social barriers

In the social barrier category, the most cited barriers were related to capacity and knowledge. These barriers were brought up by four out of the eight participants.

Capacity is related to the limits of PMs, or the project team in terms of time and pressure that is put on them. PM5-B said: *"it requires a lot of additional energy and research"*. Projects are often complex only considering the law and regulations, this is without the additional wishes the client adds. Adding circularity increases complexity, which the team might not be able to handle. This was also stated by SusEx1 as an explanation for using the perceived cost increase as an excuse to not implement circular practices.

Knowledge can be generated from previous experience of the PM or the project team. CeEx1 mentioned: *"it is always easier to do what you have been doing, because that is what you already know"*. It also relates to the absence of example projects that can be used as a source of inspiration as well as a source of knowledge. The absence of such projects leads to a higher time investment needed to gain the required knowledge. The 'novelty of reuse' barrier is also related to this.

The last barrier identified in this category, poor expectation of aesthetics, stems from the current norms and trends. It can be attributed to the user viewpoint but also to the client organization. Organization and user are not yet ready to accept small flaws and signs of use.

#### 4.1.3. Technological barriers

Barriers in this category are the need or wish for quality guarantees on reused materials (B12), bio-based materials not being proven, and the lack of performance guarantees (B13) and reused materials are not in line with the current norm (B14).

Proof of quality is sometimes required by the client in some cases. For example, in the healthcare sector, because this sector deals with high safety norms. However, in other sectors, the client still requires this proof to reduce risk. PM2-B: *"... than you do not have such a guarantee. As a client, you have to be willing to work with that, many clients don't want that."*

The increasing quality requirements of materials is another barrier related to the one-on-one reuse of materials. Materials that can be harvested from buildings build twenty-five (25) or fifty (50) years ago do not meet the current standards.

Uncertainties surrounding bio-based materials that are still experimental, are also brought up as a barrier. These materials are often not proven in practice yet and it is unknown how the material will hold up over a longer time span. This also leads to a risk that clients might not be willing to take.

#### 4.1.4. Organizational barriers

The following three organizational barriers were identified:

low commitment from management (B18), different interest within the organization (B19) and, different perspectives on circularity (B20). Two of these barriers are concerned with management, the other with diverging interests within the organization.

A lack of management commitment means that a PM must have an internal incentive to implement circularity for the incorporation of circularity to improve. This was specifically noticeable in the answers of the client PMs. PM3-B said: *“It starts with the formulation of those requirements; am I currently being triggered by my organization? [...] Up to now, that might have been an impediment. It [circularity] really has to come from within yourself then.”* And PM6-B wondered whether their organization would still be willing to provide the funds if their circular projects had to deal with a tighter budget and less positive prospects.

Lack of management commitment can also directly steer towards minimum effort for circularity. PM1-B provided an example where the organizations management, that signed the green deal, tried to limit the costs by requesting an investigation on how to get away with minimum efforts. Diverging interests within the organization was also mentioned by three interviewees, they all mentioned it in relation to the maintenance party. Implementing reused or bio-based products might cause resistance within the organization, and specifically by maintenance, because it is expected to require more maintenance.

#### 4.1.5. Cultural barriers

Two cultural barriers were identified these are the current design of the market (B21) and the perception of circularity as difficult (B22).

The flawed design of the current market stems from the standard procedures in the industry, where a request for a quotation is made and a contractor must provide a price. It is difficult, if not impossible, to base this on potentially available reused materials. PM6-B stated *“then it is not just about the contractor not being able to, but also the system around is, the market, is not set up for this. So, suppose the contractor had decided to provide our entire renovated building with recycled ceiling tiles. I think he would not be able to get them. [...] because the market is not designed for it.”*

The perception of circularity as difficulty is only mentioned by one of the interviewees and is related to the perception of circularity as difficult. They stated that almost everyone is willing to talk about circular solutions. However, this is followed immediately by questions related to the expenses, quality and uncertainties in maintenance.

#### 4.1.6. Technical barriers

The complexity around planning and storage for one-on-

one reuse (B23) was the only identified technical barrier. It relates to the complexities of storage and planning when considering reuse. Storage and planning are related but can be seen as individual problems. One interviewee stated, *“everything has to fall together with the right timing”*. The correct materials need to be available at the right time. If not, you either are missing materials or you must store them for a long time. Storage is not that simple either, space is needed, and this also relates to costs. In some cases, it is not even certain the materials will be used again in the future.

#### 4.1.7. Regulatory barriers

Inter-organizational tension (B24), uncertainty about circularity by policy makers (B25) and timely procedures for applying for subsidies (B26) were the identified regulatory barriers. Inter-organizational tensions can be a problem, when organizations policymakers miss the connection to practice. Another barrier is that government or policy makers do not really know how to deal with circularity. Lastly, subsidies can be an important driver but at the same time cost a lot of time and energy to apply for. Making them less interesting to apply for.

## 4.2. Developing a Causal Loop Diagram reflecting the uptake of circularity in the initiation and definition phase of a building project

The CLD is developed over the course of three focus group sessions. After each session the results were analysed and used as input for the following session. In this section the results of the consecutive steps to develop the CLD are explained. This is followed by an explanation of the CLD itself.

### 4.2.1. Formulation of relevant variables for circularity in the initiation and definition phase

Making use of the hexagon brainstorming technique, a total of thirty-two (32) variables were formulated. This was done around a central question: *“What influences the realization of circular ambitions in the I&D phase of a project?”*

The first step of the hexagon mapping method resulted in a total of fifty-one (51) problems. Five (5) of the identified *problems* occurred twice and one problem was mentioned on three (3) different post-its. In total forty-four (41) unique *problems* were generated. In the following step these problems were clustered in eleven (11) clusters: management, rules, material quality, behaviour organization, project budget, certainty, knowledge, behaviour personal, planning, vision/story and long-term investment. Based on these clusters the group formulated twenty-six (26) variables during the first session. By adding, removing and renaming these variables based on the data

generated during the focus group and one-on-one sessions with the participants the thirty-two (32) variables in Table 4.2 resulted. In the tables a short description of each of the variables is provided. The description is based on the data gathered during the focus groups. A further elaboration of

the steps taken during the first focus group session can be found in Appendix F.

Table 4.2. Description of the variables used in the Causal Loop Diagram

Cluster	Variable name	Description
<b>Management</b>	V1 Degree of management vision	The extent or extremity to which management of the client organisation possess a circular vision, the ambition level of that organisation.
	V2 Sustainability standard	The supra-legal requirements that an organisation imposes on itself with respect to circularity; these can become more or less stringent
	V3 Commitment management	The extent to which an organisation's management is willing and determined to make circular choices. It is concerned with vigor
<b>Behavior Organisation</b>	V4 Progressiveness organisation	Pertains to the rate at which an the client organisation, and specifically the client representative, adopts circular principles. In other words it can be formulated as openness to change or the degree of having a progressive view.
	V5 Organisation circularity ambition	The level of engagement and motivation of the client organisation, and specifically the client representative, with regards to circular principles.
<b>Long-term vision</b>	V6 Life-cycle thinking	Reflects the extent to which an organisation incorporates the full life-cycle of the products and the project into their decision-making process
	V7 Importance of residual value	Pertains to the value that the building holds for the client organisation at the conclusion of its term of use. This is related to the issue of ownership and/or use.
<b>Behavior personal</b>	V8 Support base	The level of support for implementing circularity among <b>project stakeholder</b> and the project team. There can be a lot of support, it can be indifferent but also no support at all.
	V9 Enthusiasm	Level of eagerness, excitement or intense interest of the project team individuals, and specifically the PM, towards the topic of circularity.
	V10 Ambition	It pertains the (internal) drive of project team individuals, and specifically the PM, to implement circular principles, this can be fueled by a shared goal.
	V11 Courage	Level of braveness. The willingness of the project team individuals, and specifically the PM, to confront challenges, take action and continue on the path of circular solutions despite potential risk.
	V12 Persuasiveness	The ability or tendency of project team individuals, and specifically the PM, to convince others of implementing circular principles in the project. It encapsulates the effectiveness with which the project team individuals can influence the attitudes and believes of others towards the implementation of circular principles.
	V13 Progressiveness	Pertains to the openness to change of the project team individuals, and specifically the PM.
<b>Knowledge</b>	V15 Capacity of people with knowledge	Concerns both the profundity of understanding pertaining to circular principles and materials as well as the capacity to implement this knowledge within the scope of the project. It can be attributed to all project stakeholders. It could be measured in hours or FTEs and can increase when the number of people with knowledge increases.
<b>Project budget</b>	V16 Costs	Concerns the financial expenses of a project that can increase or decrease due to various factors.

Table 4.2. Description of the variables used in the Causal Loop Diagram - Continued

	V17 Investment budget	A predetermined budget allocated to the project. This variable refers specifically to the funds made available for investing in the project, it does not include budgets designated for maintenance and operation that take place in a later stadium.
	V18 Priority of circularity in budget	Reflects the priority of circularity and how this shift with budgetary constraints. It regards the question how quick are circular measures cut when presented with budget constraints.
<b>Planning</b>	V19 Development time	Concerns the temporal investment necessary to develop the project. It is anticipated commonly that a deviation from standard procedures will result in an extended period of development.
	V20 Experience	The amount of experience a project team has with the topic of circularity in their projects
	V21 Insight	The degree of insight into the benefits of circularity and how to implement and execute it.
<b>Quality material</b>	V24 Availability of circular materials	The variable concerns the amount of bio-based and reusable materials that is available in the market. It pertains to the quantity
	V23 Material certification importance	This variable pertains to the importance of proven quality of the used materials for the client organization. New, conventional materials often include a manufacturer's warranty, certificate or proof of quality. For reused materials the warranty has often expired and must be certified again to get the proof. Bio-based materials are often revolutionary and do not have such quality marks or proof yet. Evidence of quality is not necessary for all applications and plays a larger role for some clients than for others.
<b>Certainty</b>	V25 Knowledge sharing	The degree to which information, skills, or expertise about circular practices and materials is shared between individuals within the organisation.
	V27 Degree of innovation	The generation and successful implementation of new concepts, principles and materials or products related to circularity in projects. This variable refers to frequency of successful implementing new developments.
	V28 Availability of virgin materials	Specific to scarcity of virgin materials.
	V29 Geopolitical unrest	Uncertainty and unrest in the world due to factors such as war and natural disasters.
	V30 Certainty	The degree of assurance that is available about the (innovative) circular principle and materials. It includes knowledge, beliefs and expectations.
<b>Rules</b>	V32 Law and regulation	Law and regulation determine the minimum threshold for circularity in projects. It is imposed by government and can become more or less stringent over time
<b>Vision/story</b>	V33 Social circularity norm	Relates to the broader societal discourse and support surrounding circularity
<b>Goal</b>	V34 Circularity in project brief	The extent to which circular principles and behavior is adopted in the project brief
<b>Others</b>	V35 Budget available for circular solutions	Reflects the budget allocated to circularity in the project. This variable was formulated to reflect the joined effect of V2, V7, V17 and V18 on circularity in project brief (V34).
	V36 Threshold to use circular materials	Reflects the threshold that is experienced by the project team to use circular materials. This variables was formulated to reflect the joined effect of V23, V24 and V28 on experience (V20).



Figure 4.1. Causal Loop Diagram as developed during Focus Group session 2. Source: own image

#### 4.2.2. Identification of interrelations between the relevant variables

The variables from Table 4.2. are used in the final CLD. During the second focus group session the group was asked to indicate relations between the variables as they were formulated at that time. Figure 4.1. shows the preliminary CLD at the end of the focus group session.

This model was the base input for the development of the final CLD. It was further developed in an iterative manner, one-on-one conversations with focus group participants were held and a validation session with the whole group followed. The final CLD is displayed in Figure 4.3, the final diagram includes six (6) external variables and twenty-six (26) internal variables. A further elaboration of the steps taken to get to the final diagram can be found in Appendix G.

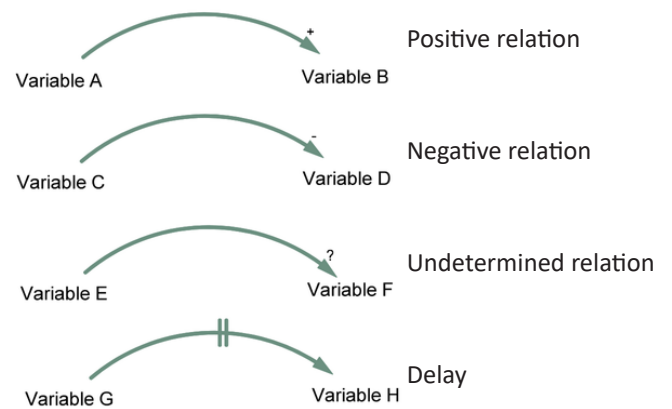


Figure 4.2. Overview of symbols used in the Causal Loop Diagram and their meaning. Source: own image

Table 4.3. Variables per stakeholder group

Project team	Client management	Client organisation
Enthusiasm	Degree of management	Progressiveness organisation
Ambition	Sustainability standards	Organisation circularity drive
Courage	Commitment management	
Persuasiveness		
Progressiveness		

**Legenda Themes**

- Certainty
- Knowledge
- Innovation
- Materials
- Courage

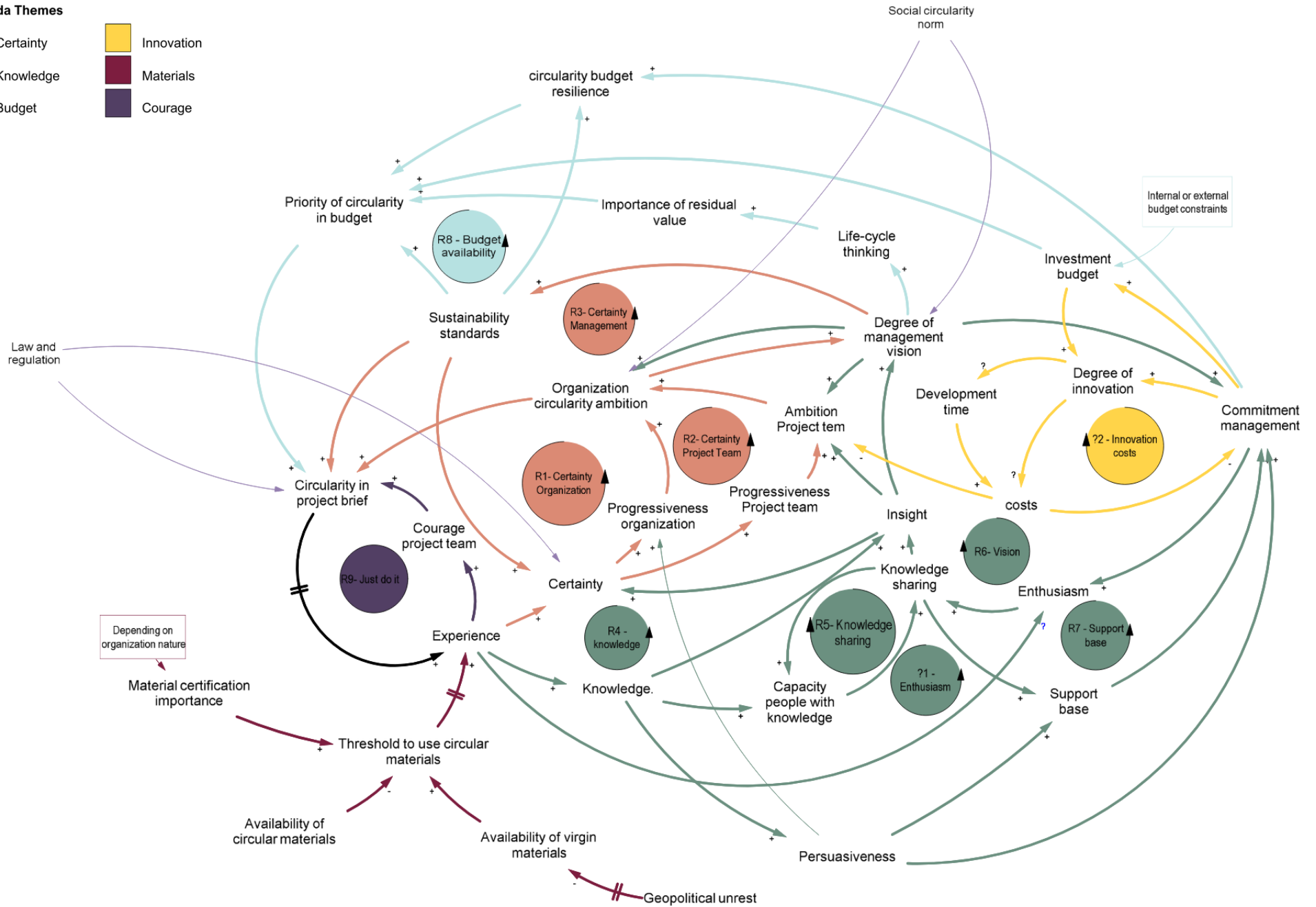


Figure 4.3. Causal diagram reflecting the process of incorporating circularity in the I&D phase of a building project, from a project managers point of view. Own image



### 4.2.3. Elaboration of the Causal Loop Diagram reflecting the uptake of circularity in the I&D phase of a building project

In this section some assumptions during the development of the CLD are discussed.

The better incorporation of circularity in the project brief is the goal of the system. As explained before, the final product of the I&D phase is the project brief (or 'programma van eisen' in Dutch). It is assumed when circularity is better incorporated in the project brief, more circular projects will be built and thus 'experience' will increase. Therefore, the variable 'circularity in project brief' was added during process of identifying relations

Three specific stakeholder groups were identified during the second focus group: client management, client organization (and specifically the client representative) and, the project team (and specifically the PM. This linking was further confirmed during the one-on-one conversations that followed. In Table 4.3 these groups and the corresponding variables are displayed. Other variables are related to all involved parties or the project.

During analysis of the CLD, multiple themes were found, these are indicated with different colours. These themes are certainty, knowledge, innovation, budget, courage and materials. Each of these themes will now be explained.

### Certainty loops

Certainty is the first theme that was found and relates to the effect if certainty on project managers ambition, organization ambition and client vision. In Figure 4.4. this theme is extracted from the complete model. The variable 'circularity in project brief' (V34) is part of this theme, it leads to experience, which in turn leads to certainty.

In general, three reinforcing feedback loops can be distinguished in this section, all indicated with a red circular arrow in the middle (Figure 4.4). The first loop, indicated as 'certainty organization', moves from certainty to progressiveness and ambition of the organization. This loop shows that through experience and thus certainty, circularity will end up in the project brief and eventually lead back to experience and certainty. The loop indicated as 'certainty project team', builds further onto the previous loop. Certainty also leads to progressiveness and ambition of the project team; through organization's ambitions this eventually leads back to experience. The third loop, indicated as 'certainty management', includes sustainability standards. It shows how certainty, through ambition of the organization, influences the management vision and in turn the organizations sustainability standards, this circles back to certainty. Figure 4.4 also shows two external variables that influence the system: social circularity norm and law and regulation. As shown in the model, social circularity norm influences the ambition of the organization and

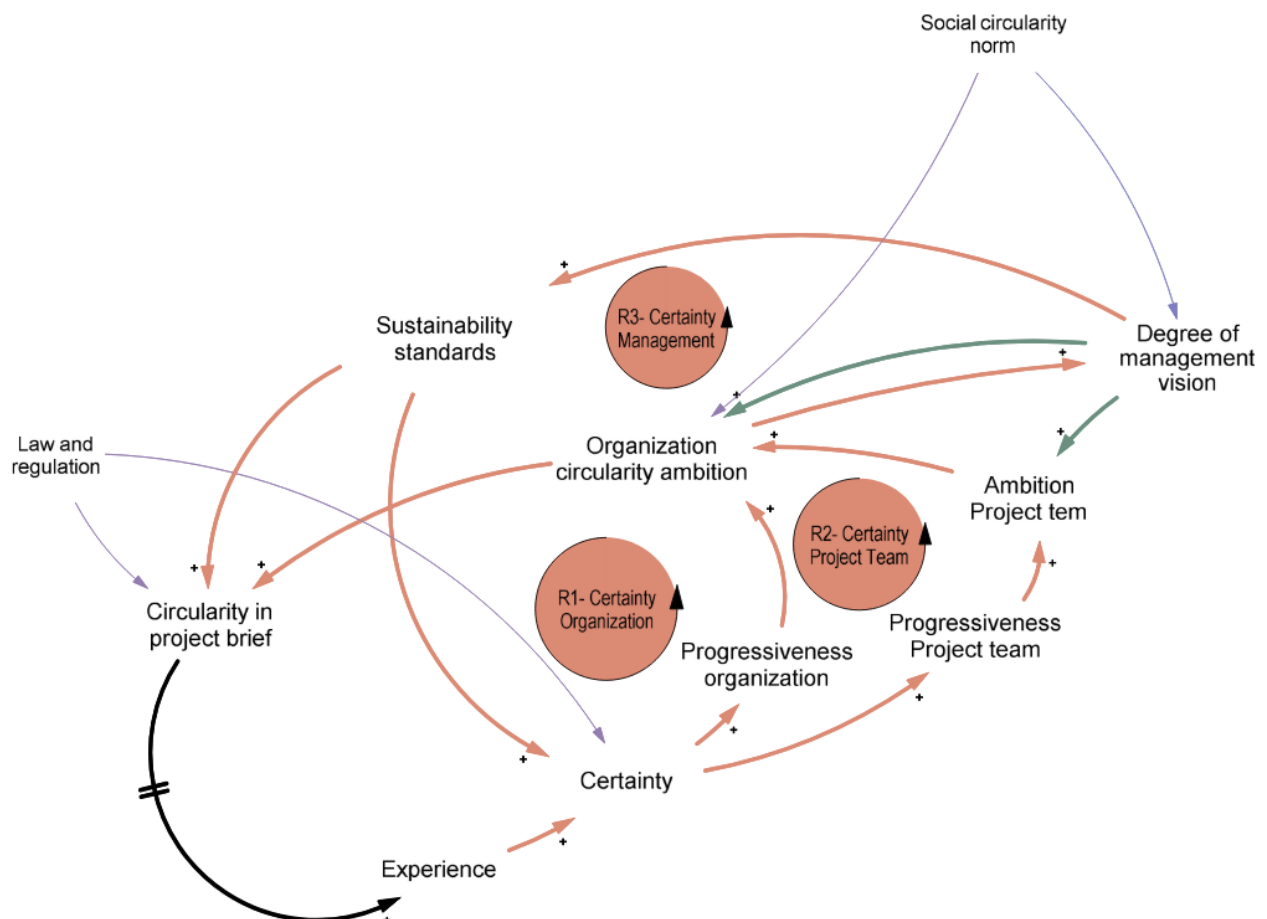


Figure 4.4. Certainty loops. source: own image





management vision. Law and regulation directly influence circularity in project brief, but the effect is also indirect through its effect in certainty.

### Knowledge loops

Loops in the knowledge theme present the role of knowledge and knowledge sharing to influence the degree of circularity in the project brief. In Figure 4.5 four reinforcing and one undetermined loop can be identified.

The enthusiasm loop is undetermined, since experience with circularity can either be positive or negative. Therefore, the effect experience has on enthusiasm can either be positive or negative. Enthusiasm also plays a role in the vision and support base loop.

### Budget loops

The degree of management vision and management commitment play a key role in the budget theme as can be seen in the extraction of the model in Figure 4.6.

Two dotted lines are added from experience to degree of management vision and commitment management. These lines replace the multiple variables and relations from experience to these two variables. Multiple variables influence the circularity in the project brief through the budget that is available for circular solutions. These variables are the importance of residual value, the investment budget and the priority of circularity in the budget. The loops presented in Figure 4.6 are all reinforcing. If budget is made available for circular solutions, this will eventually lead to more experience, and in turn to increased management vision and commitment which circles back to the available budget.

### Innovation loops

The nature of the 'innovation' loop (Figure 4.7) is undetermined. It concerns whether to apply new

innovations in the projects and degree thereof. As stated by the participants in the focus group, these innovations can either lead to an increase of costs and time needed to develop, but it could also lead to a decrease. This depends on the type of innovation and the research investment it requires.

### Material loops

The material theme is built up with external variables that influence the threshold to the use of circular materials. This theme is presented in Figure 4.8, together with the courage theme. Availability of both circular materials and virgin materials are found to influence the threshold. Availability of circular materials is needed to be able to work and design with reused materials. Whereas the absence of virgin materials will force you to use more reused materials. Another aspect of this threshold is the proven quality of the circular materials. This variable is partly external, its influence depends on the organization and application of the material.

### Courage loop

Courage is the last theme found in the CLD, it shows how (positive) experiences will increase the project team's courage, which leads to more circularity in the project brief. During the focus group this was indicated as the 'just do it' mentality that is sometimes wanted or required.

## 4.2.4. Identification of the leverage points in the system

In this section the key leverage points present in the model are identified. As introduced in chapter two, leverage points are points or variables in the system where a small adjustment can have major impact (Maani & Cavana, 2000; Raghunathan, 2021).

Leverage point in this system is presented in Table 4.4,

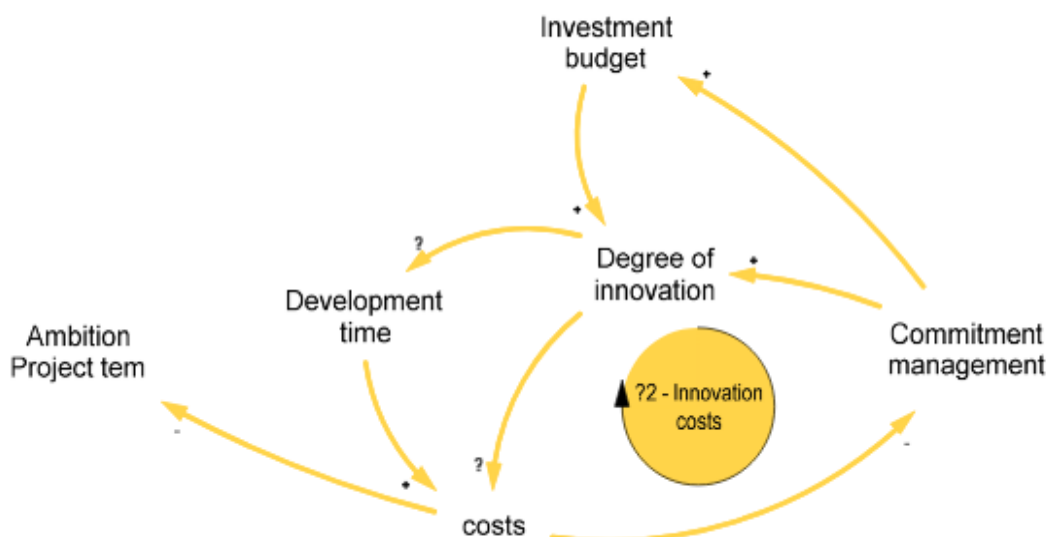


Figure 4.7. Innovation loops. Source: own image

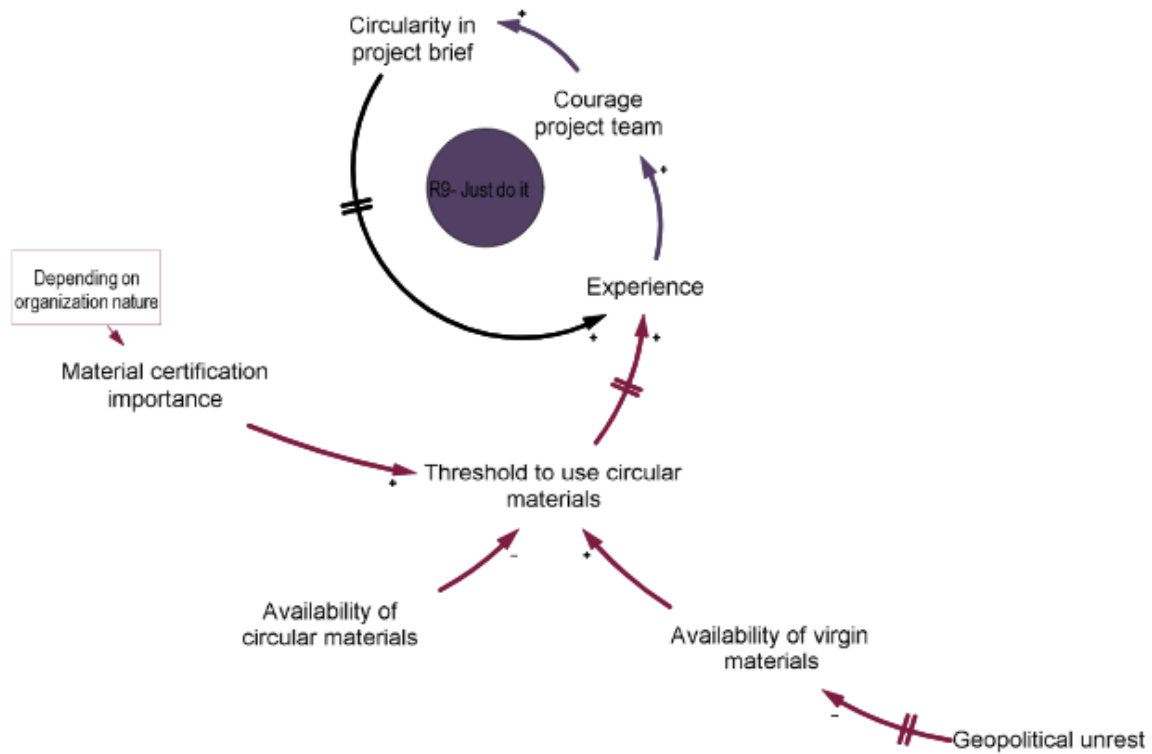


Figure 4.8. Material and courage loops. Source: own image

these are variables that are part of more than ten loops comprising of fewer than eight variables. These variables are considered potential leverage points due to their substantial systemic influence and the extensive number of variables that they affect. A comprehensive overview of this data is available in Appendix H.

‘Experience’ and ‘Circularity in project brief’ are part of the exact same loops and can be considered as one. ‘Circularity in project brief’ is the aim of this system, ‘experience’ the wanted effect.

Some of these variables, such as ‘knowledge’ and ‘insight’ and ‘degree of management vision’ and ‘commitment management’, show a direct relation. This suggests that

any intervention targeting the influencing variable is likely to precipitate alterations in the influenced variable. Nonetheless, the impact of such interventions may not be as pronounced as those enacted directly upon the influenced variable. This can be attributed to the presence of delays or other interconnections.

Based on the CLD in Figure 4.1 the focus group concluded the following leverage points: “you need the right person, the right money and the right boss” (PM5, FG2, February 7, 2024). This statement was related to the following variables in the CLD respectively: ‘ambition project team’, ‘investment budget’ or ‘costs’ and ‘degree of management vision’. This conclusion displays some overlap with the leverage points retrieved through the analysis in the VENSIM® software,

Table 4.4. Potential leverage points (key variables) and the number of loops the variable is a part of

Variable name	# loops total	# loops <8 variables
Experience = Circularity in project brief	261	35
Degree of management vision	230	30
Organisation circularity ambition	237	29
Insight	155	24
Knowledge	189	21
Commitment management	189	20
Ambition project team	179	16
Knowledge sharing	166	16
Sustainability standards	129	13
Budget available for circular solutions	155	13
Enthusiasm	108	12
Certainty	90	11

Table 4.5. Intervention strategies and when they emerged (FG = Focus Group, Int. = Interviews)

Intervention	FG1	FG2	Int.
Continuous education of PMs to ensure up-to-date knowledge and awareness	X	X	X
Consulting an external source of knowledge and experience	X	X	
Promote client awareness on the necessity and potential of circular approaches through inspiration and education	X	X	
Alleviate uncertainties regarding budget and quality	X	X	X
Create more budget space by well-considered scope revision and reallocation of funds	X	X	
Ensure a company culture that encourages innovation	X	X	
External factors such as changes in law and regulation or setbacks		X	X
Client management works on becoming more progressive	X		

where ‘ambition project team’ and ‘degree of management vision’ were also found.

### 4.3. Intervention strategies aimed at improving the uptake of circularity

Possible interventions for improving the integration of circularity in the project brief and requirements for building projects are obtained at various moments during the research. In the first place the focus group was asked about interventions before developing the CLD. After the CLD,

as shown in Figure 4.1, was developed they were asked to indicate interventions a second time, this time based on the model. In addition, interventions were also retrieved in a set of semi-structured interviews. The interviewees were asked to propose interventions and indicate the interventions they deemed most effective before the introduction of the CLD. In Table 4.5, the results of these discussions are summarized in eight different intervention strategies, and it is indicated when points contributing to that category were made.

Table 4.6. Linking intervention strategies to leverage points in the Causal Loop Diagram

Intervention strategies	Leverage variables											
	Experience	Degree of management vision	Organisation circularity ambition	Insight	Knowledge	Commitment management	Ambition project team	Knowledge sharing	Sustainability standards	Budget available for CE solutions	Ethusiasm	Certainty
Continuous education of project managers					Direct impact		Indirect impact 1-2 variables	Direct impact				
Consulting external knowledge		Indirect impact 1-2 variables	Indirect impact 1-2 variables		Direct impact		Indirect impact 1-2 variables					
Promote client awareness		Indirect impact 1-2 variables	Indirect impact 1-2 variables				Direct impact					
Alleviate uncertainties		Indirect impact 3-4 variables				Indirect impact 3-4 variables	Direct impact		Indirect impact 7-8 variables			Indirect impact 1-2 variables
Create more budget space		Indirect impact 1-2 variables				Indirect impact 3-4 variables	Direct impact		Indirect impact 3-4 variables			
Ensure a company culture that encourages innovation						Direct impact						
External factors - changing law and regulation			Indirect impact 1-2 variables			Indirect impact 3-4 variables						Indirect impact 1-2 variables
A change in client management - becoming more progressive		Direct impact				Indirect impact 3-4 variables			Indirect impact 3-4 variables	Indirect impact 3-4 variables		Indirect impact 1-2 variables

Table 4.7. Most effective interventions according to interview participants (before introducing the CLD)

Intervention	PM7	PM8	PM9	PM10
Continuous education of PMs to ensure up-to-date knowledge and awareness	X		X	X
Consulting an external source of knowledge and experience	X	X	X	
Promote client awareness on the necessity and potential of circular approaches through inspiration and education		X	X	X
Alleviate uncertainties regarding budget and quality				
Create more budget space by well-considered scope revision and reallocation of funds				
Ensure a company culture that encourages innovation	X		X	
External factors such as changes in law and regulations or setbacks	X	X		X
Client management works on becoming more progressive				

Most interventions that were mentioned during the first focus group also came forward during the second session, as presented in Table 4.5. An exception to this, are the last two interventions indicated in the table. Three of the interventions also came forward during the interviews, before introducing them to the interventions proposed by the focus group.

The proposed interventions can be linked to the leverage points as identified in section 4.2.4.. Four of the proposed interventions directly target the variables ‘knowledge’ or ‘knowledge sharing’, as can be seen in Table 4.6. All intervention strategies and their effect on the system will be further explained in the following sections.

Table 4.7 indicates the intervention strategies that were deemed most effective by the interviewees before the introduction of ST. This table indicates that the alleviation of uncertainties, creation of more budgets space and a change in client management are not seen as the most effective interventions prior to ST. An encouraging company culture is seen as relatively effective by two of the interviewees and the other intervention strategies are seen as rather effective by three of the interviewees. After the explanation of the CLD and running the interventions through the model, all participants concluded that they still believed their original indication of most effective strategies was correct and they would not suggest any other interventions.

### 4.3.1. Continuous education of project managers

The significance of knowledge emerged as a critical factor for the integration of circular principles within the focus group and various interviews. As articulated by PM5-F: *“It already starts on our side, recognizing the good examples and buttons you can turn”* (FG1, January 24, 2024). A PM must stay informed of the current market developments. Attention is required from the PM; however, it also requires the provision of opportunities by one’s employer to acquire such knowledge. PM7-F remarked during the interview, *“if I don’t know what’s going on in the market, I can’t sell it to the client, because he doesn’t know at all”* (March 19, 2024). A similar insight was disclosed during the focus group when

PM5-F stated: *“I believe that if we are capable of translating our sustainability ambitions and the sustainable practices we desire into a language that management understands and can base decisions on, then we have already made a significant step. Because my problem is, if I want to do a sustainable project at the hospital [...] to convince the board of directors [...] what story do I have? How do I convince the guy that he’s making a bad decision?”* (FG1, January 24, 2024). There is a gap in knowledge to properly convey the benefits, possibilities and need for a circular approach towards the client and its management.

The issue extends beyond mere knowledge, being informed and sharing successful projects executed by others can also exert a significant influence. As indicated *“examples inspire”*. If a colleague took part in a successful circular project and is telling about it enthusiastically this can have a contagious effect, inspiring others to do the same.

Thus, it is essential for PMs and other members of the project team to be informed about the possibilities and current developments and present them with inspiring examples. Employers can contribute to this by organizing education and inspirations sessions. This idea was aptly summarized by PM8-F: *“attention fosters growth”* (March 20, 2024). This intervention strategy relates to multiple leverage points and directly targets ‘knowledge’ and ‘knowledge sharing’. Indirectly it is expected to positively influence ‘ambition project team’ and through there, ‘experience’. The possible behaviour of these variables over time can be seen in Figure 4.9. The knowledge sharing sessions are reoccurring, and as indicated in the graph, all variables increase over time.

### 4.3.2. Consulting an external source of knowledge

As mentioned by multiple participants during the focus group and interviews there is a sentiment of ‘unknown makes unloved’. This can be explained by the risks and uncertainties that occur when deviating from the norm. Although uncertainties can also turn out to be positive, there is a tendency to avoid them.

Uncertainties and risks can be eliminated through knowledge and experience of the PM. However, PM1 also stated “..

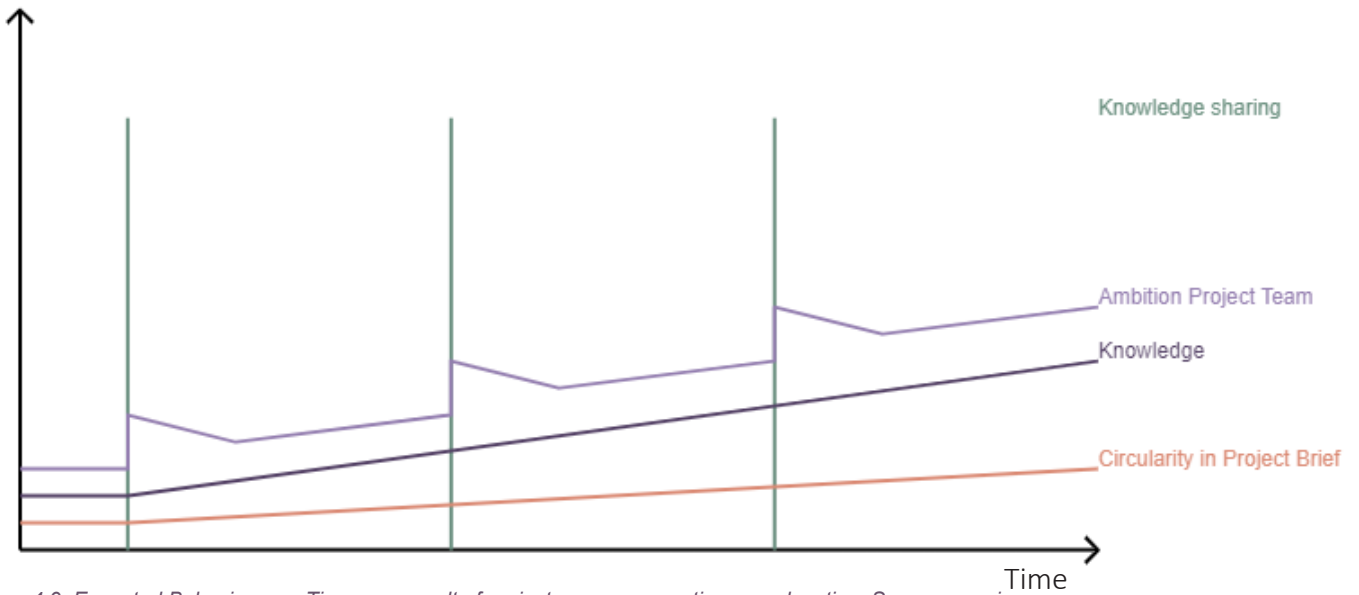


Figure 4.9. Expected Behavior over Time as a result of project managers continuous education. Source: own image

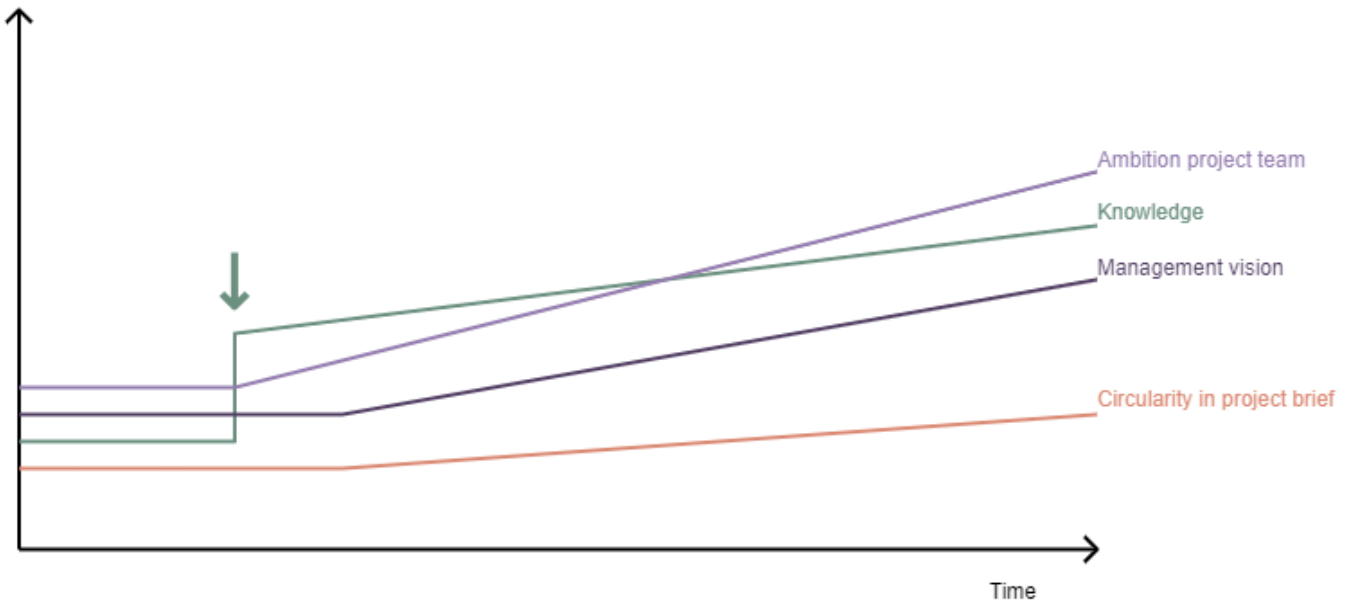


Figure 4.10. Expected Behavior over Time as a result of consulting a circularity expert. Source: own image

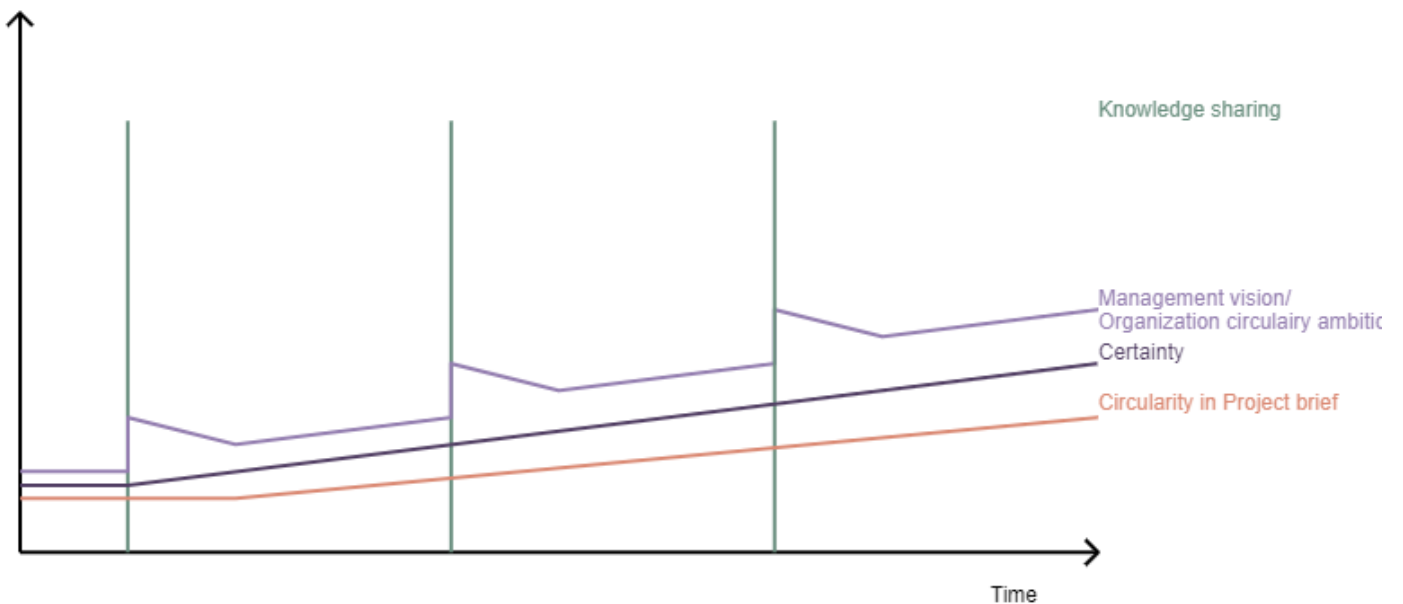


Figure 4.11. Expected behavior over Time as a result from the promotion of client awareness. Source: own image



*just as you hire a structural engineer to mitigate the risk of building collapse, why not hire a sustainability consultant to address the risk of the project being unsustainable? Then you ensure compliance with sustainability standards”* (FG2, February 7, 2024). This indicates that it is not always required of the PM to possess all required knowledge; they can also incorporate this expertise by involving someone with the appropriate knowledge and experience in their team. This would take away some of the risk and uncertainties, providing the PM with the courage for implementing innovative and circular solutions. As also described by PM2: *“But also having someone with knowledge beside you, someone to rely on, that’s what I would need as a person. That I think, well now it’s going to be alright”* (FG1, January 24, 2024).

This expert can contribute to conveying knowledge and a compelling story to the client, of which the importance already became clear in 0.. Taking on a facilitating role during brainstorm and inspiration sessions with the client is one of the potential methods for this. On the other side this expert, or external source of knowledge, can also contribute to the ambition of the project team and PM by storytelling. As PM3-F mentions: *“You need someone who says, come on guys, let’s do this, it’s important, and who also has a good story to go with it”* (FG1, January 24, 2024).

Interview participants also recognized consulting someone with knowledge and experience as a valuable intervention. As PM8 said: *“Because when I look at myself... you become a bit apprehensive... yes, because you don’t know the content in complete detail, so then you would need to bring in such an expert”* (March 20, 2024). On the other side, doubts were expressed as well. PM7 brought up the additional costs associated with adding an expert onto your project team: *“Such an expert on your team, I do think it really adds value, but I also find it challenging. It is someone who simply costs a lot of money”* (March 19, 2024). Hesitation from PM7 and PM9 were also related to the broadness and depth of the knowledge such an expert would bring. *“... it needs to be someone who also knows how things function in practice and how you can, let’s say, follow through to the end with the actual application in construction”* (PM9, March 26, 2024).

In conclusion, this intervention directly targets the leverage point ‘knowledge’. It is expected to positively contribute to the amount of knowledge sharing within the project team. Consulting an external source of knowledge, such as a circularity expert, is expected to have a positive effect on ‘ambition project team’. Furthermore, because this expert has the skills to properly convey knowledge to the client it also influences ‘degree of management vision’ and ‘organization circularity ambition’. This, in turn contributes to the incorporation of circularity in the project brief (see Figure 4.10).

### 4.3.3. Promote client awareness

The promotion of client awareness through education is targeted at changing client management’s vision towards circularity. This intervention came forward during both focus group sessions, however it was mentioned most during the first session. PM5 stated *“the biggest problem is that we do not see it as a problem. [...] We are not intrinsically convinced”* (FG1, January 24, 2024). This was backed-up by PM4 saying: *“We do not feel the urgency in society”* (FG1, January 24, 2024). Improving client awareness can be achieved by insightful visualization and communication in a way that is comprehensible and believable to the client.

Additional to painting a compelling picture to provide the client with a vision of what is possible, a compelling story that engages both client organization and its management. Painting such a picture requires knowledge, vision and endurance from the PM, as change takes time. PM2 (FG1, January 24, 2024) stated *“just keep repeating to the point of weariness. [...] even if [in] project one [it] was not successful, you should just try and repeat it again to see if it works this time”*. This indicates that giving up after the first try will not lead to success since adoption of new ideas and principles takes time and getting used to it. Client awareness and a vision can be boosted by developing a joined goal. As told by PM4: *“In a project, well, everyone directly focuses on the content, but try to rise above it. What are we doing it for in the end? For a satisfied user, but also much further, in 20 years, in 100 years. And by doing so, actually creating [client] support”* (FG1, January 24, 2024).

It was also questioned if it would be possible to convince clients management within the course of a single project. As PM3 said: *“I believe, to start, you really need a visionary. [...] someone who can convince management or is part of the management themselves. But the question is whether we can achieve that at the project level”* (FG1, January 24, 2024).

The intervention is aimed at changing the vision of client management and the ambitions of the organization. It directly targets the leverage point ‘knowledge sharing’. The leverage points ‘degree of management vision’ and ‘organization circularity ambition’ are positively impacted through this intervention. The expected behaviour over time of these variables is indicated in Figure 4.11.. Knowledge sharing sessions are expected to have an increasing effect on the relevant variables. In turn, this intervention will also lead to positive results regarding ‘experience’.

### 4.3.4. Alleviate uncertainties

Uncertainties surrounding the implementation of circular methods and approaches must be mitigated. This became evident during the focus group but was also encapsulated by PM10 during the interview: *“... a project manager and a process manager... a major priority for them is to eliminate uncertainties. That is also what they are accountable for, so*

to speak” (March 28, 2024).

Many of these uncertainties arise around the budget. It is often unclear what additional costs are of a circular approach, or if there are any at all. As stated by PM2: “... circularity sounds so big and it doesn’t have to be that way, it always has to cost more, it is always scary, it is always new. But is not like that at all” (FG1, January 24, 2024). Although circularity does not always entail additional expenses, it is still perceived as a risk. As PM5 said: “... it doesn’t have to cost extra, but I see it as a risk” (FG1, January 24, 2024). This risk can be alleviated by providing clarity regarding the costs associated with a circular approach. This idea occurred in both the focus group and in the interviews. During the focus group PM1 stated: “... if we, as an organization, manage to guarantee them [the client] upfront, so to speak, that it won’t cost more, but that it will be in wood which results in much more CO2 being captured and, metaphorically speaking, is healthier, then of course they will always say yes” (FG1, January 24, 2024). This statement is based on a scenario where there are no extra costs incurred by choosing a circular method. PM7 and PM10 take this a step further and suggest that when more clarity is provided about the additional costs, the client can also be presented with a choice and may be willing to pay extra. PM7 said “you need to get out of that vagueness” (March 19, 2024). And PM10: “in terms of finances, I think it’s important to create clarity. Because it’s [costs related to circular approaches] often seen as a threat due to its uncertainty. [...] I believe that this uncertainty needs to be eliminated, and I do think that certain clients would be willing to pay a bit more, but they often want to know what they’re getting into” (March 28, 2024).

Another significant factor of uncertainty surrounding a circular approach stems from the proven quality of the materials, this concerns both bio-based materials and the reuse of existing materials. With bio-based materials, the issue lies in their novelty; their long-term durability has not yet been proven, and they may lack the appropriate certifications. In the case of reused materials, warranties are often no longer applicable. This was elaborated upon by PM3: “But bio-based is revolutionary; it can only enter the market if it has the right certifications. Or in other words, they may already be on the market but are you then also allowed to use them in your project? [...] and with reuse, you might, for example, disassemble components from a building, store them, and then move them to a new location to reassemble. And you either have or don’t have a manufacturer’s warranty. [...] Then, for instance, if it’s 10 or 15 years old, the warranty has expired” (FG2, February 7, 2024). This uncertainty was also acknowledged during the interviews, for example by PM10: “When you want to reuse products, you are not always certain if they meet the quality requirements” and “also the new use of, for example, bio-based products [...] those are, of course, all new developments that have not yet proven whether they

will indeed last the 30 years” (March 28, 2024). Research and experience would be able to alleviate part of the uncertainties. As suggested by PM8: “Yes, then I would... if you’re talking about those warranties, I would conduct research to remove that apprehension or uncertainty” (March 20, 2024).

This intervention highlights another aspect of ‘knowledge sharing’, this time with the aim to mitigate the existing uncertainties. The alleviation of uncertainties through knowledge sharing thus has a positive effect on the leverage point ‘certainty’. This has a positive effect on the ambition of the project team and the ambition of the organization. Eventually this leads back to the uptake of circularity in the project brief, or in other words ‘experience’. The results above also suggest this intervention positively influences the ‘budget available for Circular solutions. When this is run through the model, this shows that the sharing of knowledge influences ‘degree of management vision’ and ‘commitment management’, which both have a positive relation with ‘budget available for Circular solutions’, this also leads back to ‘experience’.

#### 4.3.5. Well considered budget creation

The need for more budget space was one of the first mentioned intervention strategies. It was brought up during both focus group sessions. The answer to the question what do you need to realize a circular project was “A big jar of time and money” (PM2, FG1, January 24, 2024) and “[I need] a lot of money, a higher budget from the client” (PM4, FG2, February 7, 2024). PM7 mentioned the following about this: “... even though we do not want to, our economy still revolves around money. And if the funds are not available, it simply gets skipped. It’s then a matter of either removing requirements and going ahead with construction or not building at all. You will always choose to build. But unfortunately, [circularity] is always the first thing to be sacrificed” (March 19, 2024).

A potential intervention is to use the available budget in a conscious and creative manner as indicated by PM3, “we have a certain budget, let’s see how we can cleverly manage that budget to still achieve certain things. For instance, introducing timber construction with a compelling narrative” (FG1, January 24, 2024). A compelling narrative ensures that the client and their management are engaged and brought on board as was also explained in 4.3.1.1 and 4.3.1.3..

A suggestion is to consciously reconsider the scope of the project and make strategic choices when possible. This boils down to the application of the R-ladder. PM2 stated, “one could also consciously consider how things could be done differently” (FG2, February 7, 2024). And PM3 mentioned, “opportunities also lie in rethinking. So of course, we now have a focus on materials or adding that sustainable quality to buildings, but before that, there are also steps on the

*ladder of rethink and reuse*" (FG2, February 7, 2024). An important remark made in this context came from PM9, "well, you never see that happen in practice. It's not an option" (March 26, 2024). This highlighted the unlikelihood of modifying the scope during the definition phase to enable a circular project. It is unlikely that circular requirements will take precedence over the originally intended scope. On the other hand, PM10 considered this as a clear and effective intervention where a PM can also play a role during the I&D phases. Revising the scope is not only about what you want to achieve but also how you want to do it. They indicated that revising the project scope can mean many different things, and hence the impact of this intervention on the budget and project costs is difficult to specify.

Steering towards more life cycle or long-term thinking is another aspect of creating more investment budget. As PM1 said, "you need a long-term vision". The idea that emerged in the focus group is that by embracing long-term thinking, budget allocated for exploitation and maintenance could be relocated. PM2: "you start thinking in terms of life cycle, so your maintenance decreases and your maintenance budget goes towards your investment" (FG2, February 7, 2024). When clients realize that a circular solution cost less in the long term, they are willing to invest more. PM5: "... companies want to lower their running costs. And how do you reduce those; fewer people, less maintenance, less energy consumption. Then it may well be a more expensive investment if you can demonstrate that later it can be managed with fewer people, less energy, and less maintenance" (FG2, February 7, 2024). As a PM, you can promote long-term thinking by transferring knowledge and educating about the long-term benefits of circular solution.

The suggestions made for this intervention require a certain amount of knowledge and skills from the PM and to convey this to the client as well. Therefore in Table 4.6 it is indicated that 'knowledge sharing' is what is done, this influences 'degree of management vision' and 'commitment management'. Those both lead to 'budget available for circular solutions', which is the aim of this intervention.

#### 4.3.6. Encouraging company culture

An encouraging company culture stimulates PMs to have the courage to undertake more circular projects and deviate from the current norm. As indicated by PM5 "... you need a company culture that encourages you to do it [integrate circularity]" (FG1, January 24, 2024). Support from the employer in the form of time, space, and budget for (personal) development contributes to PMs courage and enthusiasm. Employees must feel comfortable and confident they will not be penalized by their employer if they fail. As summarized by PM1, you need "space to fail and appreciation" (FG2, February 7, 2024). Appreciation can be expressed in tangible and intangible form, for example an award or bonus, or through words of appreciation.

Appreciation can be expressed by the client, but in the case of this intervention, it pertains to recognition from the employer. By directing the attention of their team to circularity and sharing their own enthusiasm, a manager or employer can have a contagious effect. PM7 said the following: "[...] is of course very passionate about circularity as a manager. And indeed, encourages us and also helps us, and thinks it is very cool. So, I believe that motivates us to think about how things can be done differently" (March 19, 2024). This creates an external incentive or stimulus for the PM to do things differently. This is necessary when an internal impetus is absent, as indicated by PM5: "if I'm not triggered to recommend a sustainable project, then I just get away with doing the standard thing, nice and easy" (FG1, January 24, 2024).

PM3 emphasized the importance of the employer's company culture once more, stating: "I have been working for [company] for seven years; before that, I worked for another company for 23 years, but in these last seven years, I have done much more in terms of sustainability. Because it is more widely preached here" (FG3, February 28, 2024). Even though the culture and circularity vision of the company for which the PM works have some impact, PM2 commented the following, "I find it complicated because the culture in the organization [client] has a bigger impact in this" (FG1, January 24, 2024). Since a consultancy is typically hired to execute works for a client. This raises the question of how much influence and consultancies PM has. If the ambition and goal of the consultancy is to work on circular projects, they need a clear identity. Additionally, they should choose not to accept certain projects that do not align with this identity. As PM5 stated, "Because if we want to say and show the market that we are sustainable, then we have to dare to decline non-sustainable projects as well" (FG1, January 24, 2024).

Ensuring an encouraging company culture will primarily affect the leverage point 'ambition project team'. This intervention is also expected to have a positive effect on the attitude or courage of the project team. This variable is not indicated as one of the key leverage points but is confirmed by the focus group through statements such as "that also asks for a bit of courage" and to "just give it a try" (FG2, February 7, 2024). Ultimately it is expected this will lead to more circular project and to 'experience'. The effect might be limited due to the larger impact of the client's own culture.

#### 4.3.7. External change and setbacks

The elevation of the legal minimum requirements regarding circularity was mentioned as a potentially effective intervention. This is something the PMs and others involved have no control over. Nevertheless, there was largely consensus over the positive effect on the integration of circular principles in the program of requirements resulting from it. As said by PM2: "yes, so then you must"

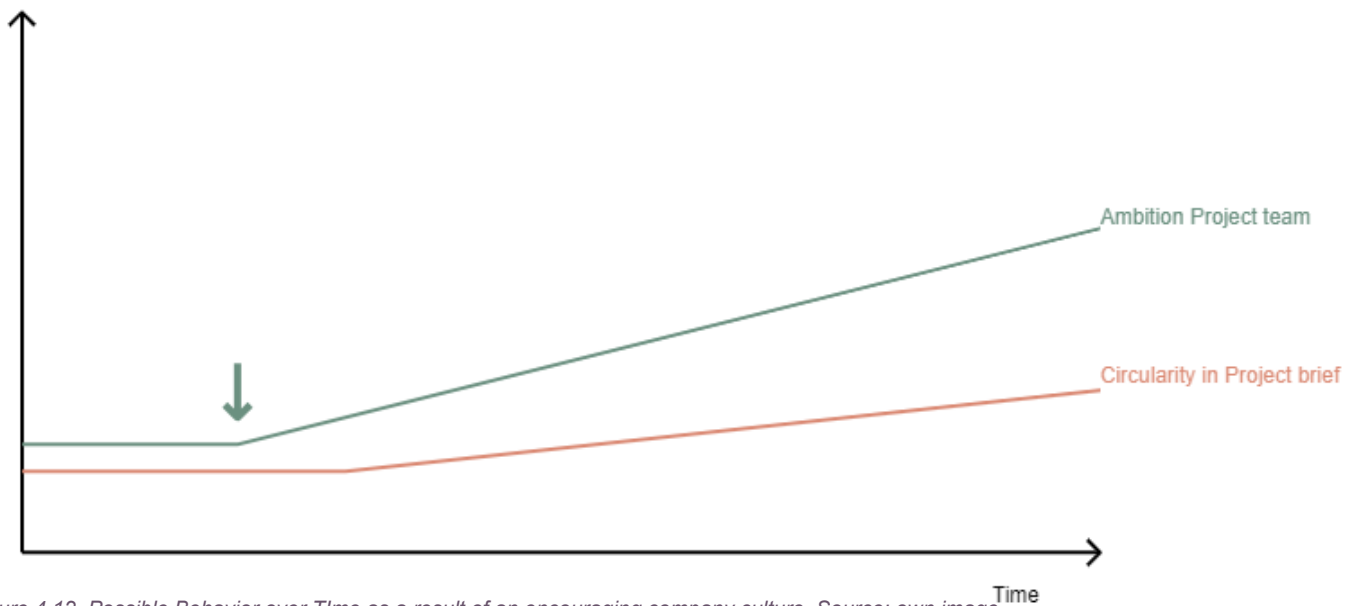


Figure 4.12. Possible Behavior over Time as a result of an encouraging company culture. Source: own image

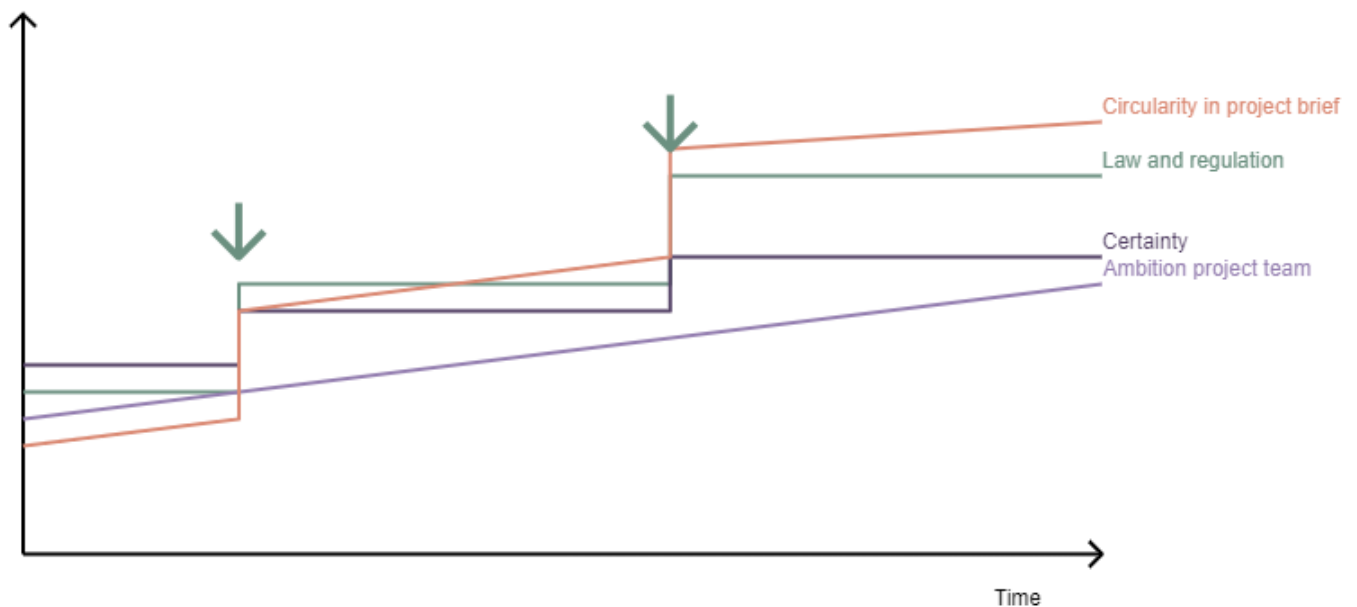


Figure 4.13. Possible Behavior over Time as a result of more stringent law and regulation. Source: own image

(FG2, February 7, 2024). It was pointed out that legal requirements are increasing over time by PM3: “I also wanted to highlight another aspect of legislation, which I brought up, law and regulations determine the minimum. There are already quite a few requirements in terms of circularity, right? Environmental performance for buildings, so just like the EPC [energy Performance Coefficient], you also have to submit an MPG [Environmental Performance Buildings] calculation for an environmental permit, not for hospitals yet, but I believe for residential and office buildings” (FG1, January 24, 2024). On the other hand, it was also mentioned that this is obviously the minimum and that one might want to do more: “it’s a bit like the bottom of the pool, right. It’s becoming less deep, so you dare to jump in more easily, but I mean, doing less is not possible” (PM5, FG1, January 24, 2024).

PM9 sees a potential danger in raising the legal minimum in that it could lead to projects that are impossible to execute. “It becomes increasingly difficult to comply with

the law, so to speak, then you block development, as well as the feasibility and viability of plans. I would actually not do that” (March 26, 2024). PM10 also saw a danger in raising legislation, albeit to a lesser degree. They stated that the ambition of the project team could possibly suffer: “people don’t like being forced to do something, so then they have a very quick reflex to protest with ‘does this really have to happen again’, you know? We already had to adjust all this last time and now we have too again. Such aversion might emerge. Like we were doing well, we were going up and we were all feeling positive about it. And now we need to do it again, it is not good enough yet. Come on. You know” (March 28, 2024).

Changes in the legal requirements are not the only form of external change that can have a potentially positive effect on the integration of circular principle. Setbacks, such as not obtaining certain permits, can prompt the project team to look at their project differently and force them to come up with innovative, circular solutions. This was mentioned

by PM7, who experienced something similar in their project: *“because we couldn’t get a grid connection, we are now forced to look at alternatives”* (March 19, 2024). According to them, such an external stimulus is the number one intervention to achieve more circularity in the program of requirements because it becomes a necessity.

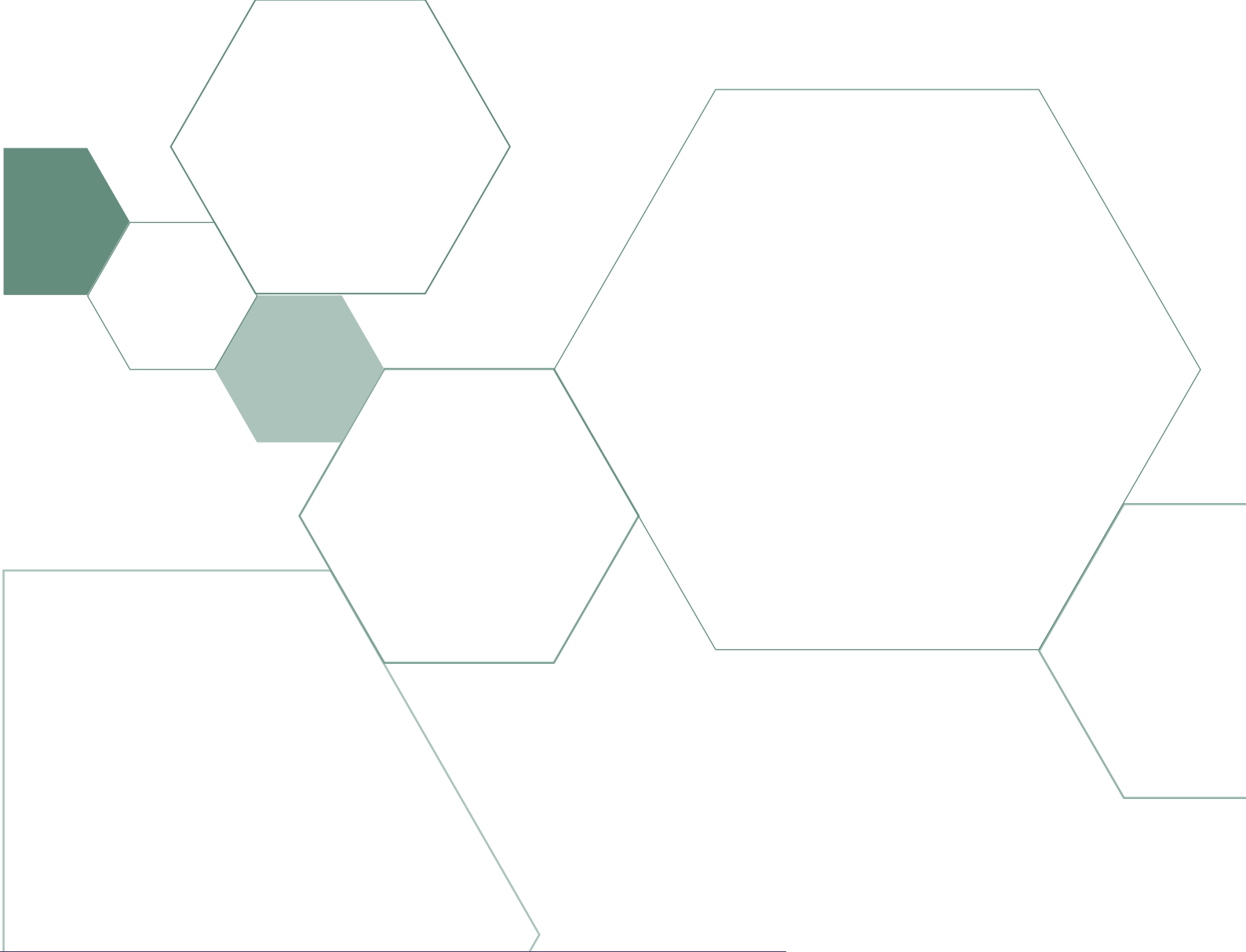
In conclusion, this is an intervention outside of the influence scope of PMs and other project stakeholders. It is forced upon the project by outside factors. When running this intervention through the CLD, it shows that an external change, such as a change in law and regulation will influence ‘certainty’ and ‘circularity in project brief’. Certainty has a positive effect on both ‘ambition project team’ and ‘organization circularity ambition’. It can be seen as an external incentive to adopt more circular practices. Via these routes ‘experience’ will raise too. In Figure 4.13, the possible behaviour over time of leverage variables is displayed as caused by more stringent law and regulation.

#### 4.3.8. Change in client management

This intervention indicates a change behaviour in the client’s management. PM2 stated, *“...if the management does not change, the rest cannot change”* (FG2, February 7, 2024). Sustainability is currently not seen as a fundamental need by many clients. The importance of a client whose management clearly has the ambition to become circular was outlined by PM9: *“... you also see that governments, I work a lot for governments, that they have the ambition. So, it [circularity] gets through more easily”* (March 26, 2024).

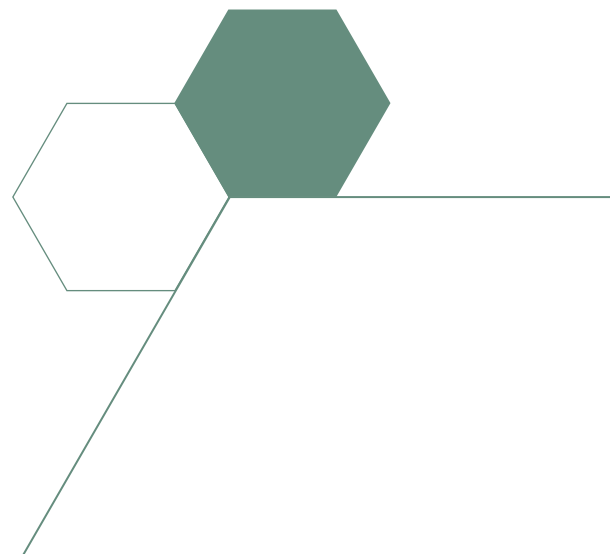
One way to facilitate this is by hiring more progressive individuals with a specific focus on circularity in those managerial layers. As PM5 said, *“you need to hire young people”* (FG2, February 7, 2024), where ‘young people’ in the discussion equates to individuals with a progressive vision. PM9, however, questioned this, saying, *“Is there a function, is that a job? That’s actually... you need to give someone who is already in the organization that role, and they must want to do this from their own passion. But hiring someone for this makes no sense”* (March 26, 2024). They saw the potential added value of someone with a role more focused on circularity, but it cannot be a sole function.

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# CHAPTER 5

# DISCUSSION



# Discussion

In this chapter the research findings will be discussed. The chapter commences with a brief repetition of the most important findings after which the findings are interpreted and related to literature. It proceeds with a brief description of the research implications. In 5.3. the limitations of the research are addressed, and the chapter is concluded with recommendations for future research.

## 5.1. Research findings

This study aimed to determine the contribution of ST in the development of intervention strategies for the better incorporation of circularity in the I&D phase of building projects. The objective was split up into two parts. First, the development of a set of intervention strategies and second determine the contribution of ST in the development thereof.

The research commenced with a literature search. Multiple advantages of ST were found, an overview is displayed in Table 1.1.. Further, the current process of incorporating circularity in the building industry was explored. It was found that every project starts with an I&D phase. This phase largely determines the outcome of the project as the following phases are all based on the project brief, which is the deliverable of the I&D phase. In literature the following barrier categories impeding the uptake of circular practices in the construction sector were identified; economic, environmental, technological, organizational, social, cultural, regulatory and technical.

The barriers found in literature were not specific to the I&D phase. This information was needed for this research; therefore, eight semi-structured interviews were conducted with field practitioners. This resulted in a total of twenty-six (26) barriers, that could be categorized into seven out of the eight identified categories in literature.

What followed was the development of a CLD reflecting the system of incorporating circular ambitions in the I&D phase of a building project. In the designed CLD, six (6) themes were identified, certainty, knowledge, budget, innovation, courage and materials.

Based on the CLD eight intervention strategies were formulated in consultation with the focus group and through one-on-one interviews. These intervention strategies are displayed in Table 4.5.

### 5.1.1. Barriers

Through the eight semi-structured interviews barriers were found in seven out of the eight barrier categories identified in literature. No environmental barriers were found. This was expected as environmental barrier usually only occur in the end-of-life phase of a project (Charef et al., 2021; Osei-Tutu et al., 2023).

Economic barriers were cited most by practitioners, indicating their perceived importance. The expected increase of costs was brought up as a barrier by all interviewees. These findings are in line with literature where the expected higher upfront costs and higher costs in general were the most cited barriers in the economic category (Charef et al., 2021; Osei-Tutu et al., 2023; Wuni, 2022). According to both literature and practitioners this barrier follows from the upfront harvesting of second-hand materials that sometimes need adjustment and the increased time and research needed to deviate from the standard.

During the interview CEx1 made an interesting remark, contradicting the above. They stated that in their experience circularity does not always have to lead to increased costs (Personal communication, December 1, 2023). Practitioners often lack comprehensive knowledge of circularity. This might lead to certain biases, that are influenced by own experience. This highlights the importance of knowledge and knowledge sharing as drivers for circularity in the I&D phase of building projects and will be further elaborated upon in 5.1.2.. Additionally, it is expected that costs are sometimes used as an excuse, given the already high workload in projects. The project team cannot take on more workload, which adding circularity, or other new concepts, will cause due to the extra time and effort required.

Both the lack of comprehensive knowledge and the high workload are mentioned as social barriers by practitioners and in literature (Ababio & Lu, 2023; Charef et al., 2021). These findings suggest interrelations between barriers. This supports the findings by Wuni (2022) who also found barriers impeding the uptake of circular practices to be interrelated.

In literature the lack of education and training about CE and the lack of interest and client demand are also brought up as key barriers in the social category. These barriers were not found during the interviews. The aim of the interviews was to determine barriers specific to the I&D phase of building project, whilst the data from literature considered the whole project life cycle. It is therefore possible that this difference can be explained by these barriers simply not occurring in the I&D phase. However, with a small sample size, caution must be applied. The findings from the interviews might not fully represent the complete picture. The same applies to the discrepancies between the barriers identified in the literature and those revealed through interviews for the remaining barrier categories.

The barriers found in the interviews do not deviate from literature. In some cases, such as 'no existing, widely used marketplace for reused materials', the barriers identified in the interviews were described more specific. In literature this was formulated as an immature recycling market. This can also be explained by the small sample size, making it



more difficult to recognize overarching themes in the data. Another note of caution is due in the interpretation of the identified barriers since the interview participants were predominantly PMs involved in all stages of the project life cycle. During the interviews they were specifically asked to focus on the I&D phase. However, due to their professional bias and experience and their function, PMs naturally tend to think ahead in the project life cycle. Because of this, barriers identified in this research might not solely belong to the I&D phase but can occur in a later project phase.

### 5.1.2. Systems thinking and the resulting intervention strategies

#### *Project managers cycles of influence*

A set of seven ST intervention strategies is identified in this research. Considering these intervention strategies in relation to the PMs influence a classification can be made. An overview of this classification can be found in Figure 5.1.. PMs have a direct influence on their own continuous education (I1) and consulting an external source for more in-depth knowledge during their project (I2).

Then there are the three intervention strategies that the PM influences but does not control. These intervention strategies are the promotion of client awareness (I3), the alleviation of uncertainties (I4) and the creation of more budget space (I5). The aim is to steer the client to make different decisions, however the PM is not in control of this decision.

The remaining interventions are beyond the PMs scope of influence. These two interventions are ensuring an encouraging company culture (I6) and external changes and setbacks (I7). These interventions are not influenced by the project manager, but they are important for the systems behaviour. This classification is like the circles of influence; control, influence and concern (Toxboe, 2023).

#### *Interpretation of the intervention strategies*

Perhaps the most interesting result of this study is the importance of education and knowledge sharing to overcome the current problems impeding the uptake of circularity in the I&D phase of a building project. Five out of the eight resulting intervention strategies tackle the improvement of their related leverage points by the promotion of knowledge transfer and education. For instance, the intervention “promote client awareness” (I3) is proposed to positively target “degree of management vision” (V1) and “organization circularity ambition” (V5), which are both indicated as important leverage points, through knowledge sharing and education. The same can be seen by other interventions, “alleviate uncertainties” (I4), “well-considered budget choices” (I5), “consult an external source of knowledge” (I2), where education and knowledge sharing function as a means to give a leverage point in the system a nudge in the right direction.

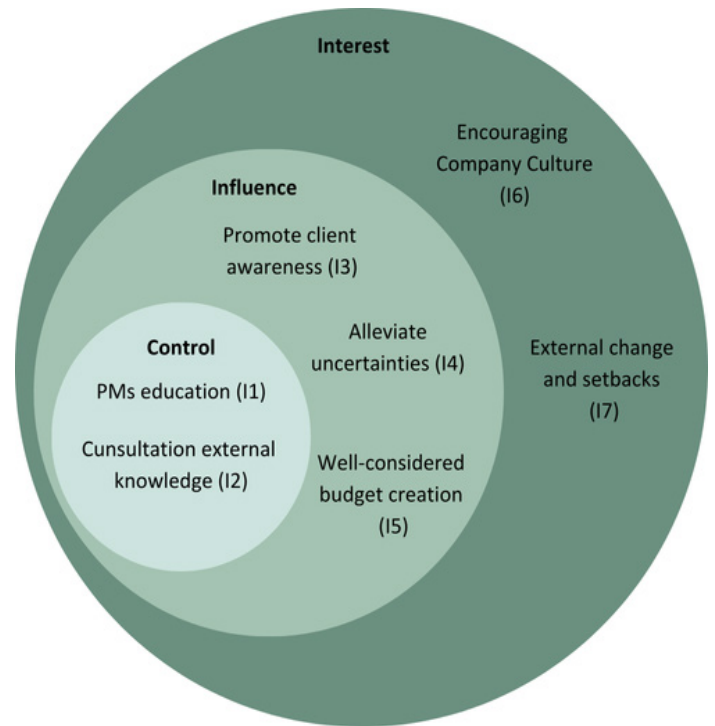


Figure 5.1. Placing of intervention strategies in the Project Managers scope of influence. Source: own image

These found intervention strategies related to the knowledge and education to improve awareness align with solutions proposed in literature. Studies on the barriers and enablers (or counterstrategies) to the uptake of circularity in the construction industry indicate the significance of knowledge and education (Ababio & Lu, 2023; Osei-Tutu et al., 2023; Wuni, 2022). In these studies, these enablers or countermeasures are predominantly proposed to mitigate social and cultural barrier. As mentioned above, this study found that social barriers were the second most cited barrier category in the I&D phase according to field practitioners. The findings in this study suggest that not only social and cultural barriers can be partly overcome by these interventions but also economic barriers (I4 and I5), which will be further explained below, and organizational barriers. An organizational barrier that can be overcome is “lack of management commitment” (B18) this barrier for instance, is tackled by “promote client awareness” (I3) and “alleviate uncertainties” (I4).

Multiple suggestions for improving knowledge sharing and education can be made based on this study and existing literature. For instance, the organization of specific circularity training courses (Wuni, 2022), coffee-corner conversations and sharing enthusiasm with colleagues (FG1, January 24, 2024) or inspiration or dialogue sessions with the client (FG2, February 7, 2024; Ababio & Lu, 2023).

Several spirited debates started on the topic of technological barriers during the focus groups. This topic was also brought up during multiple validation interviews. This indicates that this topic and its associated challenges play a significant role in the incorporation of circularity in

the project. The experienced problems are partly related to uncertainties about applying circular materials, which can be addressed by the intervention “alleviate uncertainties” (I4). However, the problems are predominantly related to the unavailability of suitable materials. Often not enough materials are available for reuse, or the available bio-based materials might not have the right certifications yet. The variables related to these problems are included in the CLD, they are captured in the ‘materials’ section of the CLD and are highlighted in figure 4.8.. Through the CLD it also becomes evident that these barriers are all related to external variables.

During the validation interview PM7 indicated that knowledge and experience do contribute to lowering the threshold for the use of circular materials, as this helps to overcome uncertainties. All other variables stay external, and are not in the scope of control of the PM.

To overcome the technological barriers, some suggestions are made in literature. For instance, Osei-Tutu et al. (2023) indicate that quality assurance standards are needed for reclaimed materials, and they further indicate the importance of education and promotion of the R-principles. The need of a tool or general used marketplace to source for reclaimed materials was also briefly suggested by some of the interviewees (Personal communication PM1-B, November 8, 2023).

### *Advantages of Systems Thinking*

As mentioned in the literature study, ST has several advantages compared to ‘event-based’ thinking. First, using ST intangible mental models are made explicit, this contributes to improve the understanding of the system. By ST tools, such as CLDs, the system is presented in a simplified manner that is relatively simple to communicate to others (Maani & Cavana, 2000; Schwaninger, 2009). Second, by providing insight in the dynamics of the system, ST supports users to behave in a way that is in the long-term best interest to the system (Sterman, 2000). Third, through ST potential intervention strategies can be explored and their expected effect on the system can be predicted (Schwaninger, 2009; Sterman, 2000).

Based on these advantages this thesis started with a hypothesis. It was expected that through ST different interventions would be suggested and indicated as most influential compared to those based on ‘event-based’ thinking. Based on the focus groups and validation interviews, this study found eight intervention strategies. Data to formulate these strategies was collected at different moments. When comparing this data, only limited difference can be noticed. All intervention strategies proposed after the ST method were also proposed before. Two intervention strategies were formulated with an event-base character. These concern the need for more money or a higher budget from the client and the need for a change

in client management.

As indicated above, higher costs is the most cited barrier by the interviewees. Its perceived importance was further supported by the focus group. A primary reaction to the question ‘what do you need to realize a circular project’, is more money or a higher budget from the client (FG1, January 24, 2024; FG2, February 7, 2024). This was brought up by the focus group both before and after going through the ST methodology.

The need for a change in client management was only proposed before ST was used. Both interventions are a direct reaction from the focus group to often encountered real-life problems. Client’s management has high ambitions on paper, but the organization does not cooperate in taking steps to achieve them. A direct solution would be a changed client management. However, with these intervention strategies, the PM shifts all responsibility away from themselves.

Both intervention strategies can be replaced by strategies with a more ST character. PMs do have influence on the behaviour of client management, for example through the promotion of client awareness (I3). The need for higher budgets is partly tackled through making well considered budget choices and steering towards strategic scope revision (I5).

Even though limited difference was noticed, the method did confirm its advantages. First, mental models were made tangible, this made it possible to convey them clearly during the validation interviews. PM2 even went as far as stating “for me it is a visualization of my brain” (FG3, February 28, 2024). Second, through the developed CLD multiple insights were gained. Perhaps most interesting insight is the key role of ‘experience’ in the model. This variable has a central role in the CLD, and a large number of loops emerge from experience. Third, the proposed intervention strategies could be run through the model and their expected influence on the variables was visualized. This improved insight and provided a basis for discussion.

### *Systems archetypes*

In ST theory, systems archetypes are also brought up as a powerful ST tool. Systems archetypes are common dynamics that are often encountered in a variety of field. The archetypes were first identified by the SD group at the Massachusetts Institute of Technology (MIT) (Kim & Lannon, 1997; Maani & Cavana, 2000). In their study Elia et al. (2020) organized brainstorm sessions to apply these existing systems archetypes to the context of project management. Project governance insights are provided that help deal with the problematic structures emerging from the archetypes.

Some of these archetypes are expected to be of impact in

the system of incorporating circular ambitions in the I&D phase of building projects, for instance, 'limits to growth'. In a project management context this can imply the need for extra human resources or time for tasks or an increase in the knowledge and assets needed. These were also brought as barriers to the incorporation of circularity in the I&D phase (see paragraph 5.2.). The 'limits to growth' archetype is displayed in Figure 5.2. This structure can be recognized in the CLD as developed in this research. In this situation it is related to a limit in time. Figure 5.3 displays a section of the CLD highlighting this structure.

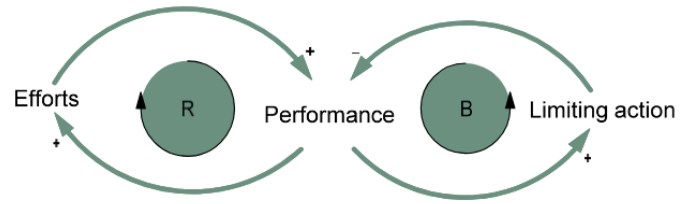


Figure 5.2. Limits to growth archetype. Source: Kim, 1993

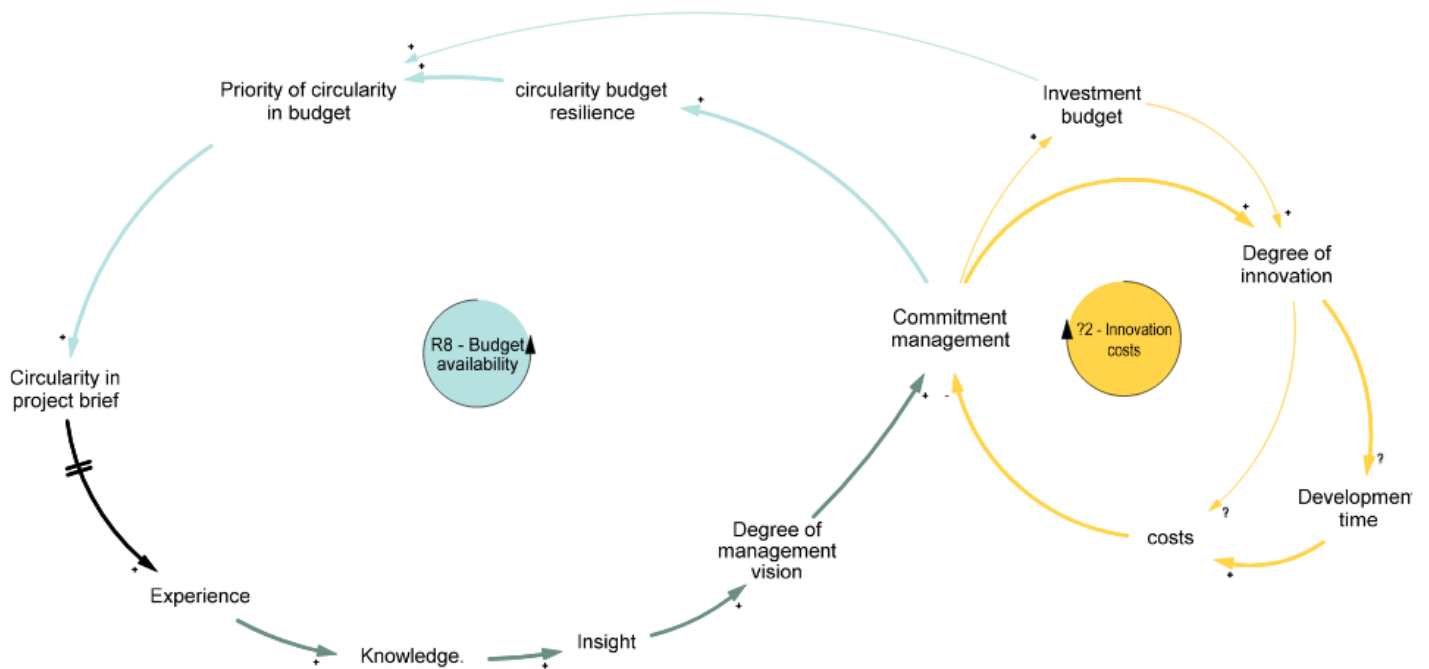


Figure 5.3. Limits to growth pattern recognized in Causal Loop Diagram reflecting the process of incorporating circularity in the initiation and definition phase of building projects. Source: own image

### 5.1.3. Triangulation for validation

Data triangulation is a way to test the validity of qualitative research. Carter et al. (2014) present four different triangulation methods, in this research data source triangulation is used. For data source triangulation, data is collected from different types of people.

Both, a focus group and in-depth semi-structured interviews were used in this thesis. These methods can provide different results. Participant interaction in focus groups stimulates discussion. A wider range of opinions and perspectives will result. The goal of the focus group was to visualize the dynamics in the I&D phase when incorporating circularity, this wide range of perspectives was necessary to draw a complete picture.

The interviews were used to discuss the finding from the focus group. The developed CLD is intimidating when first shown, due to the large number of relations and variables. The one-on-one interviews gave the opportunity to explain the CLD step by step on the speed of the interviewee.

Interviewees did not feel any reluctance to ask questions or make remarks. In a group setting this may have been the case due to peer pressure.

In general, the interviewees largely agreed with the model and recognized the patterns from their experience. Some minor adjustments were suggested, these were mainly with preferred wording or the recognition of additional relations. These remarks were not changed in the CLD, as the theory also explains that a CLD is rather depending on the group that developed it, specifically in the naming of the variables (Maani & Cavana, 2000; Sterman, 2000).

## 5.2. Research implications

This research adds to the practical and scientific knowledge on circularity in the building sector. On the scientific level this study delves into the barriers impeding the uptake of circularity in the I&D phase of building projects. This was lacking in existing literature where studies mostly focus on barriers in the construction sector over all phases of the life cycle. ST is seen as a requirement for the transition to a circular building sector (Campbell-Johnston et al., 2019;

Kristensen et al., 2021). It has been used in the context of circularity and the construction sector, often to improve safety during execution. However, it has not been used to improve the uptake of circularity in the early project stages such as the I&D phase. This study contributes by addressing this gap through a RtD study that mapped the dynamics in incorporating circularity in the I&D phase of building projects and formulating intervention strategies. The intervention strategies formulated in this research highlight the importance of knowledge and education. This also found in literature, however in literature these drivers or counter measures are often mentioned to deal with social and cultural barriers (Ababio & Lu, 2023; Osei-Tutu et al., 2023; Wuni, 2022). This research contributes by showing that knowledge and education can also be deployed to overcome economic barriers.

At the practical level this study provides valuable insights into the dynamics of incorporating circularity in the I&D phase. This is needed to increase the uptake of circularity in the sector. Several practical intervention strategies is formulated that can be used by professionals. Furthermore, the discussions emerging during the focus group were valuable and provided the participants with insight about themselves and their colleagues. Thematically discussing the concept of circularity in the building sector with practitioners has several advantages. It contributes to growth and professional maturity and offers practitioners a new perspective. Additionally, it brings the topic back on the agenda. This is also highlighted by the intervention strategies as a crucial element, encompassing knowledge and awareness. The ST method used in this study can be used as a discussion tool by practitioners. This will provide guidance for the discussion and will assist in surfacing mental models. In figure 5.4. an overview of the steps used in this study is displayed.

When using this method as a tool for discussion, it must be taken into account that it is time-intensive and at least half a working day (four hours) is needed to complete the entire workshop program. An additional reflection moment can be organized after the facilitator finishes the CLD.

### 5.3. Research limitations

Due to the small sample sizes, the barriers impeding the uptake of circularity in the I&D phase identified through interviews may not be representative for the building sector in the Netherlands as a whole. Even though interviews were conducted with a variety of people, the majority had PM function. Due to their experience and profession bias, PMs tend to think about the building life cycle. Because of this, barriers identified in this research may not occur in the I&D phase. This study was constrained by the limited number of previous research addressing barriers to circularity specific in the I&D phase. This limits the contextual understanding of the findings.

This research only included PMs for the focus group. These participants are all employees from the case company. Due to their professional bias, the results of this study may not be generalizable. In addition, projects are organized with many stakeholders. PMs mental models may not be representative for other stakeholders, such as the (public) client or circularity expert. Additionally, experience with circular projects of most participants was limited. They do have some experience and knowledge on circularity, as it featured in their projects. However, not every participant had worked on projects that were fully circular.

For validation of the findings outside of the focus group only internal experts from the case company were consulted. If this validation had included experts from other companies the generalizability of the CLD findings and resulting intervention strategies would have been stronger.

This research is conducted making use of qualitative methods. These methods rely on interpretation of the data by the researcher to develop the CLD. Qualitative methods were also used to identify barriers, the factor of interpretation by the researcher for data analysis is a limitation of this study.

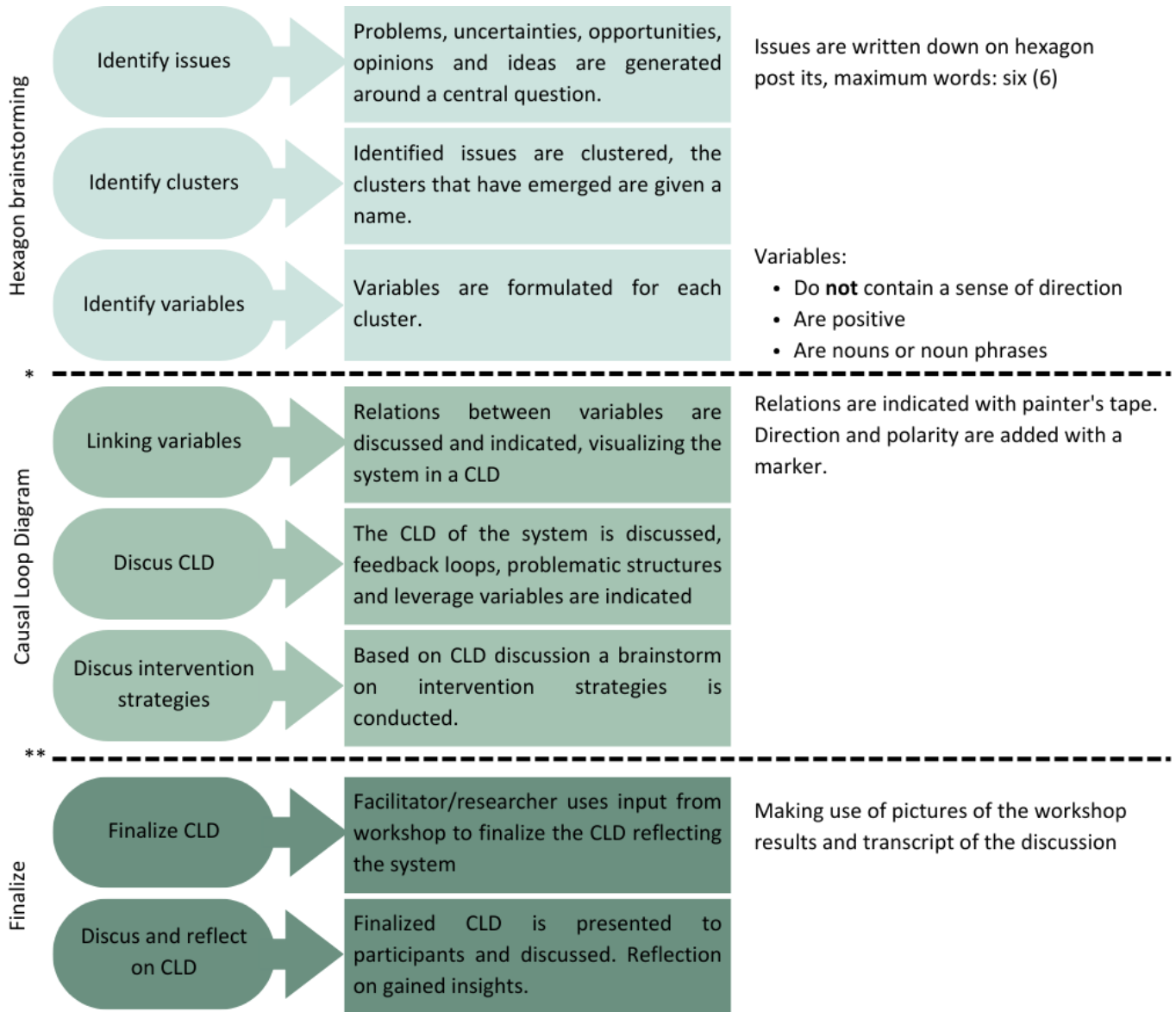
This study identified several barriers and a set of intervention strategies. A limitation in the findings of this study is that not all barriers are addressed through the intervention strategies.

### 5.4. Future research

This study focusses specifically on the use of the ST approach to develop intervention strategies to be used by PMs in the I&D phase of building projects. As indicated in the limitations, PMs have certain mental models that are likely to differ from those of other stakeholders in the process. To get a broader narrative, it is interesting to develop a CLD together with for example clients or circularity experts. Their mental models are different due to their own professional bias and experience. Future research should include a wider variety of stakeholders to determine the applicability of these findings across the building sector.

The research started with a search into the barriers that impede the uptake of circularity in the I&D phase. There is a limited body of knowledge relating barriers to the phases of the project life cycle, this study contributed to fill this gap. However, due to the small sample size these results may not be representative for the whole building sector. Further research should address this gap making use of a larger sample size.

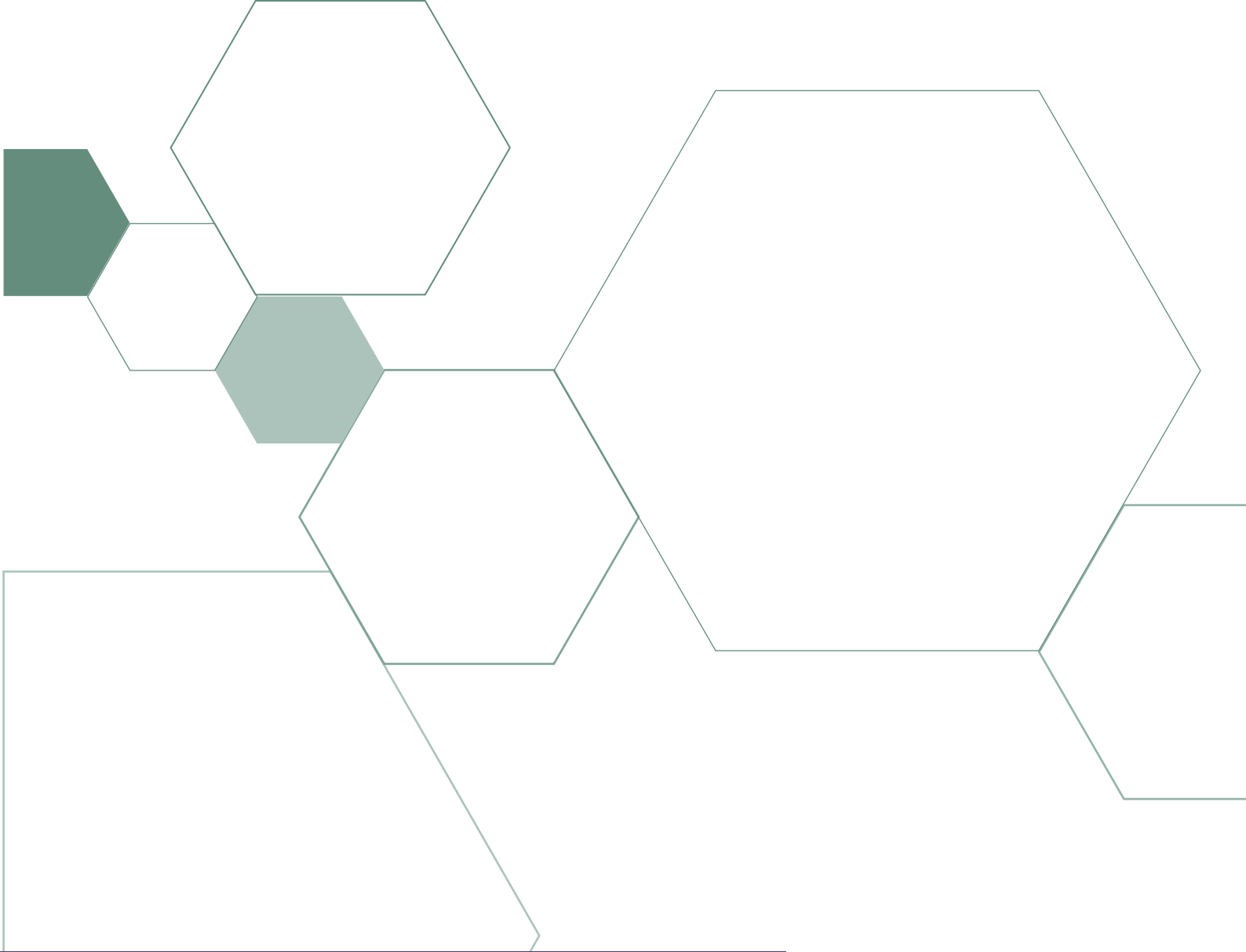
Figure 5.4. Overview ST methodology



\*After variables are identified, reflect on them to make sure the formulated variables are representative and agreed upon with the whole group. When splitting the workshop into two sessions (as done in this research) finalize session one here.

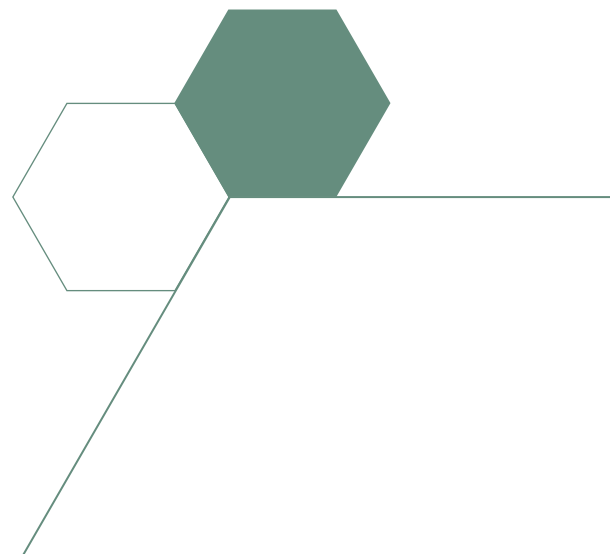
\*\*End of the full workshop (or second session when splitting the workshop into two sessions)

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# CHAPTER 6

# CONCLUSION



# Conclusion

This study set out to develop intervention strategies that can be used by PMs to improve the incorporation of circular ambition in the I&D phase of building projects. Through ST a deeper understanding of the dynamics in the system can be gained and the root cause of problems can be uncovered. Therefore, the ST methodology was used, and its contribution was evaluated. This chapter will look back on the hypothesis the study started with and answer the main and sub-questions in this research. It will conclude with a reflection on the stated research objectives.

## 6.1. Conclusion sub-research questions

Within this section, a summary of the answers is provided for each sub-research question. The collective insight from these answers will be combined to address the main research question.

***SQ1: “What is the process for incorporating circular ambitions in the I&D phase of a building project and what are the barriers in doing so?”***

Every project starts with an initiation and definition (I&D) phase. In this phase, the clients wishes and ambitions are translated into requirements and specifications (PianOo, n.d.-c). A project brief is the final product of this phase and largely determines the outcome of the project. Based on this document the design will be made and potential tenderers develop their bid (Bruggeman, 2018). Incorporating circularity in the project brief will therefore secure a minimum level of circularity in the project. Consultants, such as PMs, are often hired by the client to formulate the project goals and translate them into tangible criteria. This is done in consultation with the client and potential users (Klarenbeek, 2021).

The translation of circular ambitions to tangible criteria is found to be challenging (Loewe & Ripplin, 2015; Personal communication, October 11, 2023) and procurement with circular ambitions are often unsuccessful (Zijp et al., 2022). The existing body of knowledge addresses barriers related to circularity in the construction sector in general but lacks data specific to the I&D phase. Based on literature eight barrier categories were found impeding the uptake of circularity in the construction industry: economic, technological, environmental, organizational, social, cultural, regulatory and technical.

In this study twenty-six (26) barriers impeding the incorporation of circularity in the I&D phase of building projects were found through eight semi-structured interviews with field practitioners. These barriers were categorized based on the barrier groups found in literature. All barrier groups were represented except from environmental barriers. According to literature environmental barriers primarily occur in the end-of-life

phase of projects, it is therefore in line with the expectations that no environmental barriers were brought up. The most cited barriers in the interviews were the expected higher investment required for circular approaches; current financial models that are not organized for circularity; predetermined budgets that do not consider circularity; the limited availability of second-hand materials; the limited time and capacity of PMs; insufficient knowledge about circularity and; the complexity around planning and storage of second hand materials. A comprehensive list of the barriers found is displayed in Table 4.1 in chapter 4.

***SQ2: “What is systems thinking and how can it be used for providing insight in the dynamics of the process of incorporating circular ambitions in the I&D phase of a building project?”***

By sub-research question two the ST theory was explored and the application of ST for this thesis was determined.

ST is both a worldview and a research approach with the core idea that the root of many problems can be found within the system it is part of. As found in ST literature, a system is a collection of elements that are arranged and interconnected in a specific pattern, explaining its distinct set of behaviours (Meadows, 2008). ST steps away from the event-based worldview, in which one event leads to another in a linear manner, to a holistic view. Through the ST lens, the world and the human systems in it are seen as an intricate network in which one action never stands on its own and all elements are interlinked (Sterman, 2000). In line with this, ST does not aim at ‘fixing’ a problem as this suggests that an ideal solution to a problem exists, this ignores the complexity of the system. It rather assumes intervention strategies that exert a long-lasting effect on the system that pushes it towards the desired state (Maani & Cavana, 2000).

Through development of a CLD reflecting the process of incorporating circular ambition in the I&D phase of building projects the understanding of the system is improved. A CLD is a ST tool that provides a visual and simplified representation of the system. This diagram clarifies and surfaces the intangible mental models present in an individuals or groups mind (Sterman, 2000; Zhou, 2012).

In this study a CLD was developed based on three sessions with a Focus Group. During the first session a brainstorming technique called hexagon brainstorming was used to formulate the systems variables. The second session was used to indicate relations between those variables, making use of hexagons and painter’s tape. These two sessions were interactive, and all data was used as input to develop the model as displayed in Figure 4.1. The last session was used to present and validate the model with the focus group, final changes were made thereafter.

The developed CLD provides insight into the dynamics of the



process of incorporating circular ambition in the I&D phase of a building project by making the groups mental models explicit. One of the focus group participants stated that the CLD was a representation of their brain. The validation interviews proof that the model is largely transferable. Additionally, the interviews further support that insight in the dynamics of the system is improved. For example, the indicate how their gut feeling was confirmed by the model (personal communication, March 19, 2024).

***SQ3: “What is a CLD that reflects the process of incorporating circular ambitions in the I&D phase of a building project?”***

The result of sub-research question three is a CLD reflecting the process of incorporating circular ambitions in the I&D phase of a building project. This CLD is displayed in Figure 6.1.. This diagram was developed based on three sessions with a focus group. In total the diagram is built up out of thirty-two (32) variables, of which six (6) external. A description of each variable can be found in Table 4.2.

The following six (6) themes were identified in the CLD: certainty, knowledge, innovation, budget, materials and, courage. All themes affect the goal of the system, more circularity in the project brief. Spread over the themes, nine (9) reinforcing loops and two (2) undetermined loops are indicated in the system. The reinforcing loops are certainty organization; certainty project team; certainty management; knowledge; knowledge sharing; vision; support base; budget availability and; just do it. The undetermined loops are enthusiasm and; innovation costs. No loops were indicated in the materials theme, as the variables comprising this theme are all external.

The CLD was analysed making use of the loops tool in VENSIM®. For each variable the number of loops it is part of and the number of loops with a length of less than eight (8) variables it is part of was retrieved. All variables that are part of more than ten (10) loops of less than eight variables are indicated as leverage points. This resulted in the following leverage points; experience; degree of management vision; organization circularity ambition; insight; knowledge; commitment management; ambition project team; knowledge sharing; sustainability standards; budget available for circular solutions; enthusiasm and certainty.

***SQ4: “What intervention strategies for the incorporation of circular ambitions in I&D phase of a building project can be developed based on the CLD reflecting the process?”***

The last sub-research question aimed at the development of intervention strategies for the better incorporation of circularity in the I&D phase of building projects. A total of eight intervention strategies were identified in this research, based on the focus group session and four semi-structured

interviews. Seven of these intervention strategies were also formulated based on the CLD reflecting the process (Figure 6.1). These intervention strategies are:

1. Continuous education of PMs to ensure up-to-date knowledge and awareness
2. Consulting an external source of knowledge and experience
3. Promote client awareness on the necessity of circular approaches through inspiration and education
4. Alleviate uncertainties regarding budget and quality
5. Create more budget space by well-considered scope revision and reallocation of funds
6. Ensure a company culture that encourages innovation
7. External factors such as changes in law and regulation or setbacks.

Five out of these intervention strategies (numbers one to five) are related to the sharing of knowledge and by doing so increasing awareness. This relation is also displayed in Table 4.6 in the results chapter. This finding underscores the importance of knowledge and knowledge sharing for improving the incorporation of circularity in the I&D phase of building projects.

## 6.2. Conclusion main research question

The central question of this study was: **“How can systems thinking contribute to the development of intervention strategies for the incorporation of circular ambitions in the I&D phase of a building project?”** This question will be addressed by first reflecting on the hypothesis. Thereafter the most important findings of this study are addressed.

Based on the benefits of ST as found in literature (see Figure 1.1) this thesis started with the following hypothesis.

*“Through ST different interventions will be suggested and preferred compared to those formulated with event-based thinking.”*

It was expected that the contribution of ST would be the formulation of different intervention strategies. However, considering the findings from the focus group and validation interviews, limited difference between the event-based intervention and ST interventions was found. Two event-based interventions were formulated that could both be replaced by ST intervention strategies. These interventions are “change in client management” (I8) and the focus group mentions related to the need for more money or a high budget and were proposed before the introduction of the ST methodology. The problems addressed by these event-based interventions were also addressed by the ST interventions as formulated after the CLD was developed. The intervention “change in client management” (I8) can be replaced by “promote client awareness” (I3). The mentions related to the need for more money or budget from the client are covered by “create more budget space” (I5). A further elaboration of these interventions can be found in



chapter 4.3.1.3 and 4.3.1.5. respectively.

It can be concluded the hypothesis did not prove to be true. All intervention strategies after ST were also proposed through event-based thinking (see Table 4.5).

Nonetheless, the added value of ST becomes evident from the findings of this research. Multiple insights were gained through the development of a CLD reflecting the process of incorporating circular ambitions in the I&D phase of a building project. A first major finding is the key position of 'experience' in the model (see Figure 6.1). An increase in experience will have a positive effect on a large number of variables. It will ultimately lead to the better incorporation of circularity in the project brief by improving variables such as certainty, knowledge and courage. Yet, experience is only gained by working on circular projects. A second major finding is the importance of knowledge sharing. This became evident from the large share of intervention strategies related to knowledge and knowledge sharing as already touched upon in 6.2.4..

Furthermore, the ST methodology used in this thesis can be used as a discussion tool amongst practitioners. Using this method as a tool will provide guidance for the discussion and supports its user by surfacing mental models. These are made explicit and tangible, making it more practical to discuss them. An overview of the steps to be undertaken to use this methodology as an discussion tool can be found in figure 5.4..

To conclude, ST can be used as a discussion tool and through the development of a CLD insights in the process are gained. This contribute to increase the understanding of the system, based on which intervention strategies can be formulated and substantiated.

### 6.3. Reflection on research objective

This last section of the conclusion will reflect on the objective of this research. The main- and sub-questions as discussed in the previous sections are stepping stones to reach this goal. The goal of this research was summarized into two research objectives, that will be discussed separately.

The first objective of this research was to develop a set of intervention strategies that can be used by PMs in the I&D phase that contribute to the better incorporation of circular ambitions. As described in 6.2.4., a total eight intervention strategies were formulated based on the focus group and interviews. Seven of these intervention strategies also came forward after the ST methodology was introduced and used.

This study focused on the PMs perspective and the intervention strategies can be classified in relation to the project managers scope of influence. PMs must keep up their knowledge through continuous education. This is

to secure a base level of knowledge that is necessary to present the possibilities to the client. On the other hand, a PM does not necessarily have to know everything. For more detailed and in-depth knowledge the PM can consult an expert, in some cases this can be a colleague. Both these actions fall within the direct scope of control of the project manager.

Three intervention strategies were formulated on which the project manager has a more indirect influence. These are the promotion of client awareness, the alleviation of uncertainties and the creation of more budget space. Through education and knowledge sharing by the PM the aim is to steer towards change. However, there is no direct control, the client has to make the change in the end.

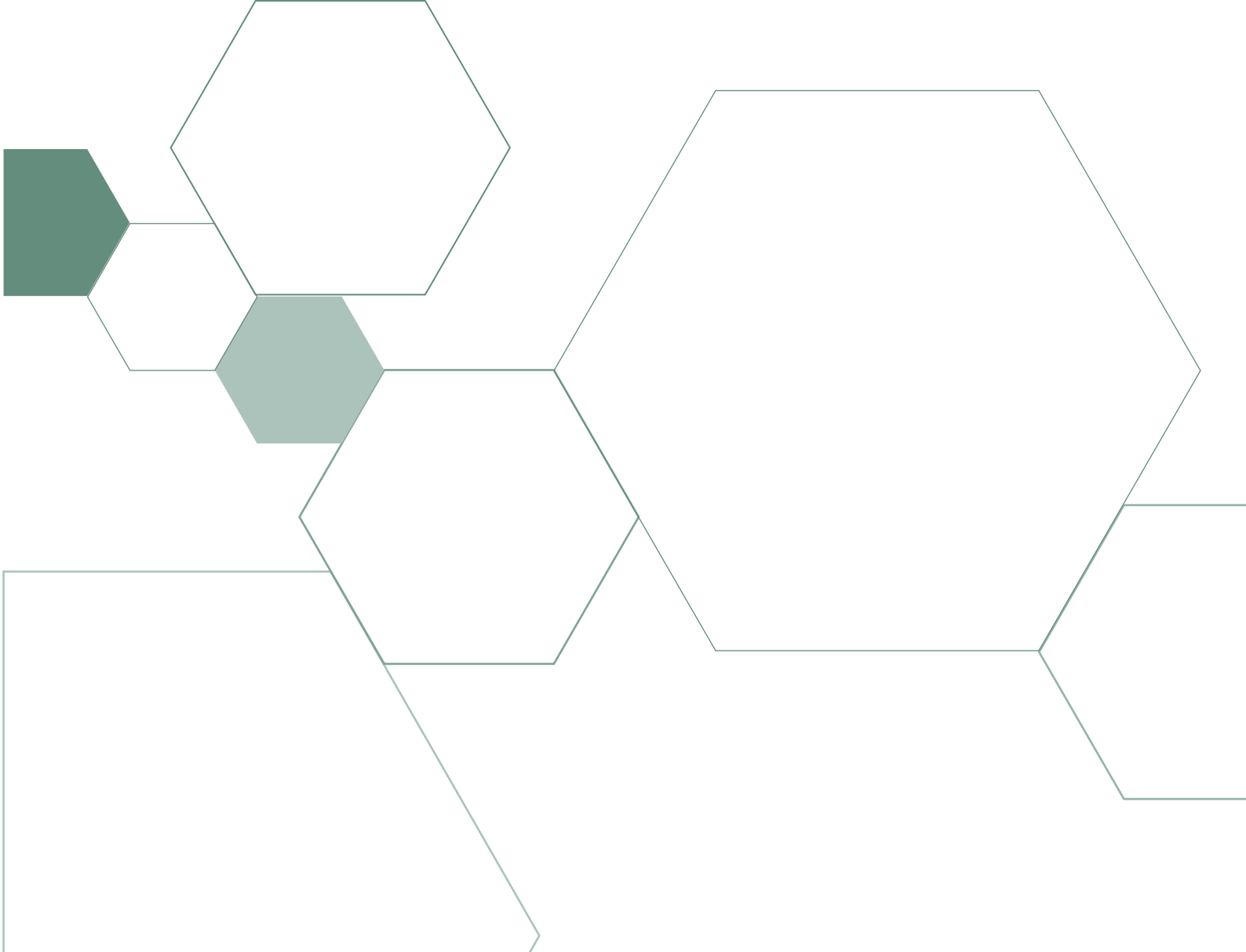
The remaining two interventions, ensuring an encouraging company culture and the external factors, do not fall within the scope of influence of the PM. The first concerns a change in the company or employer of the PM that would support and encourage them more. The second can for instance be related to changes in law and regulation, which are being implemented by government layers. Even though PMs do not have a direct influence on these interventions, based on the CLD (Figure 6.1) it becomes clear they are relevant to achieve the better incorporation of circularity in the I&D phase of building projects.

The second objective was to determine the contribution of ST in the development of these intervention strategies. Chapter 6.2. reflected on the hypothesis formulated prior to the empirical study. It was concluded that the difference between the event-based and ST interventions was minimal. ST for the use of formulating intervention strategies might therefore not be viable.

However, through ST the understanding of the dynamics and the problems faced when incorporating circularity in the I&D phase did improve. The mental models existing within the focus group were made explicit and visible in the CLD (Figure 6.1). As stated by one of the participants: "this is a representation of my brain" (FG3, February 28, 2024). Communication about the system and the problems occurring in the system was made relatively simple as resulting from the validation interviews.

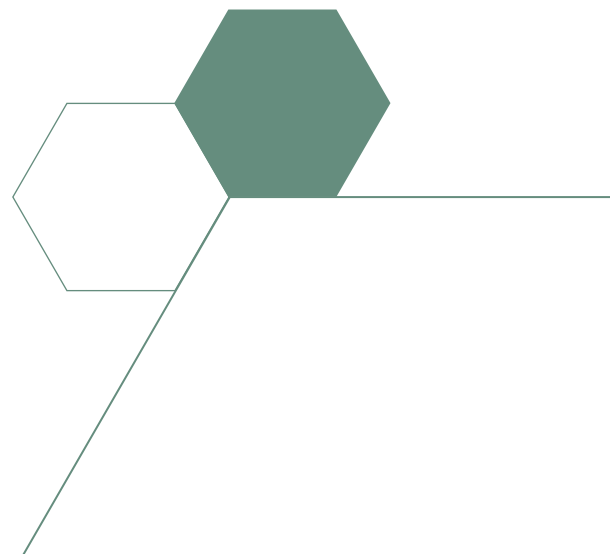
The contribution of ST might therefore not lay in the development of intervention strategies specifically but in providing a method for exploring circularity with a group. It can be used as a tool to improve awareness and discover the concept in depth, for example with a (new) client or project team. This method will surface the mental models and structures that might impede the incorporation of circularity in the project. By doing so, these can be considered, and interventions can be used to improve and overcome these problematic structures.

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# CHAPTER 7

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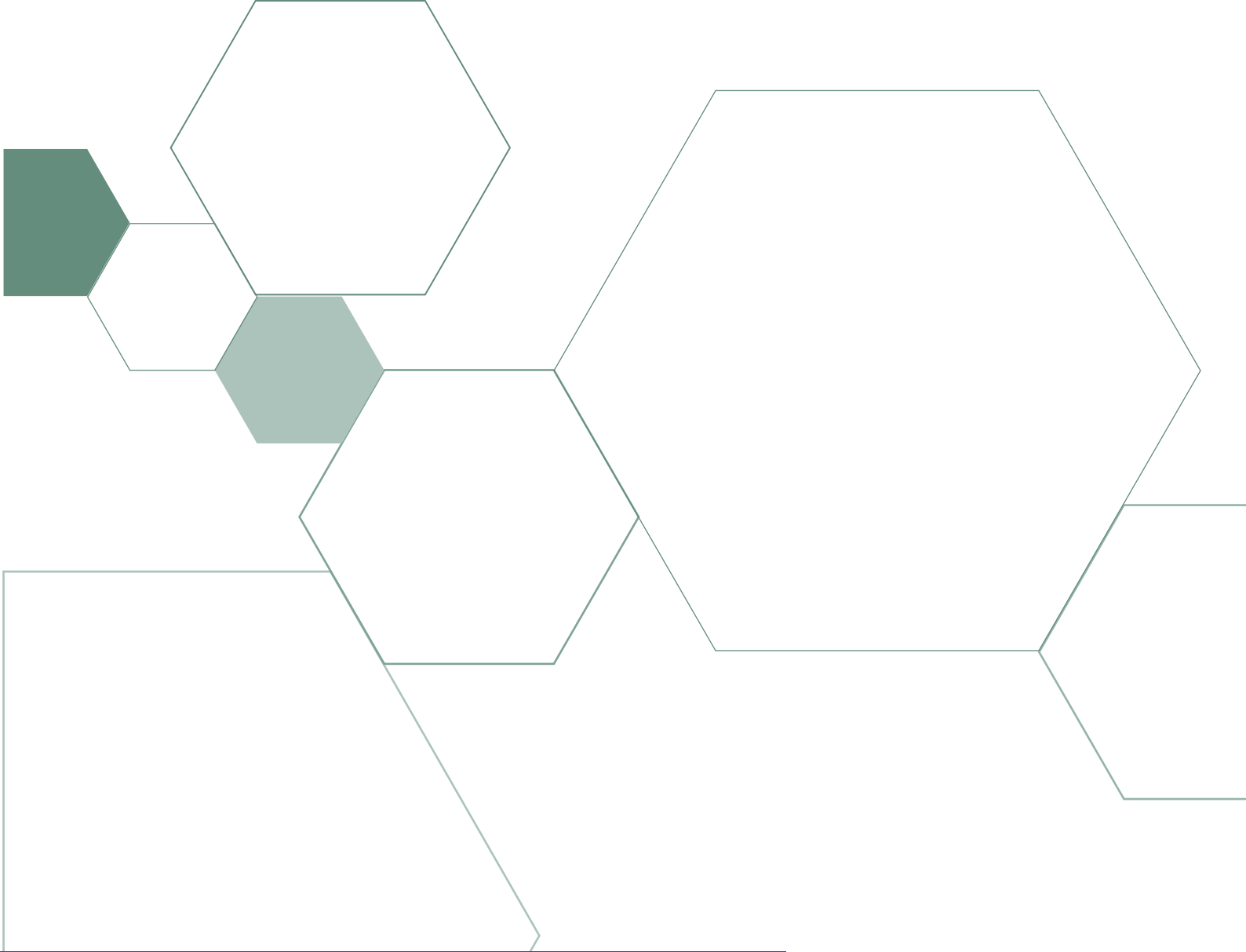
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# APPENDIX



## Appendix A – Causal loop diagramming additional information

In Figure 0.1 a simplified version of a CLD for population can be found. Using this model, the principles of CLDs will be explained. In Figure 0.1 the following variables can be identified: births, population and deaths. Variables are defined by the Cambridge Dictionary as “a number, amount, or situation that can change” (Cambridge Dictionary, n.d.). Maani & Cavana (2000) define it as “a condition, situation, action or decision which can influence and can be influenced by other variables”. Most important is that variables can increase or decrease over time and choosing a sensible variable name is very important for a proper representation of the system (Sterman, 2000). The requirements for variables in SD is further elaborated upon below.

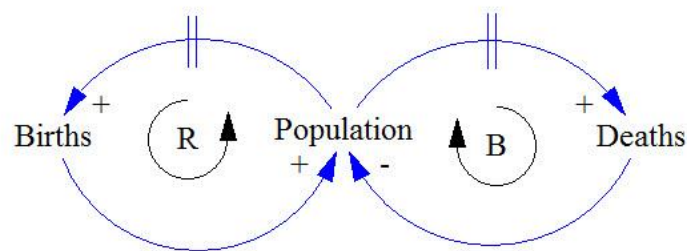


Figure 0.1. Simplified CLD with reinforcing and balancing loop that impact population. Source: Zhou, 2012

The arrows in the model present the causal relations between the variables, this relation can be positive or negative. There are two ways of denotation as presented in Figure 0.2 Sterman (2000) uses ‘+’ (positive) and ‘-’ (negative), whilst Maani & Cavana (2000) use ‘s’ (same) and ‘o’ (opposite) to indicate the nature of the relationship. The s and o notation was introduced to make CLDs even more approachable for those with little background in mathematics. However, it is argued that this notation is incorrect. If variable X increases, it does not automatically mean variable Y also increases. This is due to the multiple variables that might influence Y, therefore it cannot be said that X and Y move in the ‘same’ direction (Sterman, 2000). On the other hand, ‘+’ and ‘-’ can intuitively translate to ‘more’ or ‘less’, which might cause confusion too (Maani & Cavana, 2000). This study is conducted by a master student from a technical university, in a technical field, it is therefore expected that the ‘+’ and ‘-’ notation will not cause any reading problems. This notation will be used throughout this research and a definition of these relations can be found in Table 0.1. In some cases the link can either be positive or negative, in this case the link polarity is indicated with a question mark (?).

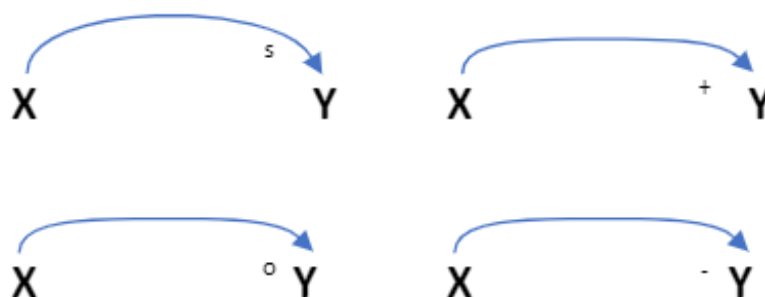
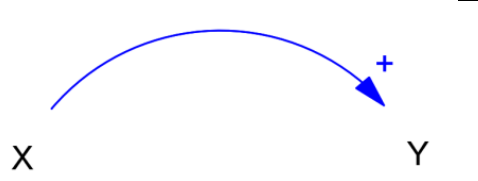
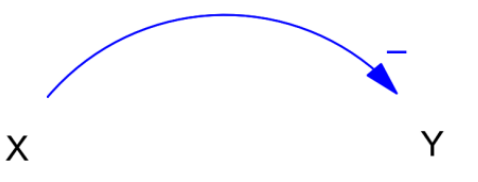
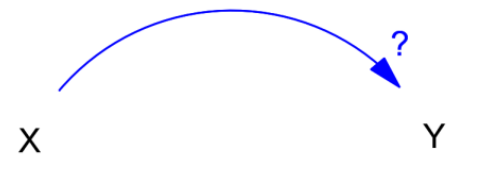
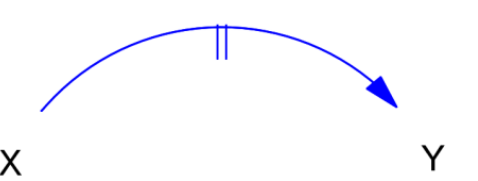
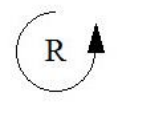
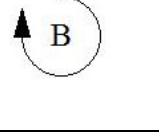


Figure 0.2. Link polarity symbols. Source: Author, based on Maani & Cavana (2000); Sterman (2000)

By indicating the causal relations between variables, feedback loops can emerge. In a feedback loop, a group of variables has been linked together and forms an uninterrupted path. A full circle is made from the starting variable, back to itself (Maani & Cavana, 2000). In Figure 0.1, two feedback loops can be identified, each loop existing out of two variables. Like the link between the variables, the loop also has a polarity. A feedback loop can be balancing (B) or reinforcing (R). Loop polarity can be determined by tracing the effect of change throughout the loop. It does not matter with which variable you start, the result should be the same (Sterman, 2000). A definition of this loop polarity can be found in Table 0.1.

Table 0.1. CLD symbol definition

Symbol	Interpretation
	Positive relation. When all other variables do not change, if X increases (or decreases), then Y would increase above (decrease below) what it was.
	Negative relation. When all other variables do not change, if X increases (decreases), then Y would decrease below (increase above) what it was.
	Undefined relation. When all other variables do not change, if X increases (or decreases), then Y could increase above or decrease below what it was.
	Delay, the influence of X on Y is noticeable with a delay.
	<b>Reinforcing loop</b> , a positive feedback system. When the starting variable increases (decreases) it will eventually lead to a further increase (decrease) of itself.
	<b>Balancing loop</b> , negative or counteractive feedback system. When the starting variable increases (decreases), this will eventually lead to a decrease (increase) of itself.

### Variable

As mentioned before, the most important characteristic of a variable is that it can increase or decrease over time. A main strength of CLDs in SD is the possibility to combine quantitative and qualitative variables in the same model (Maani & Cavana, 2000). Quantitative variables are measurable variables, such as costs and time, whereas qualitative variables cannot be measured easily. Some examples of qualitative variables are enthusiasm, motivation and stress. In SD literature some guidelines for

formulating the variables are provided . It is stressed that picking a sensible variable name is of utmost importance (Maani & Cavana, 2000; Sterman, 2000). In this research variables:

- do not contain a sense of direction
- are positive (encouragement not discouragement)
- are nouns or short noun phrases

## Appendix B – Systems thinking and modelling additional information

The Systems Thinking and Modelling (ST&M) methodology developed by Maani & Cavana (2000) is used as the guiding methodology in this research. The aim of this research is to develop intervention strategies that can be deployed by PMs in the I&D phase of a project and to test them against the system. Maani & Cavana (2000) specifically include ‘develop intervention strategies’ as one of the steps in their ST&M methodology, whereas other SD authors either do not describe their methodology in clear steps or do not explicitly include the development of interventions as a part of their methodology (Meadows, 2008; Sterman, 2000). Since this is one of the objectives of this research, the ST&M methodology was considered most appropriate for this research.

The literature stresses that not all phase are required for every research, nor all steps of a phase. Previous studies show that problems that ask for a ‘soft’, or qualitative approach, usually draw from phases one and two. Whereas ‘hard’, or quantitative, research often also deploys steps from phases three and four (Maani & Cavana, 2000). Modelling is in its nature an creative process, depending upon the problem, systems behavior and the time the researcher can commit, the method is molded to fit the study. As this is a qualitative research, steps form phases one and two will be used, this is also presented in Table 0.1. **Fout! Verwijzingsbron niet gevonden..** Some of the concepts and tools introduced by each step are explained below.

Table 0.1. Sytems thinking and modelling process. Source: Maani & Cavana, 2000

Phases	Steps	Used
<b>1.Problems structuring</b>	Identify problems or issues of concern	x
	Collect preliminary information and data	x
<b>2.Causal loop modelling</b>	Identify main variables	x
	Prepare behavior over time graphs	
	Develop Causal Loop diagram	x
	Analyze loop behavior over time	x
	Identify systems archetypes	
	Identify key leverage points	x
	Develop intervention strategies	x
<b>3.Dynamic modelling</b>	Develop a systems map or rich picture	
	Define variable types and construct stock-flow diagrams	
	Collect detailed information and data	
	Develop a simulation model	
	Simulate steady-state/stable conditions	
	Reproductive reference mode behavior	
	Validate the model	
	Perform sensitivity analysis	
	Design and analyze policies	
	Develop and test strategies	
<b>4.Scenario planning and modelling</b>	Plan general scope of scenarios	
	Identify key drivers of change and keynote uncertainties	
	Construct forced and learning scenarios	
	Simulate scenarios with the model	
	Evaluate robustness of the policies and strategies	
<b>5.Implementation and organizational learning</b>	Prepare a report and presentation	x
	Communicate results and insights	x

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Develop a micro world and learning lab based on simulation model

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Use learning lab to examine mental models and facilitate learning

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# Appendix C – Semi-structured interviews to retrieve barriers – guides and coding

## Appendix C1 - Interview guides

### Doel van het onderzoek:

Het doel van dit onderzoek is om inzicht krijgen in de dynamieken en processen in de definitiefase van een project waarin ambities op het gebied van circulariteit omgezet worden naar specificaties. Uiteindelijk zal er een lijst aan interventie strategieën worden opgesteld met als doel het beter incorporeren van circulaire ambities in de specificaties

### Doel van het interview: Semi-

Het doel van het interview is om de ervaren barrières met betrekking tot circulariteit te achterhalen.

### Literatuur:

In de literatuur staan al enkele barrières beschreven met betrekking tot circulariteit in projecten. De gevonden literatuur heeft uiteenlopende onderzoekteams en scopes, zoals een focus op energie bedrijven, stad niveau en op het hele project maar ook op transitie in het algemeen.

In het algemeen worden financiën, kennis en beleid altijd genoemd als hoofd categorieën.

### Soort vragen:

Open en gesloten vragen

---

## Interview guide – Project manager internal

1. Hoeveel jaar ervaring heeft u als project manager?

Antwoord: \_\_\_\_\_ jaar

- 1a. Heeft u verdere werk ervaring?

2. Welke projecten bent u op dit moment mee bezig?

- 2a. Wat is uw rol, en de rol van Sweco binnen die projecten?

Vervolg vraag: Kunt u uw rol aanwijzen aan de hand van dit figuur? (AUV/UAV-GC)

- 2b. Welke rol speelt het thema circulariteit (duurzaamheid) binnen deze projecten?

Vervolg vraag: Bent u specifiek gevraagd om rekening te houden met circulariteit in deze projecten?

### Definitie fase/specificaties

De komende vragen gaan over het ondersteunen van een klant bij het opstellen van specificaties. Het gaat over uw rol in de definitie fase. Hierbij mag u het onderwerp circulariteit los laten.

3. Welke stappen/acties onderneemt u wanneer u een klant ondersteunt bij het opstellen van specificaties nadat een project is geïnitieerd?

Voorafgaand aan dit interview heb ik meerdere van uw collega's gesproken over dit onderwerp. Dit heb ik samengevat in dit figuur. Deze vragen dragen bij aan het valideren en compleet maken van dit figuur.

4. Wat vindt u van de informatie in dit figuur?
  - 4a. Welke informatie ontbreekt volgens u in het figuur?
  - 4b. Welke informatie kan volgens u duidelijker worden weergegeven in dit figuur?

## **Barrières**

De transitie naar een circulaire economie is op dit moment een belangrijk onderwerp van gesprek. De hoog-over ambitie van Nederland is om volledig circulair te zijn in 2050. Dit ambitie document is opgeleverd in 2016.

Optioneel :

5. Heeft u een verandering gemerkt bij klanten naar aanleiding van deze ambitie?
  - 5a. Zo ja: Waaraan merkt u deze verandering?
6. Kunt u, uit uw eigen ervaring, een voorbeeld geven van een project waarin circulaire ambities succesvol zijn geïmplementeerd?
  - 6a. Heeft u ook een voorbeeld waarbij er wel ambities waren op gebied van circulariteit maar deze uiteindelijk niet of minimaal terug te zien waren in de specificaties en het ontwerp?
  - 6b. Op welke gebieden zijn als eerste concessies gedaan?

Deze vragen dienen als een manier om deze projecten naar de voorgrond van de gedachten te krijgen. Bij de komende vragen mag u deze projecten als referentie gebruiken maar dat hoeft niet. Het gaat om uw algemene ervaring.

7. Wat zijn enkele van de grootste uitdagingen die u bent tegen gekomen bij het integreren van circulaire ambities in specificaties en projecten?

[let hierbij op het antwoorden en stel de volgende vragen in ieder geval specifieker op de gegeven antwoorden]
8. Kunt u enkele van de interne belemmeringen beschrijven die klanten tegenkomen wanneer ze circulaire ambities willen integreren in hun bouwprojecten?

[verwachtte antwoorden: klant perceptie, klant maturity/intern beleid, kosten, klant kennis]

  - 8a. Waarom denkt u dat kosten een belemmering zijn? [ook voor de andere antwoorden]
  - 8b. Zijn er specifieke processen of procedures of functionarissen (intern bij een klant) die het moeilijk maken om circulaire ambities te integreren?
9. Kunt u enkele (externe) belemmeringen beschrijven die u heeft ondervonden vanuit de markt bij het integreren van circulaire principes in de projecten?
10. Welke vaardigheden en kennis zijn nodig (heeft u nodig) om circulaire principes effectief te kunnen integreren in uw projecten?

11. Zijn er bepaalde regelgevingen of beleidsmaatregelen die de integratie van circulaire ambities in de projecten bemoeilijken?

## Afsluiting

Is er nog iets dat u zou willen toevoegen over uw ervaring met het integreren van circulaire (of duurzame) principes?

## Interview guide – CE expert

### Introductie:

0. Kan je een definitie geven van jou functie, rol en organisatie?
  - a. Hoeveel jaar ervaring heeft u in deze rol?
  - b. Heeft u verdere relevante werkervaring?
1. Bent u op dit moment met projecten bezig?
  - a. Welke rol speelt het thema circulariteit in deze projecten?
  - b. Is dit iets waar u specifiek gevraagd bent om rekening mee te houden?

De transitie naar een circulaire economie is op dit moment een belangrijk onderwerp van gesprek. De hoog-over ambitie van Nederland is om volledig circulair te zijn in 2050. Dit ambitie document is opgeleverd in 2016.

2. Heeft u naar aanleiding van deze ambitie gemerkt dat er een verandering is opgetreden met betrekking tot de hulp vragen die je krijgt?
  - a. Welke veranderingen zijn dat dan?
3. Wat is uw rol bij het vertalen van ambities naar project specificaties/het opschrijven van het PvE?
4. Welke uitdaging bent u tegen gekomen bij het integreren en vertalen van circulaire ambities in specificaties/PvE?
5. Waarom denkt u dat het lastig is om circulaire ambities specifiek te krijgen?
6. Kunt u iets vertellen over de afweging die gemaakt wordt bij het wel of niet meenemen van CE in het PvE?
7. Zijn er belemmeringen die vanuit de markt op treden bij het integreren van circulaire principes?
8. Denkt u dat er in het algemeen voldoende ambitie en doelstelling is bij klanten bij gebied van circulariteit
  - a. Hoe komt dat?
  - b. Waarom/waarom
9. Denkt u dat er in het algemeen genoeg kennis is om circulariteit goed te integreren?
  - a. Waarom?
10. Is er bestaande regelgeving of beleid dat het meenemen van circulariteit belemmert?
  - a. Is er ook regelgeving die het juist ondersteunt?
  - b. Zou er andere regelgeving moeten worden ontwikkeld?

# Interview guide – klant

## Introductie:

0. Kan je een definitie geven van jou functie, rol en organisatie?
  - a. Hoeveel jaar ervaring heeft u in deze rol?
  - b. Heeft u verdere relevante werkervaring?

De transitie naar een circulaire economie is op dit moment een belangrijk onderwerp van gesprek. De hoog-over ambitie van Nederland is om volledig circulair te zijn in 2050. Dit ambitie document is opgeleverd in 2016.

1. Hoe wordt er binnen uw organisatie (gemeente) omgegaan met deze ambitie?
  - a. Waaraan merk je dat?
2. Denkt u dat er genoeg aandacht is voor circulariteit binnen uw organisatie (de gemeente)?
  - a. Hoe komt dat?
3. Heeft u zelf affiniteit met het concept circulariteit? Vind jij het zelf een belangrijk onderwerp
  - a. Heeft uw opdrachtgever/organisatie deze ambitie? Zo ja, waarom/waarom uit dat zich?
  - b. Waarom/waarom/waarom?
4. Je vertelde dat je hebt meegewerkt aan een bepaalde tool... kan je daar wat meer over vertellen?
  - a. Is deze tool specifiek voor de definitie fase?
  - b. Waarom wilden ze deze tool ontwikkelen?
  - c. Waarom/waarom/waarom?

Mijn onderzoek gaat specifiek over de barrières bij het opstellen van de vraag specificatie. Dus er zijn wel ambities op het gebied van circulariteit/duurzaamheid maar die komen nog niet altijd terug in de vraagspecificatie of het programma van eisen.

5. Ben jij in jou rol ook betrokken geweest bij de vertaling van ambities naar vraagspecificaties/programma van eisen.

Je gaf aan dat je twee jaar in dienst bent geweest als beleidsadviseur circulaire economie.

6. Wat houdt deze rol precies in?
7. Welke barrières ben je tegen gekomen binnen de organisatie tijdens het uitvoeren van deze rol?
  - a. Waarom denk je dat deze belemmeringen er zijn/
  - b. Waarom/waarom/waarom?
8. Hoe wordt er binnen de organisatie (door collega's) gekeken naar circulariteit in de vorm van hergebruik?
  - a. Hoe zit dat met bio-based?
9. Zijn er externe belemmeringen, vanuit de markt bijvoorbeeld, die het integreren van ambities in de specificaties bemoeilijkt?
10. Is er regelgeving of beleid die het meenemen van circulaire ambities in vraagspecificaties bemoeilijkt?
11. Hoe worden de ambities op gebied van circulariteit afgewogen en meegenomen in het PVE?
12. Waarom denkt u dat het lastig is om circulaire ambities specifiek te krijgen?

13. Welke uitdagingen bent u tegen gekomen bij het integreren en vertalen van circulaire ambities in specificaties / het programma van eisen?
14. Welke vaardigheden en kennis heeft u nodig om circulaire principes en ambities beter in de vraag specificatie op te nemen?

### **Afsluiting:**

15. Is er verder nog iets dat u zou willen toevoegen over uw ervaring met het integreren van circulaire principes in de specificatie?

## **Interview guide – Project manager extern**

0. Kan je een definitie geven van jou functie, rol en organisatie?
  - a. Hoeveel jaar ervaring heeft u in deze rol?
  - b. Heeft u verdere relevante werkervaring?
1. Bent u op dit moment met projecten bezig?
  - a. Welke rol speelt het thema circulariteit in deze projecten?
  - b. Is dit iets waar u specifiek gevraagd bent om rekening mee te houden?

De transitie naar een circulaire economie is op dit moment een belangrijk onderwerp van gesprek. De hoog-over ambitie van Nederland is om volledig circulair te zijn in 2050. Dit ambitie document is opgeleverd in 2016.

2. Heeft u binnen de organisatie verandering gemerkt naar aanleiding van deze doelstelling?
  - a. Welke veranderingen zijn dat dan?

Mijn onderzoek gaat specifiek over de barrières bij het opstellen van de vraag specificatie. Dus er zijn wel ambities op het gebied van circulariteit/duurzaamheid maar die komen nog niet altijd terug in de vraagspecificatie of het programma van eisen.

3. Heeft u zelf de ambitie om circulariteit beter te inbedden in uw projecten?
  - a. Heeft uw opdrachtgever/organisatie deze ambitie? Zo ja, waarom/waarom uit dat zich?
4. Denkt u dat er genoeg aandacht is voor circulariteit binnen uw organisatie?
  - a. Hoe komt dat?
5. Wat is uw rol bij het vertalen van ambities naar project specificaties?
6. Welke uitdagingen bent u tegen gekomen bij het integreren en vertalen van circulaire ambities in specificaties / het programma van eisen?
7. Hoe worden de ambities op gebied van circulariteit afgewogen en meegenomen in het PvE?
8. Waarom denkt u dat het lastig is om circulaire ambities specifiek te krijgen?
9. Spelen er belemmeringen van binnen uit de organisatie?
  - a. Waarom denkt u dat die belemmeringen opspelen?
10. Hoe kijkt men binnen de organisatie aan tegen hergebruikte producten?
  - a. Hoe zit dat met bio-based?
11. Zijn er externe belemmeringen, vanuit de markt bijvoorbeeld, die het integreren van ambities in de specificaties bemoeilijkt?
12. Welke vaardigheden en kennis heeft u nodig om circulaire principes en ambities beter in de vraag specificatie op te nemen?

13. Is er regelgeving of beleid die het meenemen van circulaire ambities in vraagspecificaties bemoeilijkt?

**Afsluiting:**

14. Is er verder nog iets dat u zou willen toevoegen over uw ervaring met het integreren van circulaire principes in de specificatie?

**Appendix C2 - Coding scheme**

Coding scheme for interviews into barriers in the I&D phase of a project.

Green indicate inductive variables

Barrier	External	
	Organizational	Collaboration stakeholders
		Commitment management
		Organization capacity
		Organization structure
	Technological	Accessibility tools and products
		Guarantees
	Cultural	Behavior
		Perception
	Economic	Budget constraints
		Cost increase
		Mismatch
	Regulatory	Policy
		Subsidies
	Social	Capacity
		Knowledge
Norm/trend		
Technical	Complexity	
	Storage	
Driving	Cultural	Norm
	Organizational	Commitment management
		Stakeholder collaboration
		Structure
Regulatory	Tool	
Other	Contracting	
	End-of-life	
	Goal/ambition	
	Greenwashing	
	Opinion	
	Pre-initiation	

# Appendix D – Focus group coding scheme and guides

## D1 – Coding scheme

Clusters	Behavior organization	Organization circularity drive Progressive organization
	Behavior personal	Ambition
		Courage
		Enthusiasm
		Persuasiveness
		Progressiveness
		Support base
	Certainty	Availability of virgin materials
		Certainty
		Geopolitical unrest
		Innovation rate
	Knowledge sharing	Capacity of people with knowledge
	Law and regulation	
	Long-term vision	Importance of knowledge sharing
		Life-cycle thinking
	Management	Commitment management
		Degree of management vision
	Planning	Development time
		Experience
		Insight
	Project budget	Circularity budget resilience
		Costs
		Investment budget
Quality material	Availability of certified reused materials	
	Availability of circular materials	
	Availability of proven bio-based materials	
	Material certification importance	
Vision/story		
Relations		
Intervention	Alleviate uncertainties	
	Change client management	
	Company culture	
	Consult external knowledge	
	Continuous education	
	External change	
	Just do it	
	Promote client awareness	
	Well-considered budget choices	

## D2 – Focus group guide

# Focus group session 1 – Hexagon thinking: developing variables and relations

### Algemeen

**Dag, tijd:** 24 januari 2024, 10.30 – 12.00

**Duur:** 90 minuten

**Deelnemers:** 5

**Afmeldingen:** 1

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### Benodigdheden

- Pennen, stiften, ander schrijfbaar
- Stickynotes hexagonen
- Flipover of ander groot vel papier
- Schilder tape
- Opname apparatuur
- Camera
- Uitgeprinte informed consent formulieren

### Doornemen informed consent formulier:

- Informatie puntsgewijs
- Ondertekenen

### Landen

Welkom allemaal, bedankt dat jullie hier allemaal kunnen zijn vandaag. Vandaag gaan we een workshop doen waarmee ik data verzamel voor mijn afstudeer onderzoek. Het doel van mijn onderzoek is door middel van systeem denken interventie strategieën te ontwikkelen die zullen bijdragen aan het beter integreren van circulaire ambities in de initiatie en definitie fase van een project. Ik zal mijn onderzoek en de positie van deze focus groep in het proces straks verder toelichten

### Programma

Deze groep sessie duurt ongeveer 90 minuten. We gaan straks beginnen met een opening, daarna zal ik mijn onderzoek, deze workshop en het doel daarvan introduceren. Vervolgens zullen we beginnen met de workshop die bestaat uit 4 delen die ik ook later zal toelichten.

### Opening

We gaan het vandaag hebben over circulariteit en de manier waarop omgegaan wordt met ambities op het gebied van circulariteit in de initiatie en definitie fase van een project.

1. Wanneer heb je voor het laatst iets tweedehands gekocht?



## **Circulariteit**

In mijn onderzoek neem ik de definitie voor een circulair gebouw over van CB'23: een circulair gebouw is een gebouw dat is ontworpen met circulaire principes en is gerealiseerd met circulaire producten, elementen en materialen.

Wat zijn dan circulaire principes. Hier zijn verschillende modellen van. Metabolic vind dat een definitie van een circulaire economie pas gemaakt kan worden wanneer er bekend is wat de gewenste eind situatie is wanneer we in een circulaire economie leven. Daarvoor hebben ze deze 7 pilaren geformuleerd. Deze gaan verder dan enkel het gebruik van energie, water en materiaal. Deze 7 pilaren kunnen ondersteunen in het denken en maken van keuzes.

De Nederlandse overheid gebruikt een variant van de R-ladder, de 6R ladder. Bestaande uit refuse & rethink. Reduce, reuse, repair, recycle en als laatste recover. Dit zijn allemaal strategieën die toegepast kunnen worden bij het ontwikkelen van een circulair gebouw. Je wil een zo laag mogelijke R op deze ladder gebruiken, dan is de mate van circulariteit het hoogst

Een laatste model is de butterfly diagram van de Ellen MacArthur Foundation De rechter kant van dit model is de 'technische' zijde. Hier komen strategieën uit de R-ladder terug. De linker kant representeert de 'biologische' zijde. Hierin wordt het gebruik van bio-based producten laten zien.

Concluderend zijn circulaire strategieën het toepassen van bio-based producten of de strategieën zoals laten zien in de R-ladder.

## **Doel van het onderzoek**

Doel:

Het doen van het onderzoek is tweezijdig:

- ➔ Ten eerste het ontwikkelen van interventie strategieën die project managers kunnen gebruiken tijdens de initiatie en definitie fase van een project met als doel om de circulaire ambities van een klant beter terug te laten komen in het project
- ➔ Het tweede en meer academische doel is om te onderzoeken wat de bijdrage is van systeem denken in het ontwikkelen van deze interventie strategieën.

Wat is Systeem denken dan?

Systeem denken is een onderzoek aanpak die is ontwikkeld om de problematiek in diens bredere context weer te geven. Het is eigenlijk een manier om te kijken naar de wereld, voorbij het geen dat we elke dag mee maken, de 'gebeurtenissen' – of events zoals in deze figuur, het topje van de ijsberg. Complexe problemen kunnen beter fundamenteel worden aangepakt als het systeem in kaart is gebracht en de zogenaamde mentale modellen expliciet zijn gemaakt. Er zit veel kennis (van processen) in de hoofden van mensen en daarbij komen ook de onbewuste ideeën, vooroordelen en meer.

Er zijn verschillende scholen binnen systeem denken, in mijn onderzoek gebruik ik de systeem dynamiek school. Dit is de grootste 'school' die ook binnen de meeste vakgebieden toegepast kan worden, waaronder ook de constructie industrie en de circulaire economie. Binnen deze school is de 'causal loop diagram' een belangrijk instrument. En dit ga ik ook ontwikkelen.

Een CLD is een model dat visualiseert welke variabelen in een systeem invloed op elkaar hebben. Een simpel voorbeeld van een CLD is deze over populatie. Als het aantal geboortes toe neemt, neemt de populatie ook toe. Als de populatie toe neemt, neemt het aantal geboortes ook toe. Dit is een zogenaamde reinforcing loop. Aan de andere kant zie je als de populatie toe neemt, dat het aantal sterfgevallen ook toe neemt waardoor de populatie weer af neemt. Dit is een balancing loop.

Hier zie je een CLD ontwikkeld door Gufran en collegas. Deze gaat over een onderwerp gerelateerd aan de verduurzaming van de constructie industrie.

## Doel van de workshop

Het doel van deze workshop is om stappen te zetten richting het maken van een eerste versie van zo'n CLD.

## Onderzoek flow

Ik zit nu in de derde fase van mijn onderzoek. De eerste fase was het ontwerpen van het onderzoek, het formuleren van onderzoeksvragen en een doelstelling. In de tweede fase werd het probleem beter gestructureerd, dit hield in het doen van een literatuur studie en ik heb in deze fase interviews gehouden met verschillende deelnemers, externe project managers, CE experts, met als doel barrières voor circulariteit in de initiatie en definitie fase bepalen. Deze fase heet 'causal loop modelling'. En de eerste stap die ik vandaag met jullie ga doen is brainstormen met hexagonen. Hierna zal ik de informatie analyseren en verder uitwerken aan de hand van theorie over het onderwerp. Dit wordt dan mee genomen in de volgende sessie.

## Inhoud

Brainstormen met hexagonen bestaat uit 4 stappen zoals hier afgebeeld. De eerste stap is het identificeren van 'issues' ik heb het hier vertaald naar problemen maar dit dekt niet volledig de lading. Het gaat om wie, wat, wanneer, waarom, waar...

Vervolgens gaan we deze dingen clusteren en een naam geven, hier uit worden variabelen gedefinieerd en dan gaan we verbanden leggen

## Stap 1: identificeren van problemen

### **2. Wat is er van invloed op het realiseren van circulaire ambities in de initiatie en definitie fase van een project? [15 min]**

→ Doelstelling initiatief fase zoals in DNR: De opdracht gever besluit het project al dan niet door te zetten met het opstellen van een PvE

Doelstelling projectdefinitie zoals in DNR: het analyseren van de te huisvesten organisatie(s) en processen en het opstellen van (prestatie-) eisen, wensen, verwachtingen en voorwaarden mbt het bouwerk en het documenteren daarvan in een PvE.

→ Active mode, 3 stappen:

1. Individueel opschrijven van 10 problemen
2. Opplakken en met elkaar naar kijken, probeer niet te groeperen
3. Reageren op elkaar en aanvullen

→ Doel groepsgewijs stimuleren van 'event-level' denken, barrières, problemen, vragen, factoren komen naar boven. Wie, wat, wanneer, waar en waarom?

→ Ideale situatie gaat dit door tot dat de response van de groep minimaal is.

- ➔ Vragen om voor te stellen als respons moeilijk op gang komt:
  - Welke problemen en onzekerheden spelen er
  - Welke kansen zie je ...?
  - Wat zorgt ervoor dat er geen stappen worden gezet op gebied van circulariteit?
  - Wie zijn belangrijke spelers...?

### **3. Met jou huidige kennis, welke interventies zou je nu voorstellen? [10 min]**

- ➔ Deze oplossingen worden kort samen gevat en op 'normale' post-its opgeschreven.
- ➔ Deze vraag draagt niet bij aan het ontwikkelen van de CLD maar is ter controle van de uiteindelijke interventies die volgen in FG2.

## **Stap 2: identificeren van clusters**

### **4. Welke hexagonen zijn aan elkaar gerelateerd? [10 min]**

- ➔ Verdeel de groep in 2 delen, 1 deel gaat de hexagonen clusteren, het andere deel geeft commentaar.

### **5. Welke naam past bij dit cluster? [5 min]**

- ➔ Ga alle clusters langs
- ➔ Laat de deelnemers zelf de namen bedenken, opschrijven en discussiëren

## **Stap 3: identificeren van variabelen**

Een variabele is iets die kan toe- of afnemen naarmate tijd verstrijkt. Er bestaan verschillende typen variabelen; harde en zachte variabelen. Harde variabelen voelen vaak wat natuurlijker omdat deze in een bepaalde eenheid uit te drukken zijn, ze zijn te kwantificeren. Dus bijvoorbeeld de variabele 'kosten', dit is een grootheid die wordt uitgedrukt in de eenheid euro's. tijd kan worden uitgedrukt in minuten. Zachte variabelen zijn kwalitatief. Dus bijvoorbeeld de variabele kwaliteit, dit is geen grootheid omdat hij niet direct gemeten kan worden in een eenheid. Als je deze meetbaar wil maken moet je dus een andere indicator verzinnen die wel meetbaar is. Denk aan het aantal kapotte items per 1000. We kunnen voor deze vorm van causal loop diagramming zowel harde als zachte barrières opstellen.

### **6. Welke variabelen kan je per cluster formuleren? [10 min]**

- ➔ Deel de groep op in twee delen en laat ze variabelen opschrijven per cluster.
- ➔ Breng terug naar centraal, is dit zo volledig?

## **Stap 4: causale verbanden leggen**

### **7. Welke causale verbanden bestaan er tussen deze variabelen? [10 min]**

- ➔ Schets lijnen tussen de verbanden terwijl de groep hierover discussieert

## **Uitstappen**

Vandaag hebben we de eerste stappen gezet naar het ontwikkelen van een causal loop diagram voor het systeem .... Ik zal deze workshop verder uitwerken en de ontwikkelde CLD spiegelen aan de theorie over systeem denken. In de volgende focus groep zullen we daar mee verder gaan. We gaan dan in op de interventies die kunnen worden ingezet om de problemen in dit systeem aan te pakken.

- 8. Wat nemen jullie mee van deze workshop? Wat is nieuw? [5 min]

# Focus group session 2 – Developing intervention strategies

## Algemeen

**Dag, tijd:** 7 februari 2024, 10.30 – 12.00

**Duur:** 90 minuten

**Deelnemers:** 6

**Afmeldingen:** 1

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## Benodigdheden

- Pennen, **stiften**, ander schrijfbaar
- Sticky notes hexagonalen met geformuleerde variabelen
- Schilder tape
- Flip-over of A-3 papier
- Opname apparatuur
- Camera
- Uitgeprint informed consent formulier
- Fotos van de clusters uitgeprint

## Landen

Welkom allemaal, fijn dat jullie er weer allemaal kunnen zijn. We gaan vandaag verder waar wij bij de vorige sessie zijn gebleven. Toen hebben door middel van de hexagonalen brainstorm techniek eerst de situatie geformuleerd, welke dingen er van invloed zijn op het implementeren van circulariteit in de initiatie en definitie fase van een project - (semi-)publiek gebouw. Vervolgens zijn we via verschillende stappen tot en set aan variabelen gekomen.

## Programma

Deze groep sessie duurt weer 90 minuten. Ik begin straks met vertellen wat ik de afgelopen weken met de input van de vorige sessie heb gedaan, jullie kunnen dan ook jullie input geven op de variabelen van vorige keer. Vervolgens gaan we verbanden leggen tussen de variabelen. En als laatste stap gaan we kijken of we het behulp van het causale verbanden diagram tot een aantal interventie strategieën kunnen komen.

## Opening

1. ***Wat hebben jullie meegenomen van de vorige workshop?***

## Inhoud

Een korte recap van waar mijn onderzoek over gaat:

Mijn onderzoek gaat over strategische ambities van een klant op gebied van circulariteit in de initiatie en definitie fase. De vraag is hoe systeem denken bij kan dragen aan het ontwikkelen van interventie strategieën om circulariteit beter in te bedden in deze fasen van een project.

Het doel is tweezijdig,

- aan de ene kant het ontwikkelen van interventie strategieën die ook door jullie als project managers toe gepast kunnen worden in deze fase van het project.
- Aan de ander kant onderzoeken wat de bijdrage is van systeem denken

Systeem denken is dus een manier van kijken naar de wereld waar in wordt gedacht op een dieper liggend niveau dan 'event' level denken. Event level denken kan je zien als het waarnemen van een gebeurtenis op een dag – 'het regent' is een event.

Met systeem denken plaatst deze gebeurtenissen en patronen in hun bredere systeem. In de school van systeem denken die ik gebruik is de causal loop diagram een belangrijk element. Dat zag er zo uit,

### **Doel van de workshop**

Twee weken geleden zijn we tot het formuleren van variabelen gekomen, vandaag gaan we de relaties tussen die variabelen bepalen. En voor een deel gebaseerd op theorie een aantal interventie strategieën formuleren.

### **Recap variabelen**

in de vorige sessie hebben jullie in totaal 44 verschillende invloeden geformuleerd welke verdeeld zijn over 11 clusters. Daarnaast heb ik 19 barrières toegevoegd die ik terug heb gevonden in interviews en literatuur, 5 van deze barrières komen overeen met de door jullie geformuleerde invloeden.

### **Regels voor variabelen**

Een variabele is iets die kan toe- of afnemen naarmate tijd verstrijkt. Er bestaan verschillende typen variabelen; harde en zachte variabelen. Harde variabelen voelen vaak wat natuurlijker omdat deze in een bepaalde eenheid uit te drukken zijn, ze zijn te kwantificeren. Dus bijvoorbeeld de variabele 'kosten', dit is een grootte die wordt uitgedrukt in de eenheid euro's. tijd kan worden uitgedrukt in minuten. Zachte variabelen zijn kwalitatief. Dus bijvoorbeeld de variabele kwaliteit, dit is geen grootte omdat hij niet direct gemeten kan worden in een eenheid. Als je deze meetbaar wil maken moet je dus een andere indicator verzinnen die wel meetbaar is. Denk aan het aantal kapotte items per 1000. We kunnen voor deze vorm van causal loop diagramming zowel harde als zachte barrières opstellen

Ik zal nu per cluster door de variabelen gaan die jullie hebben geformuleerd, in de eerste kolom zie je het origineel en in de tweede kolom zie je mijn aanpassing. Ik heb deze aanpassing gemaakt zodat de formulering voldoet aan de eisen die aan een variabele worden gesteld, als jullie het niet eens zijn met de verwoording dan moet je dat vooral aangeven.

#### **2. Welke verbanden bestaan er tussen de variabelen die vorige sessie zijn geformuleerd?**

- Trek lijnen tussen de verschillende hexagonalen waar de variabelen op staan
- Stel vragen zoals, heeft dit echt een directe invloed?
- Er wordt gebruik gemaakt van schildertape, hier wordt met een pen een pijl op getekend en een + wanneer er een positief verband is, een – wanneer het verband negatief is.

### 3. Waar, bij welke variabelen zitten op dit moment vaak de problemen?

→ Denk hier terug aan de barrières die ik uit de interviews heb geformuleerd:

Categorie	Barrière	frequentie
Economisch	Hogere investering	10
	Financiële modellen er niet op ingericht	5
	Budget is vooraf al vastgesteld	5
	Tweedehands materialen zijn niet beschikbaar	4
	Er is een voorinvestering nodig	2
	Externe factoren zorgen voor toenemende prijs	1
Social	Beperkte tijd en capaciteit van project betrokkenen	4
	Onvoldoende kennis over circulariteit en de mogelijkheden	4
	Weinig voorbeeld projecten/nieuwigheid hergebruik	2
	Gebruikers verwachting op gebied van esthetiek	2
	Idee dat circulariteit altijd duurder is	1
Technological	Kwaliteit keurmerken ontbreken vaak op hergebruikte materialen	3
	Garanties van bio-based materialen, vaak nog experimenteel	2
	Hergebruikte materialen voldoen niet meer aan de huidige eisen	2
		1
	er bestaat geen goede marktplaats	
	Certificering zoals BREEAM kost veel tijd	1
	Er is niet 1 meetprogramma om te bepalen wat circulair is	1
Organizational	Er is weinig toewijding vanuit management	3
	Er zijn verschillende ideeën over circulariteit in management	1
	Onderhoud is meer/onderhoud partij wil niet mee doen	3
Cultural	De markt is niet ingericht op hergebruik, er is geen tweedehands markt	3
	Stakeholders zien veel beren op de weg	1
Technical	Planning en opslag van 1-op-1 hergebruik is complex	4
Regulatory	Subsidies kosten veel tijd en energie	1
	Geen overtuigend of aansluitend beleid vanuit beleidsmakers	2

### Ontwikkelen van interventies

We hebben nu de verbanden tussen de variabelen bepaald. Nu gaan we een start maken aan het ontwikkelen van interventies. Hiervoor gaan we vandaag een of twee stappen doorlopen. De eerste is het in kaart brengen van interventies en dat kan worden gevolgd door het uitschetsen van het verwachte effect van die interventie.

Interventies kunnen worden bedacht op verschillende manieren. De eerste is door een relatie te doorbreken, de tweede door een toe te voegen en de derde door het voorkomen van delays – oponthoud.

Bij de vorige vraag hebben we vast gesteld waar op dit moment vaak de problemen zitten. Nu is de vraag hoe kunnen we die problemen dan voorkomen, waar kan een link worden toegevoegd of worden verbroken en waar zijn vertragingen die moet versnellen

Het doel is 'circulariteit in PvE', aangezien dit de uitkomst is van de definitie fase.

➔ Vermoedelijke variabelen waar zich vaker problemen voor doen:

- Toewijding management is vaak laag
- Budgetten zijn vaak niet toe reikend
- Onvoldoende capaciteit, mensen met kennis

**4. Welke verbanden moeten worden verbroken, toegevoegd of waar moet oponthoud worden voorkomen?**

- a. Van welke variabeel moet de hoeveelheid toe-/afnemen?
- b. Hoe zouden we dat kunnen doen?

**5. Wat is het effect van die interventie in de loop van de tijd?**

- 
- Een project
- Meerdere jaren waarin meerdere projecten met dezelfde klant worden uitgevoerd.

### Uitstappen

Vandaag hebben we het proces van CLD ontwikkeling voortgezet, we hebben een eerste poging gedaan tot het vaststellen van interventie strategieën. Ik ga dit nu allemaal verder uitwerken en ik kom op een later moment bij jullie terug om dit nog een keer te checken.

We hebben interventie X, Y, Z bedacht

6. Kan je 1 woord verzinnen hoe je je voelt na deze workshop?

## Focus group session 3 – Validation of CLD and reflection

### Algemeen

**Dag, tijd:** 28 februari 2024, 14.00 -15.00

**Duur:** 60 minuten

**Deelnemers:** 6

**Afmeldingen:** 1

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### Benodigdheden

- Opname apparatuur
- Laptop
- Vensim model
- Tabel en diagram uitgeprint voor deelnemers

### Landen

Fijn dat iedereen er is, vandaag gaan we terug kijken op wat we in de laatste sessie hebben gedaan. Ik zal aan jullie het causal loop diagram presenteren zoals ik die naar aanleiding van jullie input heb aangepast. Ik zal de interventies presenteren die we vorige keer hebben bedacht en het effect daarvan op het systeem laten zien. Daarna zullen we met zijn allen reflecteren op de afgelopen workshops en wat de methode jullie heeft gebracht.

Deze sessie zal maximaal een uur duren en we gaan helaas niet verder met brainstormen en lijntjes trekken.

## 1. Wat is jullie bij gebleven van de laatste workshop?

### Inhoud

#### Recap en doel workshop

In de afgelopen twee sessies hebben we samen gewerkt aan het in kaart brengen van het system rondom het integreren van circulariteit in de initiatie en definitie fasen van een project. Dit hebben we gedaan aan de hand van systeem denken waarbij we in de eerste sessie door middel van hexagoon brainstorming hebben gewerkt aan het definiëren van de relevante variabelen en in de tweede sessie hebben we relaties gelegd tussen deze variabelen.

[LAAT RESTULTATEN ZIEN VAN DIE TWEE SESSIES]

Het doel van deze laatste sessie is om het model te valideren, en dan met name de aannames en aanpassingen die ik heb gedaan in vergelijking met het model waarmee we waren geëindigd in de laatste sessie. Daarnaast wil ik deze sessie gebruiken om te reflecteren op de workshops en de resultaten daarvan.

#### Valideren

Dit is hoe ons model er na de laatste keer uitzag. Dit heb ik vervolgens letterlijk op deze manier ook in een programma gezet, VENSIM. Dat kwam er dan zo uit te zien. Hier in zie je enkele groen gekleurde variabelen en enkele rood gekleurde variabelen. Rood betekent dat ze in dit model een externen variabele zijn. Dir betekent dat in het model geen causale relatie naar deze variabele toe gaat. Groen betekent hier dat ze allen input krijgen. Gebaseerd op de transcript van beide groep sessies heb ik hier aanpassingen op gemaakt. Daarnaast heb ik zelf enkele aannames gedaan. Daar is met meerdere iteraties dit model uitgekomen. Hier heb ik jullie ook een uitgeprinte versie van gegeven. Daarnaast hebben jullie ook een lijst met de definities die ik nu aan de variabelen heb toegekend. Als iets onduidelijk is voel je dan vrij om vragen te stellen.

Een belangrijke algemene aanname die ik heb gedaan is bepaalde variabelen aan een bepaalde partij koppelen. Dit hadden jullie ook al deels gedaan in het model door progressief aan project manager te koppelen en visie aan het management.

Ik laat hier even de categorieën zien die ik gemaakt heb.

Project manager	Management opdrachtgever	Vertegenwoordiger opdrachtgever
Entusiasm	Degree of management vision	Progressiveness organization
Ambition	Sustainability standards	Organization circularity drive
Courage	Commitment management	
Persuasiveness		
Progressiveness		

In dit model heb ik de belangrijkste aannames die ik heb gedaan rood gemaakt:

- In de context van mijn thesis zorgt circulariteit in het PvE voor een uiteindelijk meer circulair project, daarmee zorgt dit ook voor ervaring. Hier zit er een vertraging in dat is wat de twee streepjes betekenen.
- Een toename aan kosten door circulaire innovaties zorgt voor een afname van management toewijding. -> zijn jullie het daarmee eens



- Leidt het relatief moeilijker zijn van het toepassen van circulaire materialen ook tot meer kosten?
2. **Waar leidt een toename in kosten nog meer toe? -> kosten werd gezien als een heel belangrijke barrière maar heeft weinig effect in dit model**
    - Het management visie leidt tot duurzaamheid standaarden bij de organisatie?
  3. **Leidt meer visie bij het management tot hogere duurzaamheid standaarden?**
    - Ik heb deze variabele toegevoegd als een soort tussen variabele: budget beschikbaar voor CE oplossingen. En via dat leidt investeringsbudget tot meer circulariteit in het PvE. Dit geldt ook voor prioriteit van CE in het budget.
    - Overtuigingskracht leidt tot het makkelijker opnemen van CE door de organisatie
    - Twee lijnen die ik hier ook nog getekend heb zijn deze van kennis deling van capaciteit van mensen met kennis. Zijn jullie het daarmee eens. En een lijn van duurzaamheid standaarden naar het belang van materiaal certificatie. Deze wil ik straks bespreken wanneer ik deze variabele ook verder heb toegelicht.
  4. **Als je er zo naar kijkt wat valt je dan direct op? Waar ben je het mee eens en waar ben je het absoluut niet mee eens? – geef paar minuten tijd om naar diagram te kijken.**

### Zekerheid

Hier zie je de feedback loops die ik zekerheid heb genoemd. Het algemene idee is dat ervaring zorgt voor meer zekerheid waardoor zowel de organisatie als het project team meer open staat voor het opnemen van circulariteit in hun project. Hier door neemt de ambitie en drive ook toe, en dit leidt weer tot meer circulaire projecten. In dit deel van het model zie je ook dat het management een rol speelt in het opstellen van bovenwettelijke standaarden bij de organisatie, deze zorgen op hun beurt voor meer zekerheid. Dit zijn allemaal reinforcing loops, dit betekent dat meer circulariteit in het PvE via ervaring uiteindelijk leidt tot meer circulariteit in het PvE.

- Op dit moment is zekerheid laag, omdat er nog weinig ervaring is. Er moet dus op een manier gezorgd worden voor meer zekerheid om deze loop gaande te krijgen.

### Kennisdeling

In dit deel van het model zie je hoe ervaring tot kennis leidt en via dat uiteindelijk tot visie/ambitie/drive bij de partijen om CE in het PvE te brengen.

Je ziet hier dat de kennis loop een reinforcing loop is, dus als er meer kennis is zorgt dit uiteindelijk voor meer circulariteit in het PvE

De enthousiasme loop kan zowel reinforcing als balancing zijn

Er is hier ook een kleinere supportbase loop, deze laat zien dat door kennisdeling de supportbase sterker wordt waardoor uiteindelijk het management meer toegewijd is.

En je ziet een reinforcing loop waarin management toewijding steeds groter wordt naarmate enthousiasme en kennisdeling toenemen

- Leidt een toename in capaciteit van mensen met kennis alleen maar tot meer kennis deling?
- Leidt ervaring direct tot inzicht, of zou ik een variabele 'kennis' moeten toevoegen die op diens beurt tot inzicht en capaciteit van mensen met kennis leidt? (laat zien in model)
- En leidt kennis dan ook direct tot zekerheid?

### Innovatie – kosten

Hier zie je loops die de toewijding van management representeren aan de hand van kosten.. deze loops, welk pad je ook volgt, kunnen zowel reinforcing als balancing zijn. Dit komt doordat we tijdens de laatste workshop hebben geconcludeerd dat innovatie kan zorgen voor zowel kosten en tijd vermindering als voor een toename.

- Zijn jullie het daar allemaal mee eens?
- Kosten werd gezien als een enorme belemmering, heeft het ook op andere dingen effect?

### **Beschikbaarheid budget**

Deze loop(s) laten vooral zien dat de beschikbaarheid van het budget sterk afhankelijk zijn van de visie en toewijding van het management. Zij bepalen het beschikbare budget, klopt dit?

- Komt budget resilience voort uit visie of uit commitment?

### **Gebruik van circulair materiaal**

Ik heb met meerderen van jullie gesproken over de materialen en de kwaliteit ik ben uiteindelijk op andere variabelen uitgekomen dan waar we vorige sessie mee zijn geëindigd.

Mijn conclusie is dat het eigenlijk allemaal gaat om het relatieve gemak waarmee circulaire materialen kunnen worden toegepast. Hier spelen dan meerdere dingen een rol bij, dit is de beschikbaarheid van circulair materiaal. Het belang dat dit gecertificeerd is en de beschikbaarheid van nieuwe materialen.

- Kunnen jullie je hier in vinden?
- Klopt het dat dit allemaal externe variabelen zijn?
- Deze relatie gaat nu naar ervaring maar deze zou ook naar 'ce in PvE' kunnen gaan, wat vinden jullie?

### **Interventies**

We hebben het vorige keer gehad over interventies. In systeem denken kan je leverage points aanduiden. Zie hier de points.

Hier hadden we in de laatste sessie deze interventies bij verzonnen.

### **Reflecteren – minimaal 20 minuten**

Notitie voor ws giver:

Systeemdenken geeft inzicht in de achterliggende problematiek en probeert het probleem in zijn bredere context te presenteren. Doormiddel van systeem denken kunnen andere oplossingen gevonden worden vergeleken met 'event-based' thinking wat mensen van nature geneigd zijn te doen. Daarnaast geeft systeem denken een methode om voorgestelde interventies te toetsen aan het model zodat vooraf (on)gewenste neven effecten kunnen worden geanticipeerd.

1. Wat is jullie algemene ervaring met de workshops en de gebruikte technieken?  
Welke aspecten werkten goed en wat werkte minder goed?
2. **In hoeverre heeft deze methode jullie nieuwe inzichten opgeleverd?**  
**Wat is een inzicht of resultaat van de workshops die je het meest bijzonder of waardevol hebt gevonden?**
3. **Hoe is jullie begrip van het integreren van circulaire principes in de initiatie en definitie fase veranderd door deze workshops?**
4. Op welke manier heeft de interactie met andere deelnemers tijdens de workshops bijgedragen aan uw leerervaring?
5. Zou je in de toekomst proberen circulaire keuzes in de initiatie en definitie fase op een andere manier te stimuleren?

### **Uitstappen**

Voor deze sessie niet relevant omdat we al afsluiten met een reflectie

# Appendix E – Semi-structured interviews guide validation and triangulation

## Doel van het onderzoek:

Het doel van dit onderzoek was door middel van systeem denken en set interventie strategieën te ontwikkelen welke bijdragen aan het vertalen van ambities op gebied van circulariteit naar projecten. Het onderzoek focust specifiek op de initiatie en definitie fasen van bouwprojecten om in deze fasen de meeste invloed uitgeoefend kan worden met betrekking tot het bepalen van de ambities in een project. Naast het ontwikkelen van de interventie strategieën wordt de bijdrage van de methodiek 'systeem denken' getoetst.

## Het interview:

Doel is om te bepalen in hoeverre het diagram te generaliseren is buiten de focusgroep

Dit interview dient ter triangulatie van het eerder ontwikkelde model.

0. Kunt u zich kort voorstellen?
  - a. Functie
  - b. Ervaring

## Introductie van het probleem

De Nederlandse overheid heeft als ambitieus doel om in 2050 volledig circulair te zijn. Stappen daarnaartoe moeten nu worden genomen en de constructie industrie is aangewezen als een van de sectoren die fundamenteel is om deze doelstelling te bereiken. Dit heeft te maken met de grote hoeveelheden energie en materialen die nodig zijn en de enorme vervuiling die het met zich mee brengt.

Sweco sluit zich aan bij deze doelstelling en wil zelfs al in 2035 circulair zijn. Zowel in haar eigen bedrijfsvoering als in services richting de klant.

Een belangrijke fase in het bouw proces om meer circulaire projecten te realiseren zijn de initiatie en definitie fase. In deze fasen is nog veel onbeslist en het eindproduct, het PvE, vormt de basis voor het vervolg van het project.

Het vertalen van circulaire ambities, die de klant vaak wel heeft, naar een praktisch PvE is vaak moeilijk en uit literatuur en interviews kunnen barrières worden geïdentificeerd in verschillende categorieën.

1. Welke interventies pas jij toe/stel jij voor om meer circulariteit in je projecten te krijgen?

De volgende interventies waren voorgesteld door de Focusgroep die ik eerder in mijn onderzoek heb geraadpleegd.

2. Wat vind jij van deze interventies?
3. Welke interventies denk jij dat het meest effectief zullen zijn?

## Introduceren van CLD

In mijn onderzoek speelt systeem denken een centrale rol. Systeem denken, of meer specifiek voor het onderzoek systeem dynamiek, is zowel een onderzoeksmethode als een wereldbeeld of kijk op de wereld. Deze kijk heeft verschillende voordelen ten opzichte van de 'conventionele' kijk op de wereld.

Ik heb met een focusgroep, bestaande uit een aantal collega's, een diagram gemaakt dat de dynamieken in het systeem van circulaire ambities naar een PvE representeert.

Ik wil dit diagram met u doornemen en ook het verwachte effect van de zojuist benoemde interventies bespreken.

- Zekerheid
    - Verhogen van wettelijk minimum
    - Visionair/ CE expert aannemen in project team
    - Externe prikkel aan project team
    - Aannemen visionair in management
  - Kennis
    - Informatie/educatie sessie management
    - Kennis deling in project team kan
  - Innovatie
    - Herzien project scope
  - Budget
    - Levens-cyclus denken -> hoe?
    - Zijn er andere interventies in budget loop???
  - Moed
    - Aanmoediging vanuit manager
  - Materiaal
4. Klopt het diagram?
  5. Herken je het patroon in de behavior over time grafieken?

	1	2	3	4
Verhogen wettelijk minimum				
CE expert in team				
Externe prikkel				
Aannemen visionair management				
Inspiratie sessie management				
Kennis deling project team				
Herzien scope				
CE voordelen tool				
Aanmoediging vanuit management				

### Reflecteren

6. Nu je dit weet zou je andere interventie strategieën voorstellen?  
Welke interventie strategie denk je nu dat het meest waardevol is?
7. In hoeverre heeft dit model jou nieuwe inzichten opgeleverd?  
Welk inzicht vind je het meest waardevol?
8. Is je begrip van het probleem veranderd door het diagram?

## Appendix F – Results focus group 1

### Identify problems

During the first focus group the hexagon brainstorming technique was used. Through the first step of the hexagon mapping method, a total of fifty-one *problems* were written down on the hexagon shaped post-its (see Figure 0.1). Five of the identified *problems* occurred twice and one *problem* was mentioned on three different post-its. In total forty-four unique *problems* were generated. The barriers to the incorporation of circularity in the initiation and definition phase of a building project, as found in literature and through interviews, described in chapter 2, were added to the *problems* by the researcher. An overview of all problems and clusters can be found in Table 0.1, the focus group took place in the Dutch and the *problems* were translated to English by the researcher. Some of these barriers were mentioned as *problems* by the group as well, this concerns: commitment by management (P3, B1), budget availability (P15/B5), project budget, higher costs and certainty. Other barriers do not fully overlap with the *problems* identified by the group, but they do show some similarity. Some examples of this are the overlap between ‘Extra time needed to deviate from traditional’ (P37) and ‘applying for subsidies is timely’ (B16) and ‘certification is timely’ (B17) and between ‘short- or long-term vision’ (P43) and ‘investment thinking’ (P44) and ‘financial models are not designed for CE’ (B19).

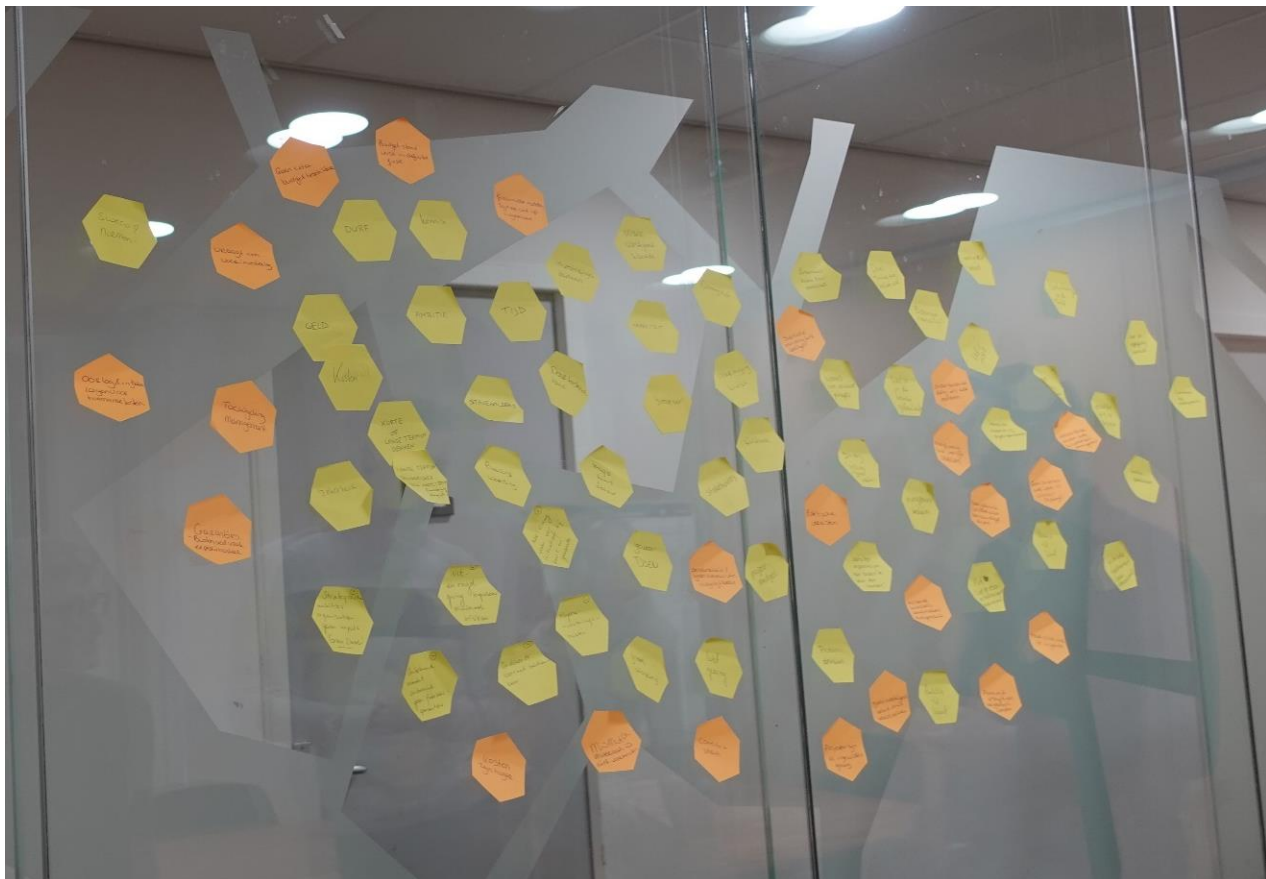


Figure 0.1. Overview problems identified by focus group

Table 0.1. Problems and clusters identified by focus group

Cluster	code	Problems by focus group	code	Barriers interviews
Management	P1	Management decisions		

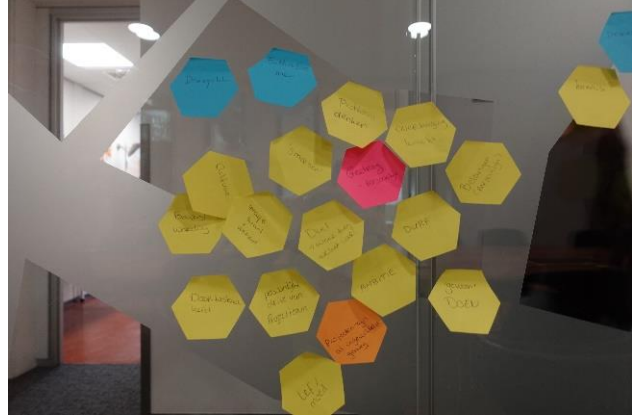
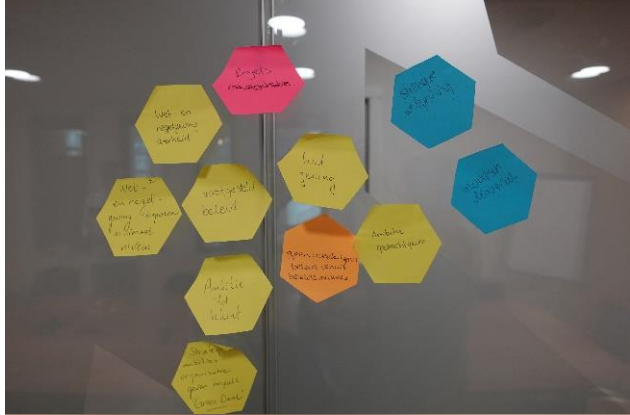
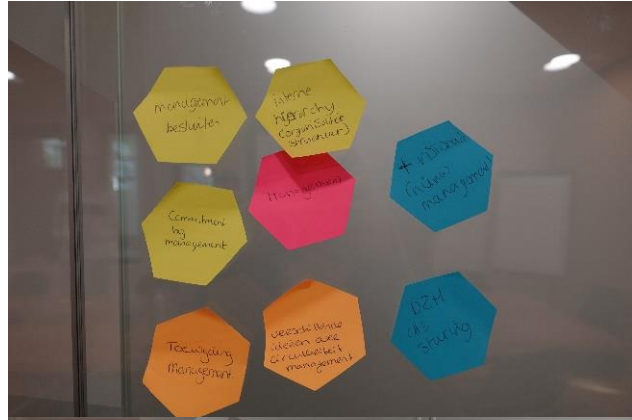
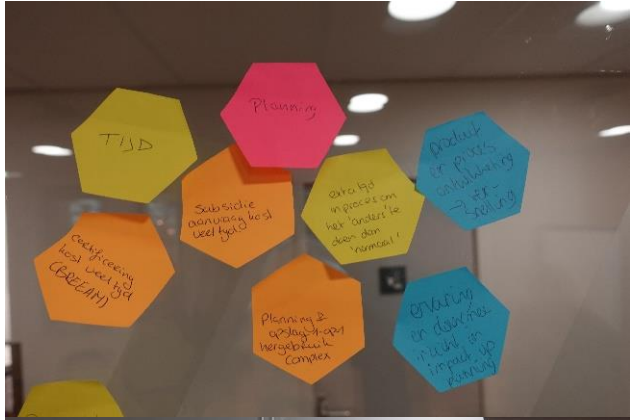
	P2	Internal hierarchy (organization structure)		
	P3	Commitment by management	B1	Commitment by management
			B2	Diverging ideas about CE in management
<b>Rules</b>	P4	Government rules and regulations determine minimum level (3x)		
	P5	Ambitions client (2x)		
	P6	Strategic ambitions can give an impulse		
			B3	No convincing policy from policy makers
<b>Material quality</b>	P7	Unknown makes unloved (onbekend maakt onbemind)		
	I8	Capacity		
	I9	Insufficient stock available		
	I10	Technical feasibility		
<b>Behavior organization</b>	I11	Norms at Sweco		
	I12	Stakeholders		
			B4	Contract form
<b>Project budget</b>	I13	Costs		
	I14	Money		
	I15	Budget increase because of ambitions	B5	No extra budgets available
	I16	Project budget	B6	Budgets is determined before definition phase
	I17	Higher investment costs	B7	Costs are higher
			B8	Requires a pre-investment
			B9	War and inflation result in cost increase
<b>Certainty</b>	I18	Program of requirements, other requirements and feasibility interfaces		
	I19	Branche standers, normal practice		
	I20	Certainty	B10	Uncertainty/limited knowledge of possibilities
			B11	Quality guaranties
			B12	Maintaining party is not positive towards CE solution
<b>Knowledge</b>	I21	Knowledge and expertise amongst project stakeholder		
	I22	Developments in sector		

	I23	Knowledge of client		
			B13	Branch is not designed for CE
<b>Behavior-personal</b>	I24	Thinking in problems		
	I25	Persuasion		
	I26	Interests		
	I27	Courage (durf/lef)		
	I28	Bravery (moed)		
	I29	Client ambition		
	I30	'just do-it' mentality		
	I31	Purpose – what is the goal		
	I32	Image towards neighborhood and local policy		
	I33	Culture		
	I34	Awareness		
	I35	Thoroughness		
	I36	Personal drive project team		
			B14	Projects are already complex
<b>Planning</b>	I37	Extra time needed to deviate from traditional		
			B15	Planning and storage is complex
			B16	Applying for subsidies is timely
			B17	Certification is timely
<b>Vision/story</b>	I38	Support base		
	I39	CE can contribute to a convincing story towards the municipality or other stakeholders		
	I40	Storytelling		
	I41	Greenwashing		
			B18	No consensus about what is most circular
<b>Long term investment</b>	I42	Vision on real estate value		
	I43	Short- or long-term vision		
	I44	Investment thinking		
			B19	Financial models are not designed for CE

## Identify clusters

The problems and barriers were clustered in eleven clusters: management, rules, material quality, behavior organization, project budget, certainty, knowledge, behavior personal, planning, vision/story and long-term investment. This separation in clusters can be found in figure ... .







## Identify variables

Based on these clusters the group was able to identify variables, these variables can be found in . Some final variables will be explained further below.

Table 0.2. During the first session twenty-six variables were formulated. In the second column the final variables can be found, variables were rephrased, deleted and added over the course of the different session. Some final variables will be explained further below.

Table 0.2. Identified variables and final adaptations

Cluster		Variable session 1 (Dutch)	Variable session 2
<b>Management</b>	1	Visionaries ( <i>visionairs</i> )	Degree of management vision ( <i>mate van management visie</i> )
	2	Sustainability as guidance ( <i>duurzaamheid als sturing</i> )	Sustainability standard ( <i>duurzaamheid standaarden</i> )
	3	-	Commitment management ( <i>toewijding management</i> )
<b>Behavior organization</b>	4	New people, young = sustainable ( <i>nieuwe mensen, jong = duurzaam</i> )	Progressiveness Organization ( <i>progressiviteit organisatie</i> )
	5	shareholders think sustainability is important ( <i>aandeelhouders vinden duurzaamheid belangrijk</i> )	Organization circularity ambition ( <i>Circulariteit drive organisatie</i> )
<b>Long-term investment</b>	6	Total cost of ownership idea ( <i>total cost of ownership gedachte</i> )	Degree of life-cycle thinking ( <i>mate van levens-cyclus denken</i> )
	7	Value thinking > include residual value of real estate in the business case ( <i>waarde denken -&gt; restwaarde vastgoed meenemen in business case</i> )	Importance residual value ( <i>belang van restwaarde</i> )
<b>Behavior personal</b>	8	Support base ( <i>draagvlak</i> )	Support base ( <i>draagvlak</i> )
	9	Enthusiasm ( <i>enthousiasme</i> )	Enthusiasm ( <i>enthousiasme</i> )
	10	-	Ambition ( <i>ambitie</i> )
	11	-	Courage ( <i>moed</i> )
	12	-	Persuasiveness ( <i>overtuigingskracht</i> )
	13	-	Progressiveness ( <i>progressiviteit</i> )
<b>Knowledge</b>	14	Support base ( <i>draagvlak</i> )	-
	15	Capacity of people with knowledge ( <i>capaciteit van mensen met kennis</i> )	Capacity of people with knowledge ( <i>capaciteit van mensen met kennis</i> )
<b>Project budget</b>	16	Costs ( <i>kosten</i> )	Costs ( <i>kosten</i> )
	17	Budget ( <i>budget</i> )	Investment budget ( <i>investerings budget</i> )
	18	Prio in budget importance sustainability ( <i>prio in budget duurzaamheid belangrijk</i> )	Priority of circularity in budget ( <i>prioriteit van circulariteit in het budget</i> )

<b>Planning</b>	19	Product and process development – acceleration ( <i>product en process ontwikkeling – versnelling</i> )	Development time ( <i>ontwikkel duur</i> )
	20	Experience and therefore insight in impact ( <i>ervaring en daarmee inzicht op impact</i> )	Experience ( <i>ervaring</i> )
	21		Insight ( <i>inzicht</i> )
<b>Quality material</b>	22	Lifespan	-
	23	Certification of new material	Material certification importance ( <i>Belang van materiaal certificatie</i> )
	24	-	Availability of circular materials ( <i>beschikbaarheid van circulair materiaal</i> )
<b>Certainty</b>	25	Knowledge sharing ( <i>kennis deling</i> )	Knowledge sharing ( <i>kennis deling</i> )
	26	Established standards ( <i>vastgestelde normen</i> )	-
	27	New developments ( <i>nieuwe ontwikkelingen</i> )	Degree of innovation (mate van innovatie)
	28	Scarcity in the market, caused by war ( <i>schaarste in de markt (grondstoffen) – oorzaak is bv oorlog</i> )	Availability of virgin materials ( <i>beschikbaarheid van nieuwe materialen</i> )
	29	-	Geopolitical unrest ( <i>geopolitieke onrust</i> )
	30	Certainty ( <i>zekerheid</i> )	Certainty ( <i>zekerheid</i> )
<b>Rules</b>	31	Social support base ( <i>maatschappelijk draagvlak</i> )	-
	32	More strict law and regulation ( <i>strengere wet en regelgeving</i> )	Law and regulation ( <i>wet en regelgeving</i> )
<b>Vision</b>	33	Social norm becomes more sustainable ( <i>maatschappelijke norm wordt meer duurzaam</i> )	Social circularity norm ( <i>maatschappelijke circulariteit norm</i> )
<b>Goal</b>	34	-	Circularity in project brief ( <i>circulariteit in programma van Eisen</i> )

## Variable discussion

The variables from the last column in Table 0.2 are used in the developing the CLD. A brief description of every variable is given in the thesis in table 4.1.. These descriptions are based upon the data gathered during the focus groups and additional conversations. Here the context and discussion around some of these variables and clusters is further elaborated upon.

First of all, the variables in the clusters ‘*management*’, ‘*behavior organization*’ and ‘*long term vision*’, are related to the client organization. The ‘*management*’ cluster focuses specifically on the management layer of the organization, whereas ‘*behavior organization*’ focuses on the organizations culture in general. However, in the context of this research, this behavior mostly depends on the client

representative. PM5 specified that in their work, they always deal with people, individuals. Therefore 'policy' is always dependent on that individual, and not just on the organizations general culture.

In the management cluster, the variables '*commitment management*' and '*degree of management vision*' are closely related. However, it is important to note that they both represent a different aspect of managements stance. '*Degree of management vision*' focuses on how visionary the management is. Vision can manifest across various degrees of extremity, whereas '*commitment management*' concentrates on the dedication level of management to adhere to its set vision and ambition. PM3 states the following about it "*Well it also concerns vigor, right? The question is whether such a visionary is also vigorous enough.*" Stressing the importance of having both, a certain level of vision in management but also consistently following through on it.

In general, variables in the cluster '*behavior personal*' can be attributed to the project team individuals. PM2 stated "*I certainly think [they are related to] the project team, and not just the project manager. I believe if a sustainability advisor is part of the team, they can, with their enthusiasm, ambition, courage, convince the project manager. But ultimately, it is the project manager who makes the decision*". In the one-on-one conversations, this statement was supported by the other participants and the importance of the role the project manager plays was highlighted.

'*Availability of circular materials*' and '*Material certification importance*', both in the cluster '*Material quality*', are factors that determine the ease of using circular materials in the project. All participants agreed that quality and quantity should be mentioned as two separate variables. Availability is always of importance, but proven quality depends on the requirements of the organization, the purpose of use and the product itself. PM3 said "*regarding certification, I think you always encounter the issue that with reused items, you no longer have the certificate. .. And it is not always a problem, but it can be. Maybe with system walls it is not an issue at all, until it becomes a fire persistent wall*".

PM2 stated: "*both are important, it should be available in quantities, but as well in proven quality. Because, if you find fifty doors, but you cannot use them, they are useless*". PM5 said "*but the point is, if you have a lot of certified products, then you might consider developing a plan with them. If you have only a few certified products, then you think, I have limited options; this restricts my design. I might as well do something new.*" Both variables are closely related and are both important in the decision to use circular materials or not, therefore an extra variable was added that represents their combined impact. This variable is called the ease of use circular materials, this variable is not included in Table 4.2 because the description is a combination of '*availability or circular materials*', '*material certification importance*' and '*availability of new materials*'.

Lastly, about the variable '*importance of residual value*' PM5 said the following: "*But the issue, I believe, also lies in the fact that societal real estate developments do not account for property value. For a school, the residual value after 30 years insignificant. However, if you construct a school that could eventually be converted into housing, thus extending its lifespan through smart design, this would not add value for a school, even though it does present added value for the owner .... I think developers will overtake us in that area. Because they see it now.*"

## Appendix G – Results focus group 2

### Identify relations

After validation of the variables during the second session, the focus group was asked to indicate relations between the variables. The variables used at this point was after the discussion in the second focus group, some more variables were added and variables were renamed again after the second focus group. The newly formulated variables were written down on hexagonal post-its and painter's tape was used to visualize the relations between the variables. The groups was asked to indicate the direction and nature of the relation by writing an arrow and plus or minus sign on the tape.

The result of the second focus groups was a first version of a CLD. In Figure 0.1, you can find the version of the CLD after addition from the focus group transcript were made. In this version a number of feedback loops could already be identified. Four of these feedback loops are related to the variables 'management vision' and 'commitment management'. Four feedback loops only concern two variables the other feedback loops include 'experience', 'knowledge sharing' and 'certainty'. The model included seven external variables and three dead-end variables (Table 0.1).

After the second focus group and analysis of the transcript, the CLD was adapted. This was an iterative process, during which the researcher made some assumptions, additional conversations with the focus group participants were held and a validation session with the full group was conducted. The final model can be found in the thesis in figure 4.2..

Table 0.1. External- and dead-end variables in diagram after focus group

External variables	Dead-end variables
Sustainability standards	Costs
Persuasiveness	Support base
Experience	Circularity in project brief.
Capacity of people with knowledge	
Importance of sustainability to shareholders	
Development	

### Assumptions CLD

The most important assumption is '*circularity in project brief*' leads to '*experience*'. As introduced, this research focuses on the initiation and definition phase of a building project. These are fundamental phases for the incorporation of circularity in the project life cycle, as these phases determine the foundation of requirements and wishes on which the final product will be based. Of course these are not the only influential phases, and many changes can be made over the project period that follows. However, in this research, and to simplify the model, it is assumed that circularity in the project brief also leads to a circular end product, and thus leads to experience.

Increased costs are seen as an important barrier for the incorporation of circularity in projects. However, in the model resulting from the focus group, this variable is a dead-end variables and does not affect any other variable. The assumption of the researcher was that increased costs lead to lower commitment by management. This was agreed upon by the focus group participants in the validation session and they additionally added a negative relation between 'costs' and 'ambition project team'.



The variables 'investment budget', 'importance of residual value' and 'life-cycle thinking' all directly led to 'circularity in project brief'. These variables are all related to the actual budget that is available for circular solutions, therefore this was added as a variable. 'Circularity budget resilience', a dead-end variable in the original model, is also added to this. During the validation session the focus group largely agreed upon this solution, however PM2 did not agree with the direct relation from 'investment budget' directly to 'budget available for Circular solutions'. They argued that 'circularity budget resilience' was a missing variable in this relation and it was suggested that an arrow was added from the variable to the relation arrow. This is not possible within this method, and realizing that the variable 'budget available for Circular solutions' was added to deal with this objection, this change was not made in the model.

The variable 'threshold to use circular materials' is added as a variable that combines the variables 'materials certification importance', 'availability of circular materials' and 'availability of virgin materials'. These variables were a general topic of debate during all session, but at the end of the validation session the group did reach consensus on it.



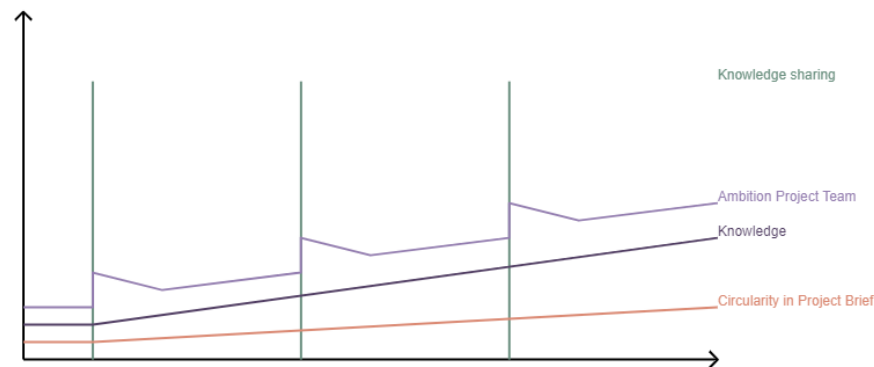
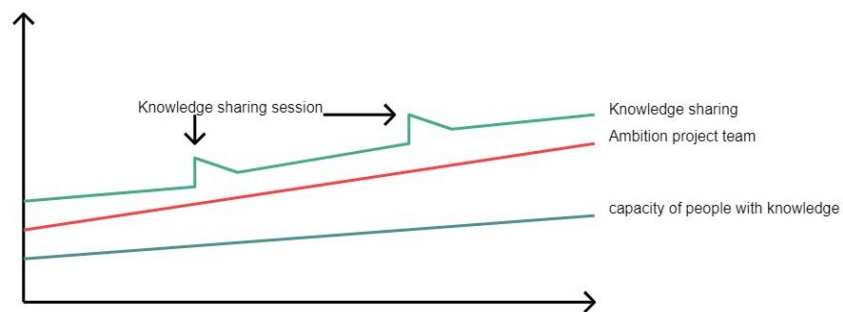
## Appendix H – Variable analyses and the Leverage points

variable name	#loops	shortest loop	longest loop	#loops <8
Experience	261	2	16	35
Circularity in project brief	261	2	16	35
Degree of management vision	230	1	16	30
Organization circularity drive	237	1	16	29
Insight	155	4	16	24
knowledge	189	5	16	21
Commitment management	189	2	16	20
Ambition project team	179	2	16	16
Knowledge sharing	166	1	16	16
Sustainability standard	129	4	16	13
Budget available for Circular solutions	155	6	16	13
Enthusiasm	108	3	16	12
Certainty	90	4	16	11
Progressiveness Organization	52	4	15	9
Costs	100	2	16	8
Innovation rate	100	2	16	8
Investment budget	69	3	16	8
Persuasiveness	97	5	16	6
Support base	90	3	16	5
Circularity budget resilience	58	6	16	5
Capacity of people with knowledge	58	1	16	4
Development time	50	3	16	4
Progressiveness project team	45	5	16	4
Degree of life-cycle thinking	39	7	16	1
Importance residual value	39	7	16	1
Courage	1	1	1	1
Material certification importance	0	0	0	0
Availability of circular materials	0	0	0	0
Availability of virgin materials	0	0	0	0
Geopolitical unrest	0	0	0	0
Law and regulation	0	0	0	0
Momentum circularity norm	0	0	0	0

## Appendix I – Expected behavior over time graphs

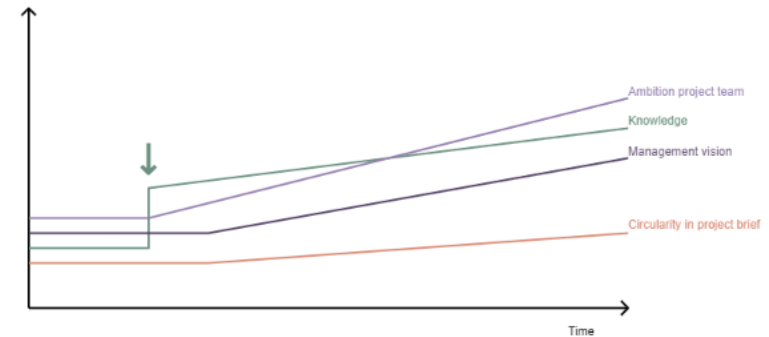
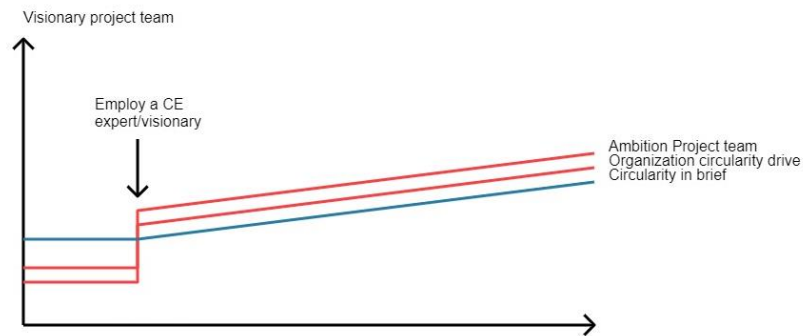
The expected behavior over time of the interventions proposed by the focus group were drawn out in 'behavior over time' graphs. These graphs were used to discuss the interventions during the validation interview. In the table below, in the left column the original drawn BoT graphs are presented. These graphs were discussed during the validation interviews. In the column on the right the BoT with changes made based on the interviews is provided. Not for all intervention strategies the BoT graphs are included in the main text. This is further explained in the table.

### Continuous education project managers



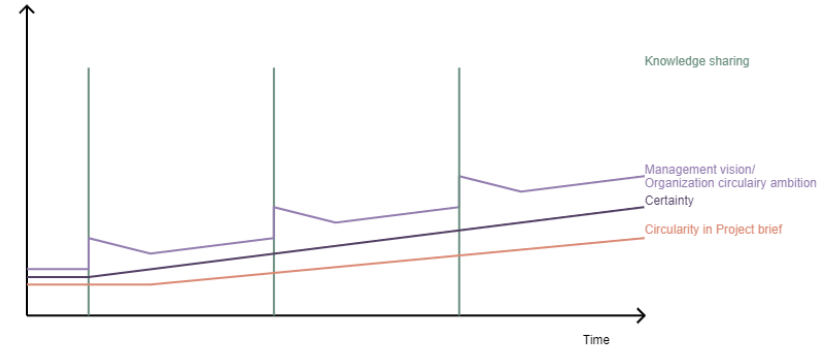
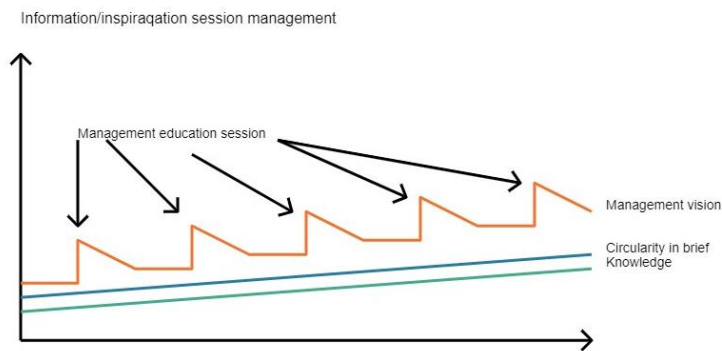
All interviewees agreed that this BoT graph would behave similarly to the one of promoting client awareness, so after each knowledge sharing session, the ambition would steeply increase but after the session it would go back down due to every-day business. PM7-F also indicated that it is difficult to implement that what they had just learned into the project, explaining the slow increase of uptake of circularity in the project brief.

## Consult external knowledge



PM10-F indicated that the message the expert would tell largely influences the ambition of the project team. In this case it is assumed the messages is positive.

## Promote client awareness



Through knowledge sharing/inspiration sessions the ambition of the organization and vision of management will increase. As supported by PM7-F, PM8-F and PM10-F, this will also decrease again. As PM7-F said “you will get back to the day to day work and it fall back to de background again”. PM8-F suggested that the incorporation of circularity in the project brief might have a similar behavior as the ambition. Because this was not explicitly indicated by the other interviewees this suggestion was not implemented but it is good to keep in mind.

PM10-F mentioned their questions concerning the relation of such an intervention to certainty

## Alleviate uncertainties

This intervention strategies was not formulated as it currently is during the validation and triangulation interviews. Therefore no graph was made to discuss with the interviewee. The interviewees were not able to respond and validate the suggested BoT, therefor no final graph is included.

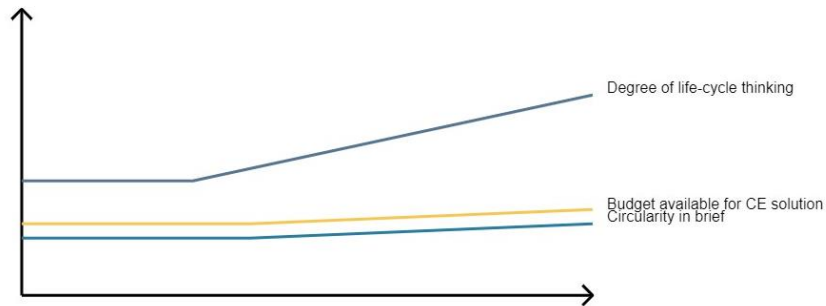
## Create more budget space

No new graph was made

Revision project scope



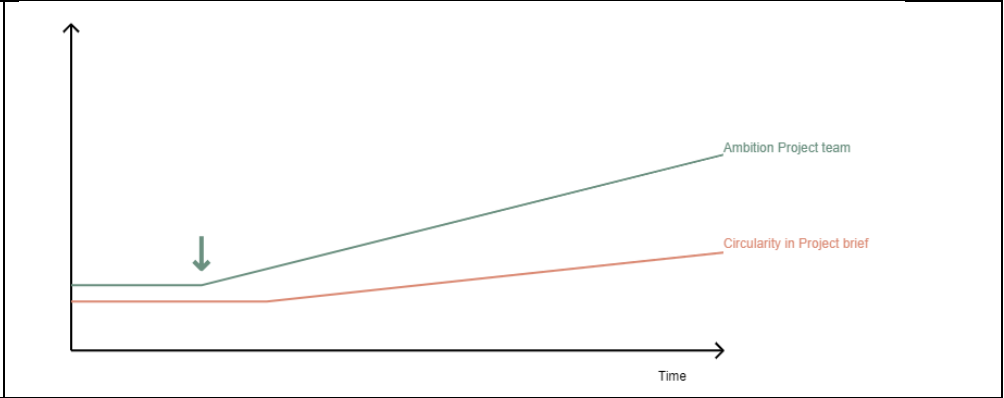
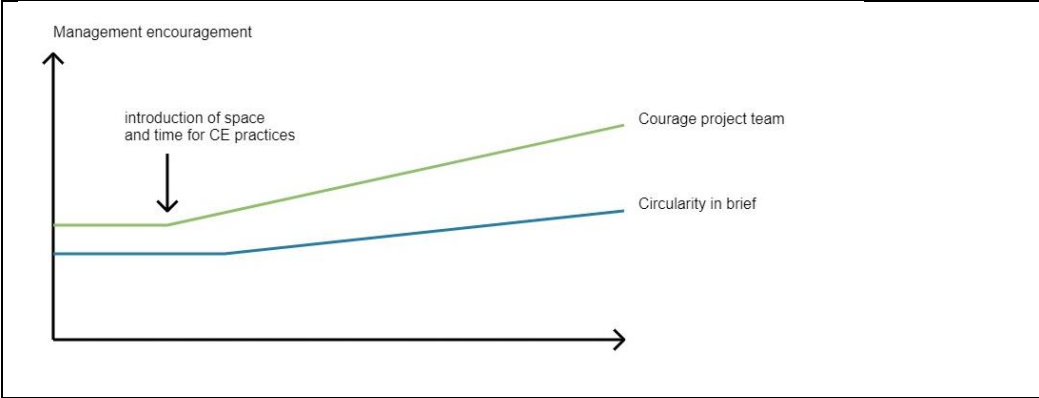
Direct to more life-cycle thinking



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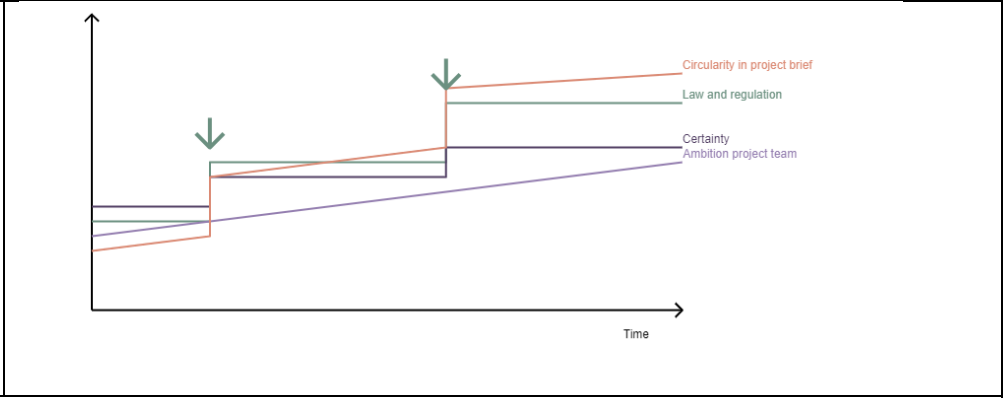
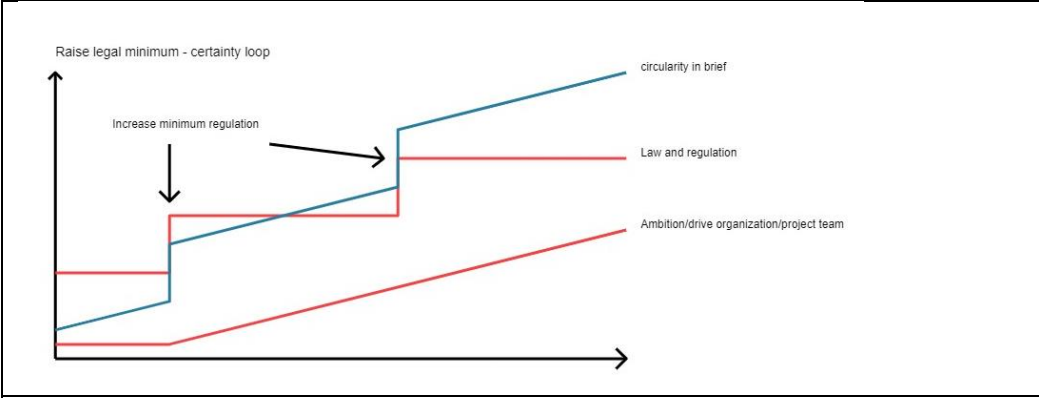
A lot of uncertainties were raised with regards to the BoT graphs drawn in relations to the creation of more budget space. The above graph was most criticized. For example, PM7-F said *“Yes and that budget also includes costs for us, so I don’t think that it has such an influence that it is such an essential difference.”* PM9-F stated that this would never happen like this in practice, because the client does not get what they want. And PM10-F indicated that they were unsure whether a scope revision would actually lead to a decrease in costs. They said *“it is a good interventions but you cannot link it to costs”*.

## Company culture



Both PM7-F and PM8-F commented that they expected the circularity in project brief to increase more steep when presented with the original line. Therefore this line was changed to increase slightly faster. PM10-F stated that they expected the ambition of the project team to fluctuate, this was not explicitly stated by the other interviewees but it might be an interesting note to keep in mind.

**Increase legal minimum**

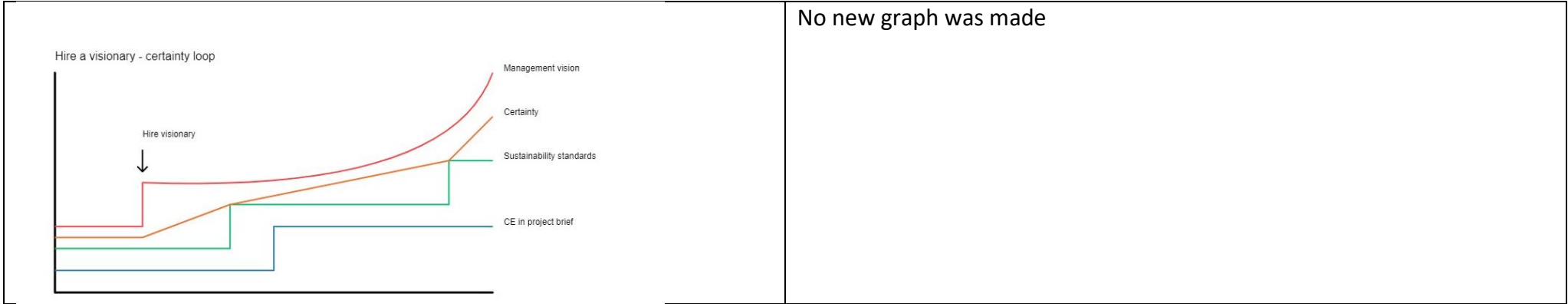


Increasing the legal minimum is an intervention proposed by the focus group. It also comes forward in literature as a potential enabler for circularity in the construction sector (Ababio & Lu, 2023; Wuni, 2022).

The figure below was presented to the interviewees, they partly agreed with the expected behavior of the leverage variables over time, however some notes were made by the participants. PM10-F suggested that it could be the case that ambition does not behave in a linear manner as drawn but would show more bumps. They stated that people do not like to be told what to do, increasing the legal minimum might cause a feeling of aversion.

PM9-F indicated that increasing the legal minimum might lead to more circularity in the project brief but questioned the positive effect it would have on the executability of the project.

**Change in client management**



No new graph was made

All interviewees agreed on the expected parabolic increase of management vision by hiring a visionary directly in clients management layers. This person would spread their enthusiasm and the rest of the team would be drawn on board. This graph was however further excluded from the thesis because the proposed intervention was marked as an 'event-based' intervention. It can be seen as a primal response to project managers experience with resisting client management and is not something the project manager can influence. The influence a project manager has on managements vision is captured in another intervention strategy; promote client awareness.

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