Circular Supply Chain Collaboration In the Built Environment

A process tool to enhance Circular Supply Chain Collaboration
when applying the aim of the Circular Economy in the building sector



Eline Leising
February 2016

Master of Industrial Ecology
Leiden University & Delft University of Technology
In cooperation with KPMG Sustainability

CIRCULAR SUPPLY CHAIN COLLABORATION IN THE BUILT ENVIRONMENT

A process tool to enhance Circular Supply Chain Collaboration when applying the aim of the Circular Economy in the building sector

GRADUATION THESIS MASTER INDUSTRIAL ECOLOGY

University: Leiden University | Delft University of Technology
Course Code: 4413TRP30Y
Research Period: August 2015 – January 2016

ELINE LEISING

Student number Delft: 1516108
Student number Leiden: 1412159
Address: Bagijnhof 95, 2611 AN Delft
Email: elineleising@gmail.com
Telephone: +316 15174576

GRADUATION COMMITTEE

First Supervisor: Dr. ir. Jaco Quist, Technology, Policy and Management Department, TU Delft
Contact details: J.N.Quist@tudelft.nl
Second Supervisor: Dr. Nancy Bocken, Industrial Design Engineering, TU Delft
Contact details: N.M.P.Bocken@tudelft.nl
Supervisor KPMG: Arnoud Walrecht
Contact details: Walrecht.Arnoud@kpmg.nl

Cover image: “Building Together”, retrieved from http://www.motivaction.nl/kennisplatform/

Executive Summary

Context
The Circular Economy (CE) concept is gaining momentum in business, but knowledge and tools to bring this concept into practice still need to be developed. The concept itself proposes an economic system that operates along cycles of energy and materials to sustain natural systems. KPMG Sustainability is looking for ways to support its sustainability services in the CE field. They therefore want to offer businesses a tool to bring their circular ambitions into practice. Based on this ambition, this research was set up. The scope of this research is formed by the Dutch building sector and it focuses on the governance part of the CE via circular supply chain collaboration.

Purpose of study
The main purpose of this study is to examine in what way supply chain collaboration in the built environment can contribute to the transition to a CE in the Netherlands. The study is structured along three main parts: (1) a theoretic part for conceptualising circular supply chain collaboration, (2) a case study where this conceptualisation is applied to three selected cases and (3) the development of a process tool to enhance circular supply chain collaboration.

Procedure
The procedure involved the application of four concepts from innovation theory and business model innovation: (1) actor networks (2) future visions, (3) actor learning and (4) business model strategies. These concepts are integrated in a conceptual framework that reveals the connections between them. An embedded multiple case study method was used consequently and data was collected via semi-structured interviews. The procedure finally used an iterative tool development method, resulting in an empirically-based process guide for circular supply chain collaboration.

Major findings
The cases studied showed there is a need for process and organisational tools. The tool developed here reveals the lessons learned in a process map with five main stages: (1) preparation and vision development, (2) involve market and supply chain, (3) process design and collaboration, (4) business model and implementation and (5) usage and prepare for next use. The major findings to stimulate circular supply chain collaboration are the following:

- A circular supply chain starts with clients asking for different/circular products and a collaborative process.
- A circular supply chain needs to be supported by a circular process, business model and technological choices.
- Clients have to think in terms of ambitions instead of requirements or complete end products.
- Based on these ambitions, market parties are invited to sharpen ambitions collectively in a co-creative process.
- Only ask for market parties that create value: conduct a system of value creation in the supply chain.
- Directly ask for multidisciplinary teams when involving market parties: think in disciplines instead of firms.
- Facilitate collaboration by connecting these disciplines; use their perspectives and aim for integral solutions.
- Apply innovative contracting based on collective aims instead of specifications and externalised responsibilities.
- Use integrated modelling and material passports of the project or product to allow tracking of material value.
- Capture long term material value by creating positive impacts and cascades of circular value propositions.
- Use incentive schemes for collaboration in business models: couple collective performance to financial rewards.
- Use take back schemes of suppliers, especially in business-to-business solutions.
- Establish a material market place where used products, components and resources can easily be exchanged.

Conclusions
This study showed that circular supply chain collaboration can contribute to a transition towards a CE by actually implementing solutions in real life projects. A new process design is needed where a variety of disciplines in the supply chain is integrated upfront. The responsibilities of these disciplines moreover need to be extended along larger parts of the supply chain in new ownership models around materials to actually close supply chains. Lessons learned in this thesis can lead to substantial spin-of and follow-up by their exemplary performance. This study also showed that collaboration depends on personal preferences. When clients or market parties have different personal preferences that do not reflect high circular ambitions, circular supply chain collaboration cannot be established.

Acknowledgements

Buildings and the built environment have always inspired me due to the impact they have on how we live, work and experience daily live. Buildings can cure, heal and create beneficial working and living environments which moved me once to start studying architecture. During this bachelor however I lost this motivation. The way we were taught to design this built environment was clearly missing something to my mind. We did not take the actual end user into account and we designed new buildings while many existing buildings needed sustainable renovation. What I missed in the architectural discussion was a focus on social aspects and sustainability. This thesis in this way is a personally motivated journey to combine my passion for the built environment with these social and sustainability aspects that I found in the field of Industrial Ecology. Here I could study projects showing that it is possible to design a building in a different way. The cases studied in this thesis do have a positive impact – both internally on the people working in them and externally on the outside world as exemplary projects. I have learned so much about the subject of circular building and personally in this journey. This is why firstly I would like to thank KPMG Sustainability for this interesting assignment and fully supporting me in carrying out the research.

My appreciations and thanks also go out to my supervisors and thesis committee members. I am grateful for their contribution, useful feedback, clarifying insights and guidance throughout the whole project. I enjoyed to work with you and combine your different perspectives into a coherent story for this thesis. Special thanks to you,

Dr. Ir. Jaco Quist, for your feedback and supervision during my research. You've introduced me to various theoretical concepts that I learned to understand and apply in my case study work. Your reflections helped me to link my findings back to the framework I developed. I greatly appreciate the time you could (also last minute!) spent to support me whenever needed. I also want to thank you for pointing out the interesting parts of my findings that may have been internalised by me, but needed to be stressed due to their innovative nature.

Dr. Nancy Bocken, for your role as my second supervisor. Due to your expertise in the Circular Economy field and Business Model Innovation you sharpened and structured the work I did in this respect. You've introduced me to the more practical side of the subject via tools and methodologies. This helped me to create valuable and practical outcomes as well.

Arnoud Walrecht, Msc, for your close guidance and support at KPMG internally. You provided a strong base for the case study work by introducing me to various stakeholders. I greatly appreciate your support in translating my findings into a relevant and practical tool. I moreover would like to thank you for reading all my rather elaborate and abstract work and helping me to condense this into a readable story. I hope I have also contributed to your work in the Circular Economy via my findings.

I could not have done this thesis research without the help of many enthusiastic stakeholders in the projects of Park 20|20, the Alliander office in Duiven and the Heerema office in Leiden. I am grateful that they all welcomed me and shared their interesting experiences with me in interviews. I really liked to conduct these interviews and to learn from the expertise of stakeholders. I would thus like to express my special gratitude and thanks to Hendrik van Zantvoort (Alliander), Owen Zachariasse (Delta Development Group), Onno Dwars (VolkerWessels Vastgoed), Cécile van Oppen (Copper8), Rob van den Broek (Delta Development Group), Alex Kragtwijk & Ed War-merdam (IBB Kondor), Jeroen Grosfeld (N3O), Peter Diepenhorst (Delta Development Group), Saskia Roelofs (Fokkema & Part-ners), Erik Korpershoek (Wessels Zeist), Martijn Niehof (Kuiper Compagnons), Paul Hoeben (Len-dering & Partners), Lonneke Leijnse (Heyligers d+p), Paul van Steijn (Homij), Kees van Es (Beelen), Hein van Tuijl (EPEA NL), Bert Siera (Heerema Marine Contractors) and Marijn Emanuel & Henk Rebel (RAU) for sharing their experiences with me.

Last but not least, I want to thank those that supported me in validating the outcomes of my research. Firstly special thanks to Cécile van Oppen (Copper8) for your useful reflections on top of your contribution via an interview. I would also like to thank Vera Moll and Shyaam Ramkumar (Circle Economy) in this respect for contributing to my tool. I finally would like to thank my fellow students and Circular Economy experts Carien van der Have-Feijen, Quinton Jie, Jorinde Vernooy and Daniël van Staveren for testing and validating my outcomes.

Eline Leising, February 2016

Table of Contents

1. Introduction 9
1.1 Context of the research 9
1.2 System innovation towards Circular Economy in the Built Environment 9
1.3 Tools and transitions 9
1.4 Relevance to Industrial Ecology 10
1.5 Research aim and research questions 10
1.6 Defining circularity in the built environment 11
1.7 Report structure 12
2. Circularity in the Built Environment: Exploring the Research Domain 13
2.1 Introduction 13
2.2 The concept of the Circular Economy 13
2.2.1 History of the concept of CE 13
2.2.2 Definition of CE 15
2.2.3 Practices that can be described as being part of CE 16
2.2.4 Trends that drive or block the development of CE 18
2.2.5 Conclusion on the Circular Economy 21
2.3 The building sector and the Circular Economy 21
2.3.1 The building sector 22
2.3.2 Market Developments and Trends 22
2.3.3 Stakeholders and composition of the supply chain 24
2.3.4 Sustainability 26
2.3.5 Innovation 27
2.3.6 CE building practices 28
2.3.7 Conclusion for CE in the building sector 31
3. Integrating visions, learning, actor networks and business models in system innovations: a literature review 32
3.1 Introduction 32
3.2 Visions 32
3.2.1 Vision concepts 33
3.2.2 Comparison and conclusion on visions 35
3.3 Learning 36
3.3.1 Concepts of learning 36
3.3.2 Comparison and conclusions for learning 39
3.4 Networks 40
3.4.1 Network theories 40
3.4.2 Conclusion on networks 44
3.5 Business Models 45
3.5.1 Business model concepts 45
3.5.2 Business models and CE 47
3.5.3 Conclusion on business models 48
3.6 Conclusion 48
4. Conceptual framework and Research Methodology 49
4.1 Conceptual framework 49
4.1.1 The vision concept in the conceptual framework 50
4.1.2 The learning concept in the conceptual framework 50
4.1.3 The network theories and collaboration aspects in the conceptual framework 50
4.1.4 Business model theories in the conceptual framework 51
4.2 Methodology 51
4.2.1 Purpose and rationale for case study 52
4.2.2 Case study design 52
4.2.3 Data collection 53
4.2.4 Selection of cases and reporting 53
5. Innovative Circular Building Projects in the Netherlands: Circular Supply Chain Collaboration by Case Results 55
5.1 Park 20|20 – Newly built Cradle to Cradle® inspired business park 55
5.1.1 Introduction 55
5.1.2 Process and project description 57
5.1.3 Analysis: actor network and collaboration 59

5.1.4 Analysis: vision aspects 63
5.1.5 Analysis: learning 64
5.1.6 Analysis: Business Model 65
5.1.7 Conclusions and discussion 68
5.2 Alliander – Renovation of an existing offices complex 70
5.2.1 Introduction 70
5.2.2 Process and project description 72
5.2.3 Analysis: actor network and collaboration 74
5.2.4 Analysis: vision aspects 77
5.2.5 Analysis: learning 79
5.2.6 Analysis: Business Model 80
5.2.7 Conclusions and discussion 82
5.3 Heerema Head Office – First BREEAM certified demolition 83
5.3.1 Introduction 83
5.3.2 Process and project description 84
5.3.3 Analysis: actor Network and collaboration 86
5.3.4 Analysis: vision aspects 89
5.3.5 Analysis: learning 90
5.3.6 Analysis: Business Model 91
5.3.7 Conclusion and discussion 92
6. Cross Case Analysis and Lessons Learned for Circular Supply Chain Collaboration 94
6.1 Understanding Circular Supply Chain Collaboration 94
6.1.1 Vision development of a circular building (process) 94
6.1.2 Actor networks and collaboration aspects 96
6.1.3 Business models for a circular supply chain 98
6.1.4 Learning processes 100
6.2 Comparative conclusion 101
6.3 Lessons learned 103
6.3.1 Drivers and barriers for CE in the built environment 103
6.3.2 Transitioning towards a circular building sector 105
6.3.3 Conclusion 107
7. A Process Tool for Circular Supply Chain Collaboration 109
7.1 Tool development method and outcomes 109
7.1.1 Outcomes first iteration: literature review and expert interviews 109
7.1.2 Tool requirements and tool comparison 111
7.1.3 Outcomes second iteration: literature review and expert brainstorm 112
7.1.4 Tool format 112
7.1.5 Outcomes third iteration: industry and student validation 113
7.2 Circular supply chain collaboration tool 114
8. Conclusions, reflections and recommendations 117
8.1 Conclusions 117
8.2 Theoretical reflections 119
8.3 Methodological reflections 121
8.4 Recommendations 122
References 124
Appendix A 133
List of interviewees 133
Appendix B 134
Interview Guide 134
Interview questions related to theoretic concepts 137
Appendix C 138
Aggregate interview results 138
Appendix D 148
Comparing case performance for the four main concepts 148
Appendix E 150
E1: The Wheel of Collaboration Tools 150
E2: Comparison of tool categories 150
E3: Examples and comparison of organising tools 152
E4: Quick scan of best practices outside the building sector 153

List of Figures

Figure 1 – Structure of research. 11
Figure 2 – Representation of decoupling 14
Figure 3 – The Butterfly Diagram that gives a schematic overview of the Circular Economy and its activities. 15
Figure 4 – Overview of circular economy business and design strategies. 17
Figure 5 – Drivers and barriers for CE. 21
Figure 6 – Improvement potential for different phases in the building process 22
Figure 7 – Turnover by company size for Dutch building sector. 23
Figure 8 – Dutch building permits and design orders for architectural projects 23
Figure 9 – Order positions for Dutch building firms 23
Figure 10 – Overview of the supply chain in the building industry 25
Figure 11 – Biggest opportunities in the building sector. 26
Figure 12 – Division of Dutch GDP per sector in 2010 and the share of potential growth in GDP via growth of CE 31
Figure 13 – Business model concept according to Mason and Spring 46
Figure 14 – Conceptual framework for a sustainable business model 47
Figure 15 – Conceptual framework for circular supply chain collaboration. 50
Figure 16 – Case Study method 53
Figure 17 – Location of the 3 case studies 54
Figure 18 – The real estate lifecycle. 54
Figure 19 – Park20|20 55
Figure 20 – Masterplan Park20|20. 55
Figure 21 – Project structure of Park 20|20 59
Figure 22 – Overview of actor network around Park 20|20. 59
Figure 23 – Actor groups at Park 20|20 plotted along real estate lifecycle. 60
Figure 24 – Eco-efficiency versus eco-effectiveness 65
Figure 25 – Comparing traditional development to value creation 66
Figure 26 – Park 20|20 BM Innovation 67
Figure 27 – Conclusion for supply chain collaboration at Park 20|20. 69
Figure 28 – Alliander Office 70
Figure 29 – Interior Alliander 70
Figure 30 – Project structure Alliander office from design phase onwards. 74
Figure 31 – Overview of actor network around the renovation of the Alliander offices in Duiven. 75
Figure 32 – Actor groups at Alliander Duiven plotted along real estate lifecycle. 76
Figure 33 – Conclusion for supply chain collaboration at Alliander offices, Duiven. 83
Figure 35 – Interior Heerema Head Office. 83
Figure 34 – Heerema Head Office 83
Figure 36 – Project structure of Vondellaan47 in realisation phase 86
Figure 37 – Overview of actor network around the project for HMC at Vondellaan 47. 86
Figure 38 – Actor groups at Vondellaan 47 plotted along real estate lifecycle. 87
Figure 39 – Conclusion for supply chain collaboration at HMC, Leiden. 93
Figure 40 – Drivers and barriers for a circular built environment. 104
Figure 41 – Developments for a circular built environment plotted in time. 107
Figure 42 – Overview of tool development method. 109
Figure 43 – Circular Supply Chain Collaboration Tool - Cycle. 114
Figure 44 – Circular Supply Chain Collaboration Tool - building sector specific. 115
Figure 45 – Circular Supply Chain Collaboration Tool - for multiple sectors. 116
Figure 46 – Conceptual framework for circular supply chain collaboration. 117
Figure 47 – Reflection on the conceptual framework. 120

List of Tables

Table 1 – Key principles of fields of study that are combined in the concept of CE 14
Table 2 – Main technical practices related to the CE 17
Table 3 – Main business practices related to the CE 18
Table 4 – Stakeholder groups in the building sector 25
Table 5 – Overview of circular design principles 30
Table 6 – Overview of options for circular material usage 30
Table 7 – Different types of visions and their discernible characteristics 33
Table 8 – Functions of visions for transitions 34
Table 9 – Comparison of different vision concepts and their embedding within different levels 35
Table 10 – Comparison of different learning concepts, their origins and levels 39
Table 11 – Four levels of using network pictures within network management 42
Table 12 – Comparison of business model classifications. 45
Table 13 – Sustainable business model archetypes 48
Table 14 – Project specifications Park 20|20 56
Table 15 – Timeline of the development of Park20|20. 58
Table 16 – Future improvement areas for the Park 20|20 BM. 68
Table 17 – Ambitions for the project in Duiven 70
Table 18 – Project specifications Alliander, Duiven 71
Table 19 – Timeline of the realisation of the project in Duiven 73
Table 20 – Future improvement areas for the BM of Alliander in Duiven. 81
Table 21 – Project specifications Heerema Head Office Leiden. 84
Table 22 – Timeline of the realisation of the demolition and renovation project for Heerema. 85
Table 23 – Future improvement areas for the BM of the HMC Head Office in Leiden. 92
Table 24 – Comparison of functioning of the vision concept for three case studies. 96
Table 25 – Comparison of functioning of actor network and collaboration for three case studies. 98
Table 26 – Comparison of BM strategies used and improvements to be made for three case studies. 100
Table 27 – Comparison of learning processes for three case studies. 101
Table 28 – Comparison of circular supply chain collaboration for three case studies 102

List of Abbreviations

BIM	Building Information Modelling
BM	Business model
BREEAM	Building Research Establishment Environmental Assessment Method
BSTE	Bounded Social-Technical Experiments
C2C	Cradle to Cradle®
CBM	Circular Business Model
CE	Circular Economy
DBFMO	Design, Build, Finance, Maintain and Operate contract
DBMO	Design, Build, Maintain and Operate contract
DGBC	Dutch Green Building Council
EMF	Ellen MacArthur Foundation
ESCo	Energy Service Company
HMC	Heerema Marine Contractors
IE	Industrial Ecology
IS	Industrial Symbiosis
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LEED	Leadership in Energy and Environmental Design
PSS	Product Service System
PPP	Public Private Partnership
SCM	Supply Chain Management
TBL	Triple Bottom Line (approach)
TTL	Triple Top Line (approach)

1. Introduction

This chapter introduces the context of this research in 1.1, before introducing the need for system innovations towards circularity in the built environment in 1.2. Based on this need the contribution of practical tools is introduced together with options for scaling up such innovations in 1.3. The relevance of this study to Industrial Ecology is explained in 1.4. The goal and research questions are introduced in 1.5 followed by a definition of circularity in the built environment in 1.6. The structure of this thesis report will finally be described in 1.7.

1.1 Context of the research

Over the last decades, it has become clear that current ways of production and consumption are putting a big burden on our planet and its environmental capacity. Growing amounts of waste are among these environmental threats. The concept of the Circular Economy is proposed to change this situation by closing material loops - using "waste" as a resource again. This concept is now gaining momentum in mainstream business, but knowledge and tools for bringing this Circular Economy into practice still need to be developed. KPMG Sustainability as a service provider is now looking into ways to support its sustainability services with the theme of the Circular Economy. KPMG Sustainability moreover seeks collaboration with front runners within the field of implementing Circular Economy solutions and wants to offer a tool for businesses to bring their circular ambitions into practice. Based on this ambition, this research was set up. In this way, KPMG Sustainability is the **external facilitator** of this research.

1.2 System innovation towards Circular Economy in the Built Environment

The concept of the Circular Economy (CE) entails continuous economic development without significant resource and environmental challenges. It proposes an economic system that operates according to cycling principles of energy and materials to sustain natural systems (Zhu, Geng, & Lai, 2011) In doing so, it will result in positive economic, ecological and social impacts. New business models have been proposed to contribute to the implementation of CE (Kok, Wurpel, & Ten Wolde, 2013). In these models supply chains will be closed: waste of a certain process will become input for another process. This involves cascades of repaired, reused and recycled materials and products (Preston, 2012). Essential elements on this approach are circling of resources in short cycles, keeping materials in their purest form and keeping the quality of materials as high as possible over longest possible time frames (Kok et al., 2013).

In creating a circular business model it is important that enterprises collaborate with partners in their supply chain (Lai, Cheng, & Tang, 2010). Supply chain collaboration therefore is an essential element and at the same time one of the main challenges in creating **closed loop supply chains**. The focus of this thesis is on supply chain collaboration that in turn is part of the broader field of supply chain management. Supply chains are **regarded as a network of businesses.** Innovative solutions tend to develop in such networks or 'innovation systems' instead of in society as a whole (Geels, 2004). It thus makes sense to select a particular 'innovation system' as the unit of analysis.

Several cases in the **building sector** were selected for this research as innovation systems, since this sector is a traditional sector where innovation diffuses rather slowly (BIS, 2013; Fernie, Leiringer, & Thorpe, 2006). This means changing business operations is in general not regarded as positive, making it even more relevant to provide practical tools that allow to implement changes and start a transition to CE. Moreover, a building is a complex object with several layers like structure, skin, services, space plan and stuff (Duffy, 1994) that each have their own time frame for operation. These different time frames of components make collaboration along the supply chain challenging here.

1.3 Tools and transitions

Studying the Circular Economy can be seen as incorporating different fields of study. The concept of the Circular Economy can be considered a movement or paradigm, based on schools of thought like Cradle to Cradle, Biomimicry and Industrial Ecology (see also Chapter 2). These fields all aim at creating additional value from wasted resources, decoupling, a shift towards system-based innovation and the creation of a sustainable system. Although quite some drivers for the CE are present, **some major barriers currently inhibit** many businesses in implementing CE into their practices. In order to be able to assist in the transition to a CE, **practical tools are required to provide support** (Bocken, Short, Rana, & Evans, 2013; Evans & Bocken, 2015).

These practical tools are needed on the local level of firms changing their practices, but this does not directly lead to a CE for the built environment. Different levels can be distinguished at which changes have to be established in **a transition pathway** in order to completely develop an innovation. A last challenge thus has to deal with the diffusion in society to establish a circular building sector.

1.4 Relevance to Industrial Ecology

In Industrial Ecology (IE) our industrialised society should be organised in a way that supports "cyclic flows of materials within the entire industrial ecosystem" (Graedel, 1994, p. 26). This corresponds with the basic principles of the CE concept. IE is based on principles of ecosystems where one species' waste is the feedstock for the other. Industrial systems are part of the natural system and should be transformed in a compatible way with this natural system. Four main rules have been proposed for supporting the development towards this compatibility (Ayres & Ayres, 1996):

a. Work towards closed material loops
b. Aim at dematerialising industrial production
c. Make thermodynamically efficient use of energy sources (e.g. energy cascading)
d. Avoid disturbing natural cycles

So far the field of IE has mainly focused on industrial practices via concepts like Industrial Symbiosis (as explained in section 2.2.3) or eco-industrial parks. Until recently, the **built environment received little attention** from IE scholars. However, interest in urban areas as focus point for research is growing (Vernay, 2013). The projects that are central in this thesis can be seen as industrial-symbiosis like practices in the building sector. They work explicitly towards closing material loops since this is one of the combined aims or strategies of both IE and CE.

Moreover, a challenge for IE is to recognise that "the shape and dynamics of industrial systems is often determined by **social relations** that cut across the boundaries of the physical embodiments of these systems" (Green & Randles, 2006, p. 308). This shows a **need to develop a framework for analysing how actors deal with practices of industrial collaboration**, their upscaling and how their activities are shaped by their context. The context that is central here is the business context with a focus on the building sector. In this context, environmental standards, certifications and CE are increasing in acceptance, leading to a greater role for supply chain management in organisational practices (Sarkis, 1995). In the supply chain management field a clear deficit in studying the social issues was reported as well (Gimenez & Tachizawa, 2012; Seuring & Müller, 2008); strengthening the need to focus especially on these governance aspects. The conceptual needs are also mentioned by Seuring and Müller (2008) who observe a gap in the theoretical background for empirical research into sustainable supply chain management and by Barratt (2004) who looks into collaboration in supply chains and observes a need for a **greater understandig of the elements that constitute this supply chain collaboration**. This research has its theoretical focus thus on supply chain collaboration specifically which is (only) a part of the field of sustainable supply chain management.

Next to the theoretical need, the focus on supply chain collaboration calls for a **tools and guidance to support decision making** in management (Bocken et al., 2013; Sarkis, 2003). This decision making at strategic level deals with business models and value propositions. These value propositions bridge the practical aspects of this thesis with the more conceptual and holistic approach of CE, resulting in both theoretical and practical relevance of this thesis to IE.

1.5 Research aim and research questions

This research firstly proposes to develop a framework for analysing how actors deal with circular practices in the built environment, bridging several concepts of innovation theory.

This framework will support the investigation of how pioneering cases of circular practices in the built environment were established organisationally which leads to the second research aim of developing a case study methodology to investigate cases of circular building practices.

This thesis finally aims at developing a process tool that helps businesses to implement supply chain collaboration in the building sector. This third objective involves identification of lessons learned for establishing a circular supply chain based on supply chain collaboration. Related to this final objective is the exploration of broader implications of the outcomes of the case study results via options for scaling up and sketching out recommendations to stimulate widespread implementation of a CE in the Dutch building sector. This leads to the following research questions that will be answered in this thesis:

How can new ways of supply chain collaboration in the built environment contribute to the transition towards a Circular Economy in the Netherlands?

Specific research questions that need to be answered in order to answer this main research question are:

1. How can system innovation concepts be used to develop a framework to evaluate innovative circular cases in the building sector regarding their visions, network/actor dynamics, business models and learning?
2. What is the contribution and relevance of visions, network/actor dynamics, business models and learning for supply chain collaboration in selected circular cases in the building sector?
3. What methods are useful for developing new circular projects in the building sector and how can these be applied in a process tool to enhance circular supply chain collaboration?

Based on these three main aims and research question the research is structured as depicted in Figure 1. The blue boxes represent the first part of the research that focuses on the development of a conceptual framework. The second aim of the development of a case study methodology is depicted in Figure 1 within the steps in the green box. In the red boxes in Figure 1 the final aim of the use of the generated knowledge via tool development is presented. This step will be supported by the input from the case analysis that in turn is based on the perspective of the developed framework and methodology in step 1 and 2. The third step finally involves a stakeholder consultation to validate and test the process tool.

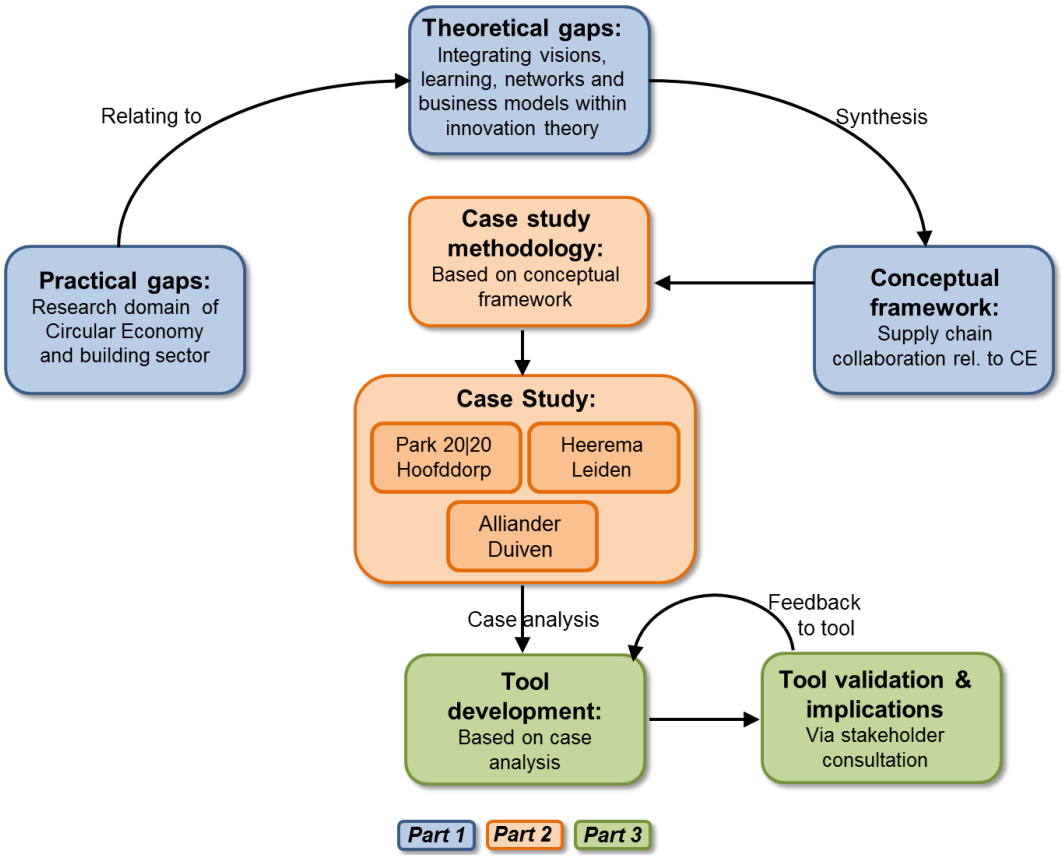


***Figure 1** – Structure of research.*

1.6 Defining circularity in the built environment

Circularity in the built environment is defined by the focus on the total lifecycle of a built object. Practices that are part of a circular building sector include design for optimisation of the useful lifetime of a building and integrating the end-of-life phase in the design. A circular supply chain is based on new ownership models. Resources are no longer sold to a general contractor and the final 'product' is no longer sold to an investor. The services of living and working will be central, provided by e.g. a consortium, while all different producers of building materials and components still own their resources that are temporarily stored in a building (ABN Amro, 2014).

This new model implies looking at the **total costs of ownership** and reducing these (Circle Economy, van Odijk, & van Bovene, 2014). A well-insulated building for instance will result in net-savings along the total lifecycle of a building. Maintenance of structure, facades and services will be integrated in contract and can be supported by the use of smart sensors. Sharing information is key, supported via Building Information Modelling (BIM) (TU Delft, 2013) and resources passports (Damen, 2012). All these measurements help to design, plan and optimise re-using materials and resources. New ownership models also ask for new ways of financing with other (longer) payback times and residual values. Instead of the current model of financing building projects based on expected cash flows or with collateral real estate, in a new model banks could for instance finance the resources in the building or the service of housing or a pleasant working environment (Circle Economy et al., 2014).

With regard to the scope and system boundary, spatially the boundary is formed by the context of the Netherlands. The cases under investigation (see section 4.2.4 Selection of cases) are all located in the Netherlands and mainly established by stakeholders in the Dutch building sector. With regard to boundaries in time, the period of 2011 until 2015 will be used as the base for data gathering in this study, since this was the period for the case studies to be developed. The research will take the impacts of the cases into account regarding people, planet and profit according to the Triple Top Line (TTL) approach of Lodder et al. (2014). Since profit has been the main focus for many stakeholders and institutions, the new value propositions will focus more on societal and environmental value creation within the newly established collaboration types. The topic of this thesis makes for a focus on social sciences around (transition) management, business studies and business modelling. Within these social analyses around the value chain only direct collaboration of single cooperation partners will be taken into account.

1.7 Report structure

This thesis report is structured as follows. Part 1 out of Figure 1 starts with an exploration of the research domain in **Chapter 2.** This domain exploration contains a study of the concept of the Circular Economy and its relevance for the built environment. **Chapter 3** presents a literature review exploring different concepts and theories related to transition theory. This chapter aims to extract those concepts that can be used in a conceptual framework to investigate innovative cases that show the way to a circular building sector. Chapter 3 moreover reveals the relevance of this research to the field of Industrial Ecology. In **Chapter 4** the conceptual framework is presented based on the theoretical concepts. The framework aims to evaluate the selected innovative cases. This fourth Chapter also reveals the research methodology used in this thesis research.

Part 2 of this research contains the case study of circular building projects in **Chapter 5.** In this chapter the cases are described along the four main concepts out of the conceptual framework: visions, learning processes, actor networks and business models. The relationships between all these elements and between the different cases will be explored in a cross case analysis in **Chapter 6**.

Part 3 of the thesis structure can be found in **Chapter 7** that will go into the practical implementation of this research. This chapter presents the collaboration tool and the tool development. The main research questions consequently will be answered in **Chapter 8** which moreover reflects on the research and provides recommendations for further research.

2. Circularity in the Built Environment: Exploring the Research Domain

In this chapter the guiding questions for the exploration of the research domain are formulated in section 2.1, before describing the concept of CE in 2.2, the Dutch building sector and the relevance of the Circular Economy to this sector in 2.3. Based on this exploration, conclusions will be presented in section 2.4.

2.1 Introduction

The research domain that is central in this thesis research project is the overarching concept of the Circular Economy applied to the built environment. This domain will be explored alongside the following guiding questions:

1. What does the Circular Economy encompass?
2. What entails CE for the building sector?

2.2 The concept of the Circular Economy

To be able to apply the concept of the Circular Economy to the building sector a proper definition of the overall CE concept is needed. Since CE aims to shift our linear model of production and consumption into a circular model, it will entail a paradigm shift. In such a paradigm shift multiple levels of change can be distinguished at which CE has to operate. For answering the first guiding question about the concept of CE, these different levels need to be addressed. Therefore the following study focuses on five aspects of CE: (1) history of the concept of CE. (2) definition of CE for this research. (3) practices that can be described as being part of CE. (4) trends that drive or block the development of CE.

2.2.1 History of the concept of CE

The concept of a 'Circular Economy' is not a new idea since it was already used in 1966 by Boulding (1966). He described a "cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy" (Boulding, 1966, p. 8). This as opposed to the linear system that was described at that time as reckless and exploitative and with headed for global overshoot and collapse (Boulding, 1966; Meadows & Club of Rome, 1972). The main difficulties addressed were the growing scarcity of resources needed to sustain economic growth based in a linear system and dealing with all the waste, resulting from this system without disturbing society and eco-systems (Meadows & Club of Rome, 1972). A circular model ideally lacks these difficulties and can create economic opportunities at maximal value with minimal costs.

Next to these early publications, many scholars (Andersen, 2007; Damen, 2012; Greyson, 2007; Jackson, Lederwasch, & Giurco, 2014; Su, Heshmati, Geng, & Yu, 2013) track the CE concept back to the work of Pearce and Turner (1990) who worked on the development of a model for a circular economy. Recently however the concept of CE gained ground (partly) due to propagation from the Ellen MacArthur Foundation (EMF). This institution published a series of reports (Ellen MacArthur Foundation, 2012, 2013, 2014) that promote the opportunities of a CE. In doing so, EMF gains new attention for the concept from academics, businesses and governments (Mentink, 2014). The timing of EMF appears to be right since the 30-year update of the Club of Rome's report concluded that all our changes in policies had been insufficient to get on a sustainable track (Meadows, Randers, & Meadows, 2004). Moreover, the current financial crisis can be seen as a symptom of our economy that suffers from the linear system (Ellen MacArthur Foundation, 2012; Jackson et al., 2014; KPMG, 2012). What is thus needed is to break the current strong bond between material consumption and prosperity (Preston, 2012; WBCSD, 2011). To reach this goal, two options are present, as illustrated in Figure 2:

1. Resource decoupling: making economic success independent from resource use and impact decoupling: minimising the environmental impacts of resource usage.
2. Welfare decoupling: reorientation from production of goods (GDP) to other measures of well-being (Kok et al., 2013).

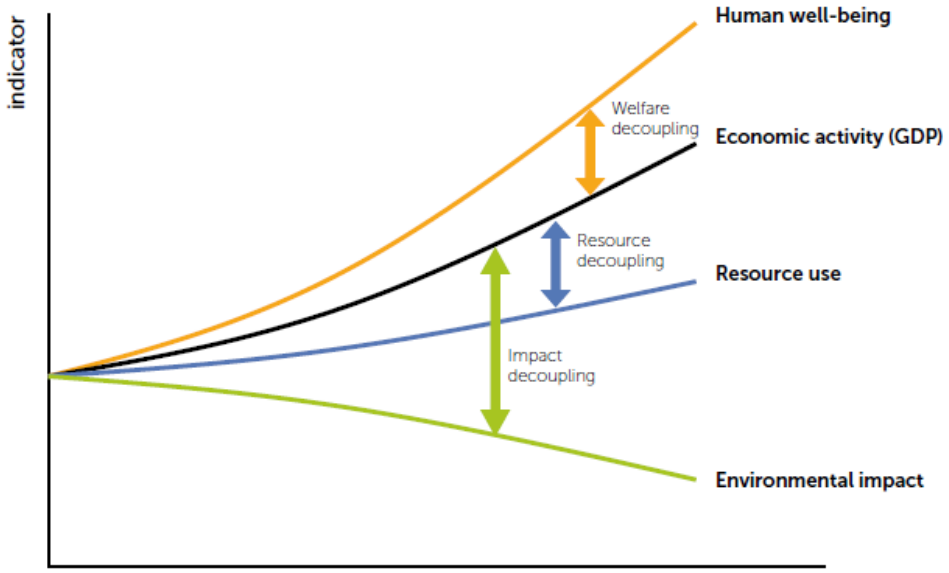


***Figure 2** – Representation of decoupling (Kok et al., 2013).*

In this example in Figure 2 human well-being grows faster than GDP that represents economic activity while relatively little growth in resource use occurs. The environmental impact of economic activity is completely decoupled here: the total environmental impact is decreasing while economic growth and human well-being increase. This is a hypothetical representation not linked to any scenario, only meant to illustrate the principle of (types) of decoupling.

Decoupling is one of the key concepts present in different schools of thought that constitute CE. In fact, the CE concept has been developed in parallel as part of different schools of thought. CE can thus be considered a movement based on different fields of study, such as C2C, Biomimicry, Industrial Ecology or Performance Economy (see Table 1). Although these fields have different focus areas, like design, business or economy, they also show an overlap in goals. They all aim at creating additional value from wasted resources, decoupling, a shift towards system-based innovation and the creation of a sustainable system. All these concepts combined shape the new paradigm of the CE.

Field of Study	Key Principles
Performance Economy (Stahel & Reday-Mulvey, 1981)	Product-service systems for paying per service or use to prevent ownership, Performance-based, to reduce resource use and waste production.
Industrial Ecology (Graedel, 1994)	A concept that uses a systemic approach to human problems, combining technical, environmental and social aspects. It aims to optimise materials use and minimise energy use along the lifecycle of a product or service.
Regenerative Design (Lyle, 1996)	Design method that renews its sources of energy (usage or renewable sources) and material.
Biomimicry (Benyus, 1997)	Nature as a model (imitation and learning), measure (norms) and mentor (value) in order to create solutions that provide benefits for society, economy and the environment.
Cradle to Cradle® (McDonough & Braungart, 2002)	Waste equals food, celebrate diversity, use current solar income, separate biological recovery cycle and technocycle, eco-effectiveness over eco-efficiency.
Blue Economy (Pauli, 2010)	Cascading principle to make sure one's waste is another's income.
The Natural Step (The Natural Step, 2015)	Using system thinking to create a sustainable world where extraction of virgin raw materials and creation of unnatural materials is minimised, and where all natural processes (including humans) can fulfil their basic needs.

***Table 1** – Key principles of fields of study that are combined in the concept of CE (EMF, 2013; Mentink, 2014).*

2.2.2 Definition of CE

The EMF perspective on the circular economy will be used as the main reference for a definition since it is based on system thinking, just as in the approach of the Master of Industrial Ecology. Moreover, this perspective has been widely adopted by industry, government and academia. EMF (2013) defines the concept as "an industrial economy that is restorative by intention. It aims to enable effective flows of materials, energy, labour and information so that natural capital can be rebuilt" (Ellen MacArthur Foundation, 2013, p. 26). The word 'restorative' is used in this definition as feeding back wasted material flows into the original material sources of economic activities (Mentink, 2014). The fact that this addition is needed already points to the fact that there is no clearly articulated definition of CE within EMF themselves. This clearly articulated definition cannot be found in other CE studies either, but these do provide some common characteristics for a definition.

One important common characteristic that scholars provide is the closure of material loops (Damen, 2012; Preston, 2012; Yuan, Bi, & Moriguichi, 2006). Another characteristic that is mentioned is pursuing change on a system level which requires system thinking (Kok et al., 2013; Preston, 2012; Rietveld, Roelofs, Bastein, & Hoogendoorn, 2013). A main difference is the reduction of material usage as described in the '3R strategy' of 'reduce, reuse and recycle' (Yuan et al., 2006). Some scholars describe the 3R strategy as being part of the definition of CE, while others name this only as a strategy. Based on the EMF perspective (Ellen MacArthur Foundation, 2013) and supported by definitions of scholars including (Damen, 2012; Kok et al., 2013; Mentink, 2014; Preston, 2012; Rietveld et al., 2013) the following definition of CE will be used in this thesis:

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

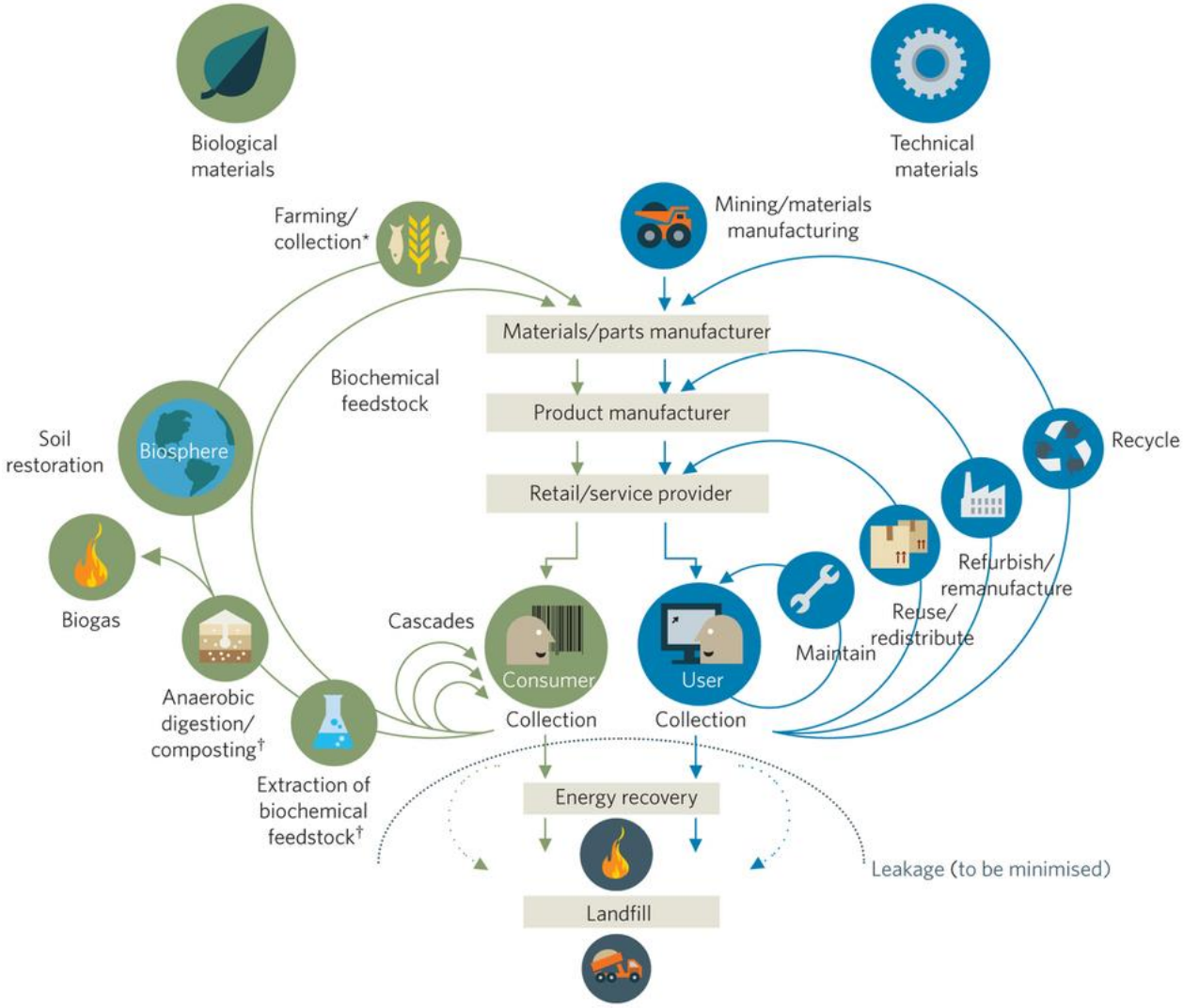


Figure 3 *– The Butterfly Diagram that gives a schematic overview of the Circular Economy and its activities (Ellen MacArthur Foundation, 2013).*

Closing material loops and creating value along the whole system requires specific economic activities like remanufacturing or recycling. Figure 3, the so-called Butterfly diagram, visualises the CE with its closed material loops. Five main principles are presented by EMF (2013) in order to get the CE concept into operation:

1. Design out of waste
2. Build resilience through diversity
3. Shift to renewable energy sources
4. Think in systems
5. Think in cascades

Central in this butterfly diagram are cascades of cycles that present the consecutive use of materials in multiple economic processes or activities before restoring the material flow to its original source (Ellen MacArthur Foundation, 2013; Mentink, 2014). During cascading material orders decline, yet energy is extracted. The CE cycles as presented in Figure 3 have a certain hierarchy. In general, the inner circles are preferred. In some cases however, the bigger cycles can be preferred. The hierarchy for technical materials can be described along the following order (based on Damen, 2012; Ellen MacArthur Foundation, 2013; Mentink, 2014):

1.	Maintenance	Extending the lifetime of a product or material by preventing faults or break down. Maintenance often occurs as a scheduled activity.
2.	Repair	Returning a faulty or broken product or component back to its usable state (Bakker, den Hollander, van Hinte, & Zijlstra, 2014)
3.	Refurbishment reconditioning	Returning a used product to a working condition that is satisfactory by rebuilding or repairing major components that are close to failure (Bakker et al., 2014). It could thus be a combination of maintenance and repair.
4.	Redistribution	Reuse without treatment: capturing product value by finding users with different needs that the product can still match (Mentink, 2014). This usually involves a digital or physical trading place (like Marktplaats or second hand shops).
5.	Upgrading	Replacing outdated modules or components with technologically superior ones (Parlikad, McFarlane, Fleisch, & Gross, 2003). Also as part of refurbishment.
6.	Remanufacturing	Returning a used product or at least its original performance with a warranty that is equivalent or better than that of the original product (Bakker et al., 2014).
7.	Recycling	Reusing materials from used products and parts by various separation processes in the production of the original or other products (Parlikad et al., 2003).
8.	Energy recovery	Winning back (part of) the energy content of used product before disposal (Mentink, 2014). This energy could take the form of heat, fuel or electricity.
9.	Disposal	The final resort of a material flow. In a CE it is recommended to consider all other circles for ways to capture value before disposal.

2.2.3 Practices that can be described as being part of CE

Next to the abovementioned conceptualisation of the CE and its principles, many practices/strategies are related to CE. These strategies will be explained in Figure 4 according to a main distinction between the strategic or business level and the technical or design level as proposed by Bocken, Bakker and Pauw (2015). Another main structural element that will be added to the analysis of practices is a distinction between two fundamentally different type of loops within a CE as discussed by Stahel (1994) and Bocken, Bakker and Pauw (2015):

1. Slowing resource loops – prolonging use of goods, reusing them over time (i.e. reuse, maintenance and repair).
2. Closing resource loops – reusing materials via recycling, closing loops between post-use and consumption (i.e. recycling). Together these elements result in the following overview of practices as depicted within Figure 4.

	Technical level	Strategic level
Slowing loops	Design practices for slowing loops	Business practices for slowing loops
Closing loops	Design practices for closing loops	Business practices for closing loops

***Figure 4** – Overview of circular economy business and design strategies (based on Bocken, Bakker & Pauw, 2015).*

The different practices that are part of the four main categories are plotted in Table 2 and Table 3. Some of the cycles within the hierarchy explained above can also be identified as practices and will be categorised below.

Strategy & practices	Definition
Technical / design strategies for slowing resource loops	
Designing long-life products	Ensuring a long period of product utilisation via design for both durability and reliability (Bocken, Bakker, & de Pauw, 2015).
• Reliability	Probability that products will function according to designed utilisation period; when used according to producers' instructions (Moss, 1985 in Bocken, et al., 2015).
• Durability: emotional/physical	The ability to withstand threats like damage or pressure. Physical durability relates to the connection" resistance of materials and/or connections, while emotional durability relates to the "between the product and its user.
Design for product-life extension	Extending the period of utilisation of a product via (a combination of) services like reusing, maintenance, upgrading or repair.
• Maintenance	Preventing faults or break down via servicing or inspection.
• Repair (incl. recondition, refurbishment)	Returning a broken product or component back into its usable state (Bakker et al., 2014).
• Upgrade	Replacing outdated components with technologically higher-level ones (Parlikad et al., 2003).
• Remanufacture	To return a used product or its original performance with a warranty that is equivalent or better than that of the original product (Bakker et al., 2014).
Technical / design strategies for closing resource loops	
Design for a technological cycle	Design with products or materials that can continuously be recycled into new products and materials (McDonough & Braungart, 2002).
• Primary recycling	Recycling process where resources retain high-quality (McDonough & Braungart, 2002).
• Tertiary recycling	Breakdown of materials and products into their raw material components and successive build up to reach the properties of the original product or material (Kumar et al., 2011 in Bocken, Bakker, et al., 2015).
• Upcycling	A process of converting materials into new materials of higher quality and increased functionality (Ellen MacArthur Foundation, 2014).
• Cradle to cradle design	A biomimetic approach to the design of products and systems. Based on nature's processes it models human industry viewing materials as nutrients circulating in healthy, safe metabolisms (McDonough & Braungart, 2002).
• Resources passport	An instrument that contains data about all materials in a certain supply chain to inform all actors with transparent information (Damen, 2012).
Design for a biological cycle	Design products with biological nutrients that will create nutriment for (natural) ecosystems throughout their lifecycle (McDonough & Braungart, 2002).
• Biodegradation and composting	Capability of degrading by biological activities where biological matter is decomposed by microorganisms.
Design for recycling in a linear economy	Design products consisting of materials that can be used within in new products again, but with a loss in quality of the material or energy content.
• Downcycling	Reprocessing materials into a product with a lower value than the original.

***Table 2** – Main technical practices related to the CE. Developed from Bocken, Bakker & Pauw, 2015; Bakker et al., 2014; Mentink, 2014.*

Srategy & practices	Definition
Technical / design strategies for slowing resource loops	
Access and performance model	Satisfying user needs by providing services or capabilities without the need to obtain and own the actual products (Bocken, Bakker, et al., 2015).
• Collaborative consumption	Consumption pattern where ownership is replaced by new models including sharing, lending and renting. Also known as the 'sharing economy'.
• Product-Service Systems (PSS)	Replacing traditional ways of product utilisation by more dematerialised services, also associated with changes in ownership structure (Mont, 2002).
Extending product value	Using the residual value of products or collecting products between different business entities (Bocken, Bakker, et al., 2015).
Encourage sufficiency	Reducing consumption via services, warrantees, reparability and an approach that does not stimulate consumerism within marketing and sales for instance.
• Reflecting environmental costs	Reflecting the true costs of products in their pricing including costs of emissions, resource extraction, land use, health impacts etc.
• True Value	Method to asses a firms true earnings including its positive and negative externalities financially quantified (van Bergen, Mackinthosh, & McKenzie, 2014).
Business strategies for closing resource loops	
Extending resource value	Using the residual value of resources (e.g. collecting otherwise discarded resources and turning them into new ways of value).
Industrial Symbiosis	Collaboration between industries involving the physical exchange of by-products, materials, energy or water (Chertow, 2000).
Chain management	Connecting and reinforcing a network of actors within their supply chain by appointing a managing role to a person or an institution.
• Cross-chain collaboration	Connecting and reinforcing a network of actors within their supply chain by managing transparency of data, transactions, material flows, responsibilities and sharing benefits (Ellen MacArthur Foundation, 2013).
• Reverse logistics	Logistics to return of end-of-use or end-of-life products to manufacturers or other processing businesses, in order to facilitate reuse and recycling.

***Table 3** – Main business practices related to the CE. Developed from Bocken et al., 2014; Bocken, Bakker & Pauw, 2015; Bakker et al., 2014; Mentink, 2014.*

2.2.4 Trends that drive or block the development of CE

As has become clear now, the concept of CE has a wide scope. This is due to its system perspective that addresses realms of economics, technology, environment, education and policy as well as its conceptual nature, combining different schools of thought as explained in Table 1. This wide scope offers opportunities for the CE concept because many stakeholders have been able to reflect their specific goals and interests in CE (Mentink, 2014). At the same time this wide range also results in several barriers. The drivers and barriers for the development of CE are explained below according to their financial, institutional, infrastructural, societal and technological aspects. A summary of these trends can be found in Figure 5 on page 21. Although the classification used here makes it easier to understand the overall picture of the CE development, some obstacles will return in different classification categories.

Drivers

Financial:

Resource scarcity risks are already present or will show their influence in the near future (Ellen MacArthur Foundation, 2013; WBCSD, 2011). This has financial consequences for business due to limited availability of materials for production. Other financial consequences will occur due to geopolitical problems that are related to resource scarcity, reflected in trade barriers and thus reflected in prices of materials (Kok et al., 2013). CE offers opportunities to turn around these risks, thereby driving the development of the concept. Another driving trend for CE is the current financial crisis. This crisis urges companies to look for ways to save costs.

The practices described along the CE cycles in Table 3 are ways that could potentially lead to costs savings. CE thus offers interesting business opportunities. The first EMF report quantified this opportunity of CE to range from $380 billion up to $630 billion per year for Europe (Ellen MacArthur Foundation, 2012).

Institutional:
Governments have started to provide positive incentives and rewards when adopting circular business models (Ellen MacArthur Foundation, 2014). Costs for linear processes are increased, stimulating circular ways of doing business. EU member states for instance increased landfill costs for discarding construction and demolition waste, which has effectively boosted the recycling and reuse rates of timber, concrete and steel, and it improved processes in construction to reduce waste (EC Dg Env, 2011). This interest is stimulated by concerns about long term security of supply of critical resources (EC, 2012).

Infrastructure:
As of today, over half of the world's population lives in urban areas. By 2020, urban population is expected to rise by another 20% to over 4.2 billion (Dobbs et al., 2012). This increase in urbanisation will have its influence on the infrastructure needed for a CE. It means simpler logistics, a higher drop-off and pick-up density and a greater appeal and scale for service providers. Centralised use in urban areas means that reverse logistics (see Table 3) becomes more cost-effective and more efficient.

Societal and value-related:
Consumer preferences are shifting away from ownership: from products to services. This important trend among especially young urban and rural consumers' choices has the power to shift the linear system to a circular system. Driven by the economic recession and widespread youth unemployment, this trend emerges in necessity (Ellen MacArthur Foundation, 2014). It feeds the development of the sharing economy: "a peer-to-peer-based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services" (Hamari & Ukkonen, 2013, p. 2).

Technology:
Information and industrial technology is now available or already being deployed at scale, which supports closure of material loops. These advances in technology allow tracking of materials, support collaboration and knowledge sharing, and improve forward and reverse logistics (Ellen MacArthur Foundation, 2014).

Barriers
Financial:
Shifting from a linear to a circular business model requires major up-front investment costs (Kok et al., 2013). Although CE is projected to result in opportunities worth billions (Ellen MacArthur Foundation, 2012), concrete value propositions are required before these opportunities will result in return on individual investments. A major bottleneck is now formed by current ways of financial decision making where the costs of circular measures are based on the decision makers' understanding of the avoided risks, the opportunities and the risks of change. Another trend in the financial sector is the fact that environmental costs (externalities) are not reflected in the prices of products. This results in a discrepancy between financial flows and material flows (Kok et al., 2013; van Bergen et al., 2014) and a negative incentive for industry to take a closer look at the impacts of the resources in their products and services. Moreover, shareholders in corporations dominate corporate decision making with their focus on short term goals and profit maximisation. This is due to the current Anglo-Saxon corporate governance model, where shareholders have a considerable amount of power. These shareholders have limited liability, which results in a preference for short term benefits instead of long-term achievements (Dangerman & Schellnhuber, 2013). Issues around the costs of establishing a CE are a final financial barrier. These costs are related to both materials (since recycled materials are often more expensive than virgin ones) and labour costs (since higher costs are associated with management and planning around a reverse logistics network) (Kok et al., 2013).

Institutional:
Although government shows interest in CE, current rules and regulations create an unlevel playing field for circular businesses. Next to these rules in the legal system, financial incentives also still support the linear economy. This is due to VAT that stimulates high material consumption since labour is relatively highly taxed (Ellen MacArthur Foundation, 2012). Circularity moreover is not effectively integrated in innovation policy (Kok et al., 2013) and competition legislation inhibits collaboration between companies within and cross-chain. A final barrier considers waste policy: recycling policies are ineffective to obtain high-quality recycling.

Infrastructure:
The main barrier for infrastructure is a lack of an information exchange system. Next to the development of such a system, confidentiality and trust issues hamper exchange of information (Damen, 2012) and the establishment of value co-creation (Romero & Molina, 2009). Exchange of materials is limited by the capacity of reverse logistics. As of today, cost-efficient and user-friendly reverse logistics systems with infrastructure supporting high quality products and/or materials are missing (Damen, 2012; Ellen MacArthur Foundation, 2012). Furthermore, issues of health and safety in reverse logistics could potentially limit effectiveness and hence recycling rates (Joseph Sarkis, Helms, & Hervani, 2010).

Societal and value-related:
Although some driving trends in society were described, public awareness of the importance of CE is in general quite limited, also in business. Moreover, we use indicators like GDP, that actually do not show the true progress or decline of our society (Stiglitz, Sen, & Fitoussi, 2009; Talberth, Cobb, & Slattery, 2007). Related to a factor like GDP is the nature of our economic system: closed material loops require zero material inputs. This requires a steady state economy, but our current economic system is expected to grow due to population growth and growing prosperity rates (Preston, 2012). Finally there is resistance from the current regime with its powerful stakeholders that will hinder the transition.

Technology:
Technology is advancing (see CE drivers), but recycling technologies often lead to downcycling of materials (Kok et al., 2013). Next to this, closed loops require zero loss of materials – especially valuable technical materials. This asks for ideal recollection systems that are able to collect every tiny bit of technical material (Mentink, 2014). This is practically impossible to create. Another technological issue is the fact that many technical materials can only be reused or recycled a certain number of times.

The concept of CE with its bio- and technocycle (Figure 3) brings in an additional challenge of separating biodegradable products from waste streams. This separate collection system is still lacking at this moment (Wurpel, van den Akker, Pors, & Ten Wolde, 2011). Bioplastics are among the biggest of these biodegradable products and in the current collection system these are often found in the recycling process of ordinary plastics or incinerated in waste facilities.

Regarding energy technologies, a main barrier is the current rootedness of linear technologies. The current system that is based on fossil fuels determines room for manoeuvring decisions for our future; known as path-dependency. This inhibits the establishment of a circular economy since we keep following the same track (Greyson, 2007). This is reflected in rules and regulations that mainly focus on efficiency instead of innovation of the system. A final barrier around energy technologies are these new technologies themselves: endless loops as presented by the CE concept require endless energy to drive them (especially recycling requires a lot of energy). Renewable energy however is not infinite available since it in turn requires need a lot of materials that practically are not available (Kleijn, 2012).

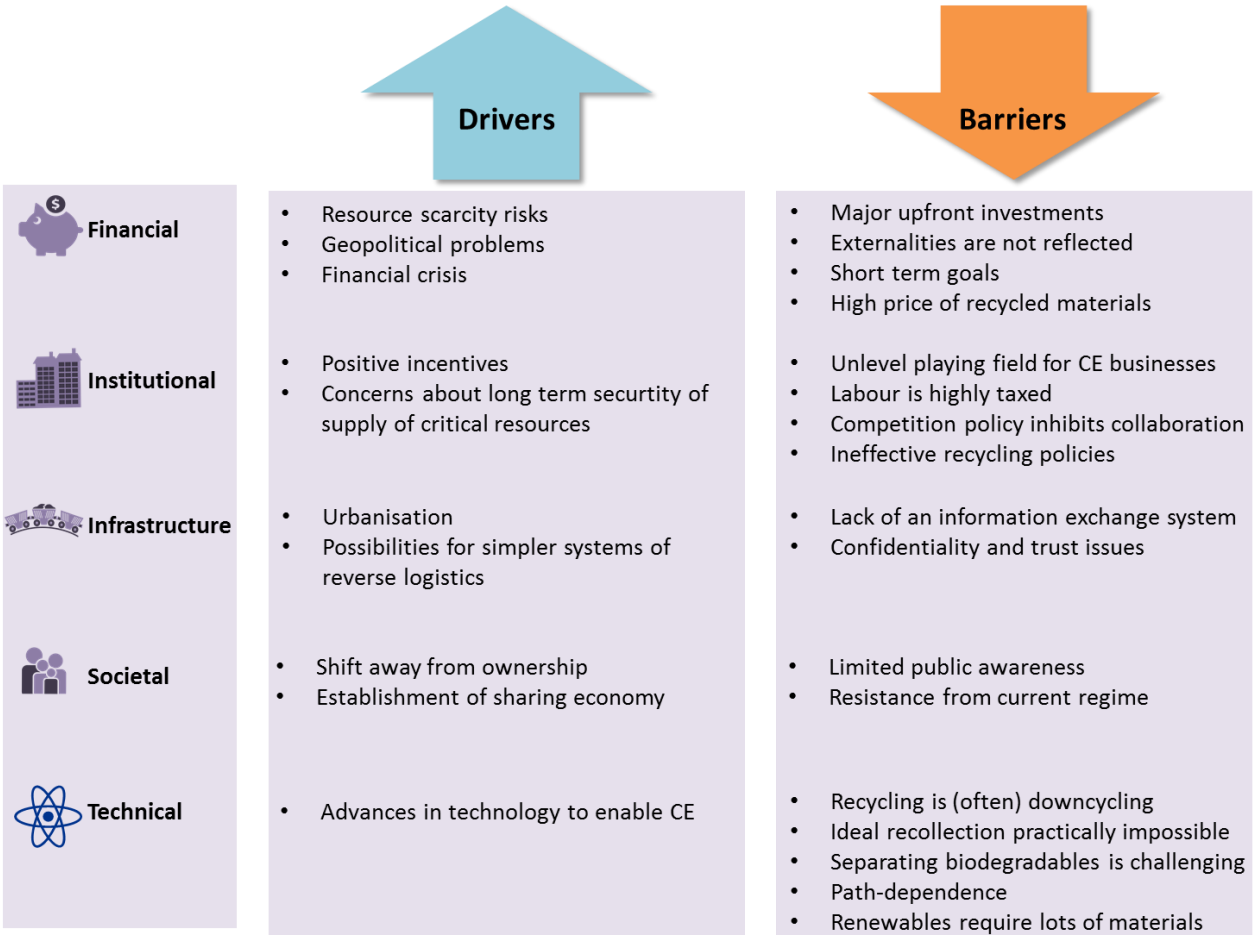


Figure 5 *– Drivers and barriers for CE.*

2.2.5 Conclusion on the Circular Economy

Studying the Circular Economy can be seen as incorporating different fields of study. The concept of the Circular Economy can be considered a movement or paradigm, based on schools of thought like Cradle to Cradle, Biomimicry, Industrial Ecology or Performance Economy. They all aim for creating additional value from wasted natural resources, decoupling, a shift towards system-based innovation and the creation of a sustainable system. Although quite some drivers for the CE are present, **some major barriers currently inhibit** many businesses in implementing CE in their practices. In order to be able to assist in the transition to a CE, **practical tools are required to provide support**. This conclusion is supported by findings of other scholars that stress the need of a tool for business that gives them insights into the opportunities of the CE in a practical way (Bocken, Allwood, Willey, & King, 2011; Bocken, Short, Rana, & Evans, 2013; Evans & Bocken, 2015).

2.3 The building sector and the Circular Economy

For motivating the choice of selecting the building sector, the relevance of CE for this sector should be discussed. For this discussion, the sector should first be defined along the following elements:

- Defining the sector and its core characteristics,
- Market developments and trends,
- Different stakeholders present in supply chains,
- Sustainability of the sector,
- Innovation within the sector,
- CE practices that can be implemented in this sector.

2.3.1 The building sector

The building sector consists of firms and agents engaged in constructing, renovating, and demolishing buildings. The sector knows contractors in commercial and residential construction. Specialised trades for this sector include work that is frequently subcontracted, like plumbing, heating, painting or masonry (US EPA, 2008).

The building sector stands out from other sectors because of the complexity of its product: buildings have long lifetimes, often over fifty years, and it is difficult to predict the whole lifecycle of a building. Moreover, a building may be subjected to many changes during its lifespan in both its form and function and these changes can be even more significant than the construction of the original product (Khasreen, Banfill, & Menzies, 2009). Many important decisions about the functioning of the building are made in the initiating stage during the design process (see also Figure 6). In this it is decided for instance what the ease will be to make changes and what the opportunity will be to minimise the environmental effects of changes. Many of the environmental effects of a building occur during its use, which calls for proper design and material selection to minimise in-use environmental loads (Khasreen et al., 2009). Finally the building industry has a complex stakeholder field: the designer for instance makes decisions about the final building but does not produce the components or build the building. Traditionally, a building is a unique product and is designed as such. Very little standardisation is present in the building sector, so new choices have to be made for each situation.

Since trends and market developments of the building sector differ per region and country, the focus of this research is on the Dutch market. Most businesses in the building industry in the Netherlands are SME's and small companies that employ between ten and twenty workers only (EFBWW, 2015). Only a few big corporations are present. This structure implies that multiple companies together frequently join in the realisation of building projects. Subcontracting is another phenomenon that is widely present. The collaboration between these subcontracting parties is often embedded in a dedicated construction team (in Dutch: 'bouwteam'). In such a construction team, the general contractor leads the design and realisation of the building project, coordinating the other team partners. The Dutch building sector employs 6% of all the employees in the country (Wikipedia, 2015) and it contributes 4,8% to the national GDP (in 2013) with a turnover of 72 milliard euro (Circle Economy et al., 2014). More trends and developments of the building sector will be explained in the next section.

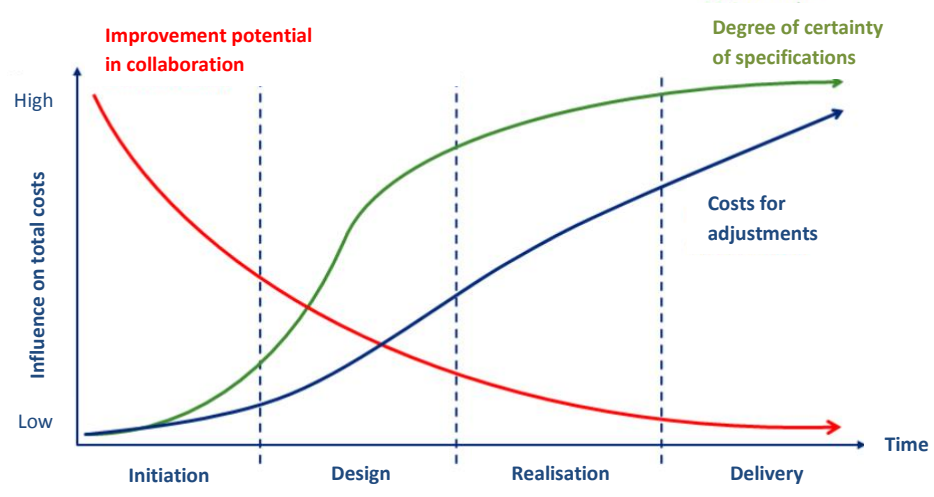
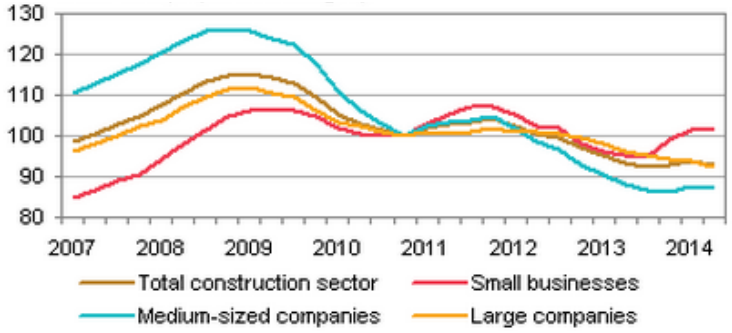


Figure 6 *– Improvement potential for different phases in the building process (Marcel Noordhuis & Vrijhoef, 2011).*

2.3.2 Market Developments and Trends

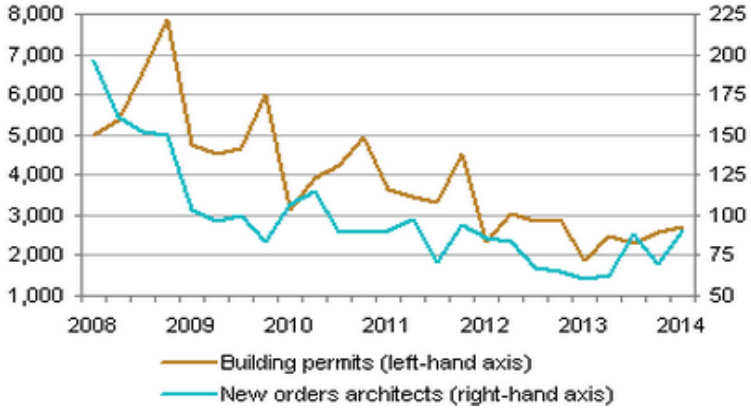
The Dutch building sector experienced economic downturn due to the housing market crisis that started in 2008. This still has its effects: construction turnover was 2.4 percent down in the second quarter of 2014 from the same period in 2013 (CBS, 2014; Figure 7). The decrease was present across all branches in the sector: from residential and non-residential building to civil engineering and from small companies and SME's to large companies. Only small businesses achieved turnover growth in 2014. The low VAT rate on labour costs for renovation and repair boosted these smaller businesses.

Figure 7 *– Turnover by company size for Dutch building sector (CBS, 2014).*



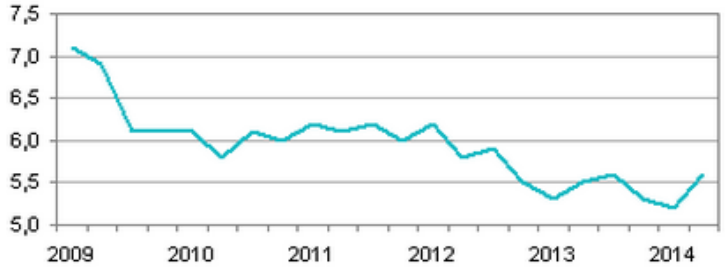
This substantial downturn was expected however, since in 2013 the total building sum of new orders received by architectural firms reached the lowest level in many years (Figure 8). These new orders are an important indicator for future building activities because they are at the beginning of the building cycle. The increase in orders in the second quarter of 2014 is due to the mild weather conditions in the winter of 2014 where building activities were not interrupted.

Figure 8 *– Dutch building permits and design orders for architectural projects (CBS, 2014).*



Signs of improvement in the economic position of the building sector are present. The total building sum of new building projects has increased since autumn 2013 (CBS, 2014). The overall value of permits is increasing and so are house sales in the first half of 2014. Order positions are improving after having reached the lowest level at the beginning of 2014 (Figure 9). For 2015 a growth of 2% is expected in building production, driven by the Dutch economic revival (Circle Economy et al., 2014).

Figure 9 *– Order positions for Dutch building firms (CBS, 2014).*



As a result of the economic uncertainty, the building industry is experiencing increasing competition from both existing and new competitors (KPMG, 2015). The competitive situation in the sector becomes evident when looking at the strong pressure to drive prices down. Negative effects of this competitive pressure are the relatively high amount of bankruptcies and a high incidence of fraud (EFBWW, 2015).

When looking at the 'customer' or user in the building sector and its behaviour, the influence of the economic situation is clearly visible. During the crisis, prices of houses decreased by 20% (Verwoerd & Mulder, 2015). For commercial real estate, values dropped on average with 10%, with the offices market on top (15-20%), followed by the retail market (8-12%). Industrial and logistics real estate kept most of its value with a decrease of only 0-5% (Vastgoedmarkt, 2012). For a part of the building owners this means that the actual value of their property is below their mortgage loans, resulting in a negative value. When selling their property this negative value will manifest itself in a residual depth. Part of the households that experience the negative value do not move out of fear for losses, while they have the financial means to move. It has been investigated that loss aversion leads to a one third lower mobility rate in moving houses (Verwoerd & Mulder, 2015).

Market segments that can be distinguished in the building sector can be very broad segments like newly constructing residential and non-residential buildings and renovating or maintaining (non-) residential buildings. Within the residential segment for instance further refinement in additional segments can be made. This includes aspects like household structure, type of housing, characteristics of the house and surroundings, lifestyle, location and characteristics of the residents (van der Veen & Laudy, 2005). When combining preferences of different market segments with their behaviour, the overall trend shows that they are aligned, especially at the group level. Young professionals show a clear development path: from starting renting rooms, via rented accommodation to entering the owner-occupied sector (Poulus, van Leeuwen, Omtzigt, & Heida, 2014).

The Dutch market moreover shows a mismatch in the current building portfolio: vacancy of buildings is increasing. At the start of 2014 a vacancy rate of 6% was reported (CBS, 2013). This is remarkable because the production rate of building houses decreased by 70% between 2000 and 2013 (Circle Economy et al., 2014). Especially the offices market suffers from high vacancy rates. In 2014 this rate was 17%. Among this percentage half of the vacancies counts as structural: vacant for (over) three years (Circle Economy et al., 2014). Indeed, the non-residential building market decreased by 25%, while the market for renovating residential buildings increased significantly by 50% (CBS, 2015).

Another trend in the Dutch building market is the introduction of new forms of tendering. Due to increasing complexity of projects, integral tendering is now officially part of national policy. Integral contracts cover costs and environmental impacts along the complete lifecycle (see also Figure 10). Since principals cooperate and are responsible for the complete lifecycle of the project, planning and prices are maximised (Circle Economy et al., 2014). Related to this tendering policy are policy measures to support a transition towards a sustainable building sector. Examples of these measures are the policies around energy savings in the existing built environment (Meer Met Minder, 2015) and within newly built houses (LenteAkkoord, 2015).

2.3.3 Stakeholders and composition of the supply chain

Identifying stakeholders in the building sector is important since they can change the system with their influence on other stakeholders in their network and/or supply chain. Understanding the influence and interests of stakeholders gives relevant insights into which stakeholders to mobilise for a systemic transition process like the development of CE (Ellen MacArthur Foundation, 2014). Some stakeholders are not directly part of the supply chain, but have an influencing role in the system, such as unions or research institutes.

Stakeholder Group	Types of organisations
Principals, initiators	Real estate developers, housing corporations, government (local or national), private and other principals
Investors	Investment funds, Private equity, crowd funding
Designers	Architects and structural engineers, Consultants
Contractors	General building contractors, (Non-) residential building contractors, Civil building contractors, Building contractors maintenance, Demolition contractor
Suppliers	Direct suppliers, Building material merchandisers
Subcontractors	Subcontractors and specialised subcontractors
Users/residents	Companies, Residents, Government, Other

Government	EU (European Commission), National government (Ministry of Infrastructure and the Environment, Ministry of Economic Affairs, Ministry of the Interior and Kingdom Relations), Local government (Provinces and municipalities)
Industry organisations	Trade unions (FNV, CNV, De Unie), Trade organisations (Bouwend Nederland, BNA, MKB Bouw, MKB Infra)
Research and knowledge institutes	General knowledge institutes: ○ Universities (TU Delft, TU Eindhoven, Wageningen University) ○ Other (KNAW, SenterNovem, TNO, Deltares) Knowledge institutes for building information (STABU, IBR, SBR, CROW) Knowledge institutes built environment (PSIBouw, Klimaat voor Ruimte)
Influencing agents	MVO Nederland, Circle Economy, C2C certified

***Table 4** – Stakeholder groups in the building sector (Noordhuis & Vrijhoef, 2011; Vrijhoef & Koskela, 1999).*

With the abovementioned information the supply chain in the building sector can be depicted. This is done in a way that supports circular thinking: alongside the lifecycle of a building. This lifecycle thinking, supported by the analytical lifecycle analysis method (LCA), allows for systemically revealing the environmental impacts of a system along four different lifecycle stages: (1) production - blue stage in Figure 10; (2) construction or realisation - yellow stage in Figure 10; (3) usage - red stage in Figure 10; (4) end - green stage in Figure 10.

When combining the overview of the supply chain with a categorisation of the real estate lifecycle as developed by Ceron (Ceron, 2006), the following additional management stages can be distinguished:

- Asset Management: an investors' analysis of fixed assets, supporting his actions and decisions around supplementing these fixed assets with new real estate.
- Property Management: planning, designing and contracting a building project during the production phase of the process.
- Facility Management: maintaining real estate by real estate managers.

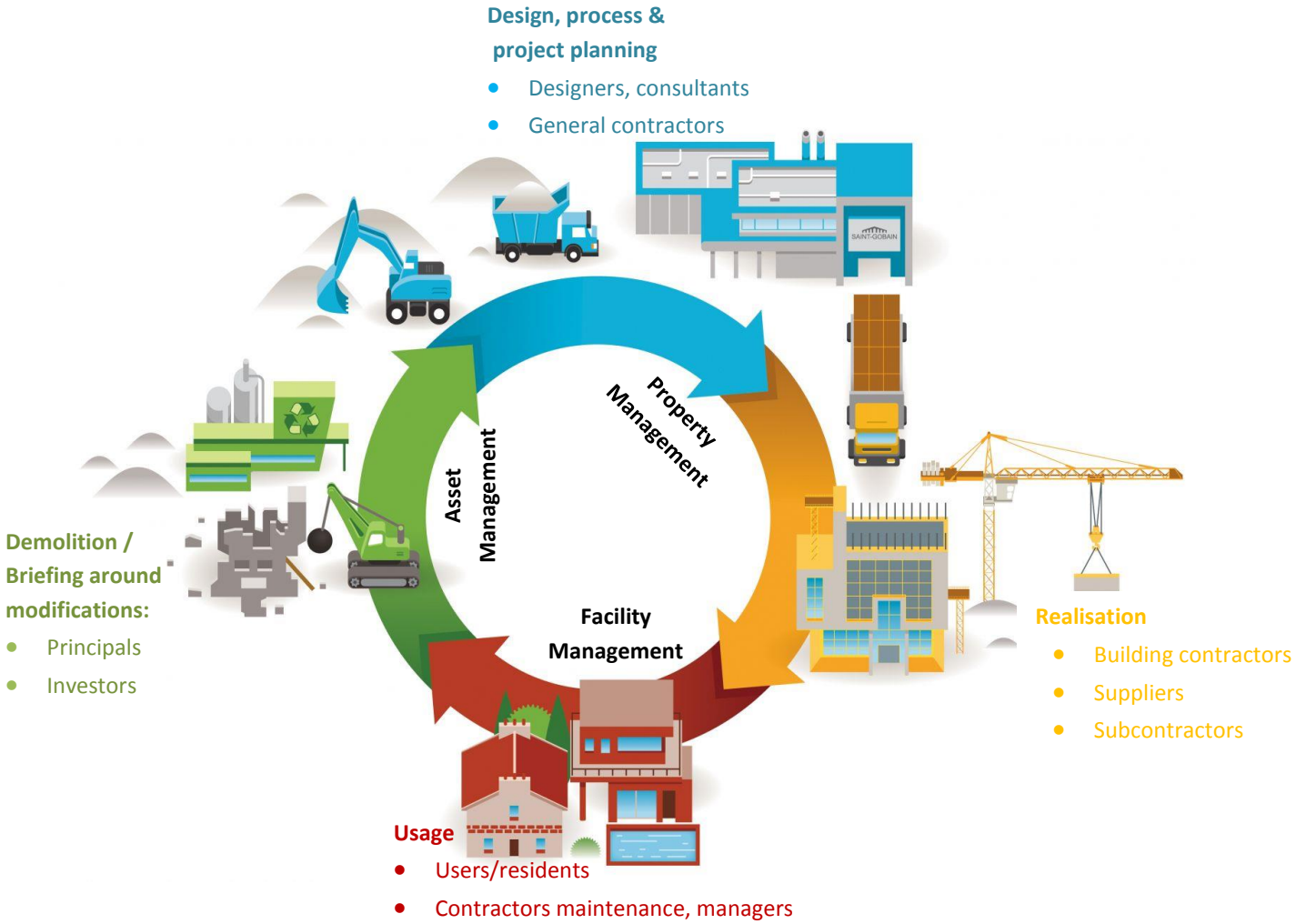


***Figure 10** – Overview of the supply chain in the building industry (based on Saint-Gobain, 2015).*

2.3.4 Sustainability

The building sector is a promising sector for sustainable solutions since there is ample room for improvement; the built environment currently is one of the top contributors to several environmental problems (Khasreen et al., 2009). Especially when seen from a material point of view the built environment is of importance since it consumes lots of materials, energy and water. The built environment moreover greatly contributes to problems like resource depletion, climate change and pollution (van Bueren, 2012). In 2010 the built environment accounted for 32% of total global final energy use, 19% of energy-related greenhouse gas emissions and approximately one-third of black carbon emissions (Lucon & Urge-Vorsatz, 2014). In addition, the embodied environmental impacts generated by a building during the use phase of the lifecycle are of utmost importance: this phase has an impact that is five times above the impacts of the other stages (Circle Economy et al., 2014). Especially energy and water use and waste production have their impacts in the usage phase. With regard to materials, the building industry consumes 40% of the materials entering the global economy (Khasreen et al., 2009).

Recent data on the sustainability of the Dutch building sector regarding resources show the following problems: 37% of the total waste produced in the Netherlands is generated by this industry and 5% of the country's CO_2 emissions are caused by manufacturing of building materials (ABN Amro, 2014). Recycling methods for construction and demolition waste are far from optimal and reclamation of raw materials and other resources is unprofitable. The sector moreover relies heavily on fossil fuels that account for 96% of the fuels used (Circle Economy et al., 2014).

Driven by these impacts, the building sector shows some trends towards increasing the sustainability of their operations (Circle Economy et al., 2014; US EPA, 2008):

- Construction-related energy use is increasing faster than the growth in construction activity;
- The percentage of construction and demolition materials recycled varies per sub segment: materials are recycled more in highway construction than within building construction;
- Bio-adaptive facades;
- 3D-printing of building elements and materials;
- Energy-generating road pavements;

Research by USP (van der Gaag, de Graaf, & Vuik, 2014) confirms this trend towards increasing sustainability within the Dutch building sector. They distinguish between trends amongst principals and contractors. Principals have a focus on sustainability, while constructors are looking for opportunities that will result in direct projects prioritising the renovation market (Figure 11).

Figure 11 *– Biggest opportunities in the building sector (based on van der Gaag et al., 2014).*



These trends and opportunities are (partly) driven by legislative trends. Certification is such a driver with regard to sustainability in buildings. Certification schemes and labels around environmental performance of buildings started to develop in the Netherlands from 1995 onwards (Zaaijer, Grouls, & van der Molen, 2009). The first performance criterion was the Energy Performance Coefficient (EPC). The EPC is part of the Dutch building decree and it dictates the requirements for energy efficiency of new buildings (RVO, 2015a). 'GPR Gebouw' was the first measurement and certification scheme that looked into the different lifecycle stages of a building to assess its performance for energy, environment, health, user quality and future value (GPR, 2015). The Greencalc+ instrument and index was developed next to measure the sustainability of all kinds of buildings, not only focused on energy use, but also on material use and water usage (GreenCalc, 2015). Specifically for the field of building materials, the Dutch Institute for building biology and ecology (NIBE) developed a classification and comparing tool around 2006 (Zaaijer et al., 2009). The next development was the so called 'energy label' for buildings that reveals the energy efficiency of a building to potential new home owners. In this way the Dutch government allows home owners to consider the environmental performance when opting for a new home. From the beginning of 2015 onwards this energy label became an obligation to everyone selling or renting a house or building, risking a fine when the official label is absent (Milieu Centraal, 2015). At this moment the BREEAM certification is most widely used within the Netherlands. This method was initially developed in the UK and adapted to the Dutch regulations by the Dutch Green Building Council (DGBC) which makes them a national scheme operator (BREAAM NL, 2015). The energy label and the EPC are integrated within the BREEAM methodology (BREAAM NL, 2015). This makes for the following timeline of developments in sustainability certification schemes:

1995:	EPC	Energy Performance requirement for new buildings
1996:	GPR-building	Measurement and certification scheme for overall environmental performance
1997:	GreenCalc+	Instrument and index to measure sustainability of a building
2006:	NIBE	Classification and comparing of building materials
2008:	Energy label	Public (obligatory) label revealing the energy efficiency of a building
2009:	BREEAM NL	Sustainability certification for buildings
2020:	Energy neutral	All new buildings should be at least energy neutral from 2020 onwards

The BREEAM methodology is mostly used in the Netherlands at this moment and it distinguishes five categories: Pass, Good, Very Good, Excellent and Outstanding. Worldwide, the LEED certification is the standard. This original U.S. based programme distinguishes between five aspects of the building industry: building design and construction, interior design, operations and maintenance, homes and neighbourhood development (MVO Nederland, 2015). Next to these branches the method looks into six categories: sustainable sites, energy and atmosphere, water, materials and resources, indoor environmental quality and innovation (MVO Nederland, 2015).

2.3.5 Innovation

Housing and building construction is a very traditional sector, where innovations do not diffuse very quickly (BIS, 2013; Fernie & Thorpe, 2007). The rate of innovation in the sector has been described as being "below par" (BIS, 2013). The industry aims at the ability to introduce change, but this is seen by the supply chain as a source of waste, a cause of uncertainty and a stimulus for greater friction between businesses. Many firms confirm that they conceive the costs of implementing change as higher than any income benefits they might receive from the change (BIS, 2013).

When looking at sustainable innovation in particular, the same low innovation rates are present. Lucon and Urge-Vorsatz (2014) conclude that strong **barriers** hinder the market uptake of sustainable and cost-effective applications and technologies in the building sector. Among these barriers are imperfect communication, industry fragmentation, split incentives, transaction costs and poor access to financing (Lucon & Urge-Vorsatz, 2014). Next to these internal organisational barriers that hinder sustainable innovations around buildings, two additional characteristics of the built environment influence a transition towards a sustainable built environment. Firstly, the built environment experiences strong lock-in effects due to the long lifespans of buildings and built objects, resulting in an even higher priority of ambitious and immediate activities for retrofitting (Chalmers, 2014; Khasreen et al., 2009). A second influencing factor is formed by lifestyle, culture and behaviour that all have a major effect on the sustainability of a building and specifically its energy use (Chalmers, 2014; Lucon & Urge-Vorsatz, 2014).

Innovation in the sector is also linked to business models and supply chain management. Most business models applied focus on **short-term** profits and do not reward suppliers that deliver sustainable solutions on the long run. This is why there is a need to adopt new business models that promote change by finding ways to incentivise long-term value creation (BIS, 2013). This value creation is linked to supply chains, where value chain consolidation is required as opposed to the current situation of increased supply chain **fragmentation** hindering performance improvement. This fragmentation and thus low level of vertical integration is caused by sub-contracting. Sub-contracting in the industry is blocking "free flow of information and innovation through a significant number of industry bodies, and results in a single voice for the industry" (Wolstonholme, 2009 in BIS, 2013, p. 31).

A survey amongst the Dutch construction industry (Doove & Prince, 2013) confirms the abovementioned trends and characteristics: SME's in the Netherlands are least innovative. The most important obstacle that prevents these businesses from innovating is a lack of resources. These resources include financial means, time and knowledge. Many businesses mention situations where personnel does not want to cooperate when it comes to changes and innovations (Doove & Prince, 2013). **Cooperation is also least dispersed** among the construction industry: where across all other sectors on average one third of surveyed businesses collaborated with other firms for innovation, it is only 24% that looks for partners in the building sector (Doove & Prince, 2013). This calls for new collaborative approaches of which supply chain management is part. Collaboration within supply chains is assessed to be crucial when enabling innovation in the building sector (Suurs, van Niekerk, van Barreveld, & Urlings, 2011; van der Gaag et al., 2014).

The Dutch building industry moreover lacks real innovators who cause excitement and dare to counter the current regime. "Three out of five enterprises [in the building industry] are waiting and think economic growth will come again and they will be ok. This won't happen. Businesses that do not change to a demand-driven approach, new concepts and new business models will disappear" (Rotmans in Dukker, 2015). Rotmans moreover mentions industry organisations as blocking forces in the sector. They are interested in new ideas and concepts, but have to consult their members to reach consensus and that is where things slow down (Dukker, 2015).

On the positive side of innovation in the building sector are some socio-organisational examples. Development of collaboration types like Public-Private Partnerships (PPPs) supported by DBFMO contracts are amongst these. A PPP is a **partnership** between a governmental institution, a private party, research institute or a civil society organisation (Government of the Netherlands, 2015). New in these type of partnerships is the role of the government that shifts from a focus on the input (the realisation of the building project) to a focus on the output (the goal of the building project). In this way, market parties get the opportunity to pursue the realisation in their own way and have the possibility to innovate (Government of the Netherlands, 2015). Realising a PPP often happens using a Design, Build, Finance, Maintain and Operate **contract** (DBFMO contract). The project owner is responsible for the components named in the contract and can outsource these to subcontractors, making market parties completely responsible for the realisation of the project. Since only one tender for all the components is made, transaction costs will be saved as well.

Another socio-organisational innovation specifically aimed at sustainability within buildings is the Energy Service Company (**ESCo**). Within an ESCo an owner or user of a building outsources the energy supply and management to an external party. The aim of this is to realise substantial savings for the costs of energy use and to realise quality and lower maintenance costs for installations (Esco netwerk, 2015). The external party taking over the energy supply and management mostly consists of a consortium of parties like technical experts and investors (Esco netwerk, 2015).

2.3.6 CE building practices

A circular building sector is defined by its lifecycle approach. This will include design that optimises the useful life of a building or construction, integrating the end-of life phase. A circular supply chain is based on a new model of ownership. Resources are no longer sold to a developer and the final 'product' is no longer sold to an owner. The services of living and working are central, provided by a consortium for instance, while the different producers of all materials and components still own their resources that are temporarily stored in the building (ABN Amro, 2014).

This situation implies looking at **total costs of ownership** and how these can be reduced (Circle Economy et al., 2014). A well-insulated building for instance will result in net savings along the total lifecycle, just like many other energy saving measures. Maintenance of a buildings' structure, skin and services will be part of the contract and can be supported with smart sensors. Sharing information is key, supported via Building Information Modelling (BIM) (TU Delft, 2013) and resources passports (Damen, 2012; see section 2.2.3). Via BIM technology a digital model of a building is constructed that contains accurate geometry and data needed to support the different phases of the lifecycle of a building (Eastman et al. in TU Delft, 2013). This helps to design, plan and optimise reusing resources – even along changing roles and relationships in project teams. A new ownership model also asks for new ways of financing with other payback times and residual values. At this moment banks finance construction projects based on expected cash flows or with collateral real estate. In a new model, banks could finance the resources in the building or the service of housing (Circle Economy et al., 2014).

In the building and demolition industry, three important themes of circular practices can be distinguished:

1. Reducing impacts during the use phase:
   Main impacts occur in this phase due to electricity usage, heating and water use. Reducing these via:
   - Profitable renovation:
     The existing built environment forms a big challenge with regard to sustainability. Renovation projects show a solid business case since they significantly reduce energy demands along the lifecycle of a building.
   - Possibilities in new buildings:
     Standards like BREAAM and LEED are widely applied and policy puts up high standards. From 2020 onwards all newly built houses have to be energy neutral for instance (Circle Economy et al., 2014).
   - IT solutions:
     Real-time monitoring and IT solutions are essential for significant impact reduction. This does not only cover energy usage, but also areas like waste management, waste- and rainwater management and environmental factors.
   - Mobility choices:
     The civil building sector also has to reduce its impacts during use. Logistics and mobility are main causes of societal hinder. This considers for example sound, emissions, energy use and particulate matter. Circular practices entail coordinating supply and demand via IT solutions. Residual demand should make use of most sustainable choices with regard to mobility.

2. Optimise and reuse existing building and infrastructure:
   In a circular economy, renovation, refurbishment and creative solutions for the existing environment are preferred to building new structures.
   - More does not equal less:
     When there is a demand for living or working space, creating more supply is not always the best option. Sometimes additional demand will result in induced demand (Circle Economy et al., 2014). Circular practices prefer looking for solutions that respond in a different way to demand.

3. Design circular buildings:
   In a circular building (and demolition!) sector, circular principles dictate the design process (see Table 5). Next to this circular innovative building materials are used (see Table 6). This implies changed structures of ownership and end-of-life scenarios for building materials.
   - Design for disassembly, reuse and adaptation:
     Circular design means that a building consists of dismountable components. The components used moreover have to consist of resources that are easily recyclable. Disconnecting structural and architectural elements also enhances the adaptability of a building. Table 5 gives an overview of circular design principles:

Principle	Explanation
Modular building	Modular building uses prefabricated components, like walls or ceiling parts. The advantage of this principle is that material losses on site are minimal since parts have tailor-made dimensions. It moreover eases assembly of a building.
Extending life-time	Protecting a building against weather influences while using ventilation and drainage for instance.
Anticipative building	Multifunctional usage of assets to support adaptability. Integrating solar panels in pavement for instance.
Standardised dimensions	Structural components with standardised dimensions enhance reusability and will result in a higher residual value of the components and materials.
Separate construc-tion and appearance	Increased adaptability of a buildings structure; important note is to make sure a structure is able to accommodate new architectonic appearances.
Integrate services into construction	This can be a profitable strategy, although disconnecting services and construction might be a better option in other cases. It may lead to higher flexibility around maintenance and renovation.
Use dismountable components	Permanent joints (chemical or mechanical joints) increase the complexity of components, slow down the demolition process and thus decrease reusability.
Use recycled resources	Reducing the demand for (virgin) building materials has a top priority due to all its impacts. Both structural and functional elements can be recycled. Moreover, local materials can be used to decrease negative impacts of transport.

***Table 5** – Overview of circular design principles (based on Circular Economy et al., 2014).*

- Circular building materials:
  A conscious choice for materials is needed to lower lifecycle impacts, increase the lifespan of materials and enhance reusability and recyclability. Using circular materials will save costs and the materials will even have a positive residual value. Options for circular material usage are listed below:

Principle	Explanation
Reduce material mass	Mass can be reduced by using less robust structures like steel framing instead of heavily built concrete or wooden structures.
Eliminate toxic & non-degradable materials	Many building materials contain toxic substances that are not biological degradable and are harmful to people and the environment. There is a growing number of harmless materials like paints, bricks or cements.
Increase lifespan of materials	Materials like steel and concrete have long lifespans in principle, but weather influences can reduce this lifespan considerably. By using remote sensing for instance, maintenance demands can be monitored and acted upon.
Improve a buildings' Performance	Thermal performance for instance can be influenced by material usage. Green roofs for instance can keep water and cool buildings while facades with algae can generate energy and provide shade.

***Table 6** – Overview of options for circular material usage (based on Circular Economy et al., 2014).*

Some of these more general practices have already been put into new concepts, like the '4P-Tetraëdermodel'. This model connects the three P's of People, Planet and Profit with the actual realisation of a building via the fourth P: 'Project' (Ministerie van VROM, 2010). Within this 'Project' it is about spatial quality, flexibility, diversity, beauty and balance. Another concept for instance is IFD (building industrial, flexible and disassembled). This concept focuses more on the building process and organisation. In IFD, building materials are already processed into complete facades or sanitation units, transforming the traditional construction site into a place for assembling parts (Ministerie van VROM, 2010). Cradle to Cradle® (C2C) is a concept that was already explained in section 2.2 and another concept directed at the building process is 'Slimbouwen' (smart building). Slimbouwen is a strategy aimed at physical and

organisational decoupling of installations (Slimbouwen, 2015). This increases flexibility, allows for industrial building and leads to an efficient building process. Slimbouwen moreover revises material usage hereby reducing a buildings' environmental impact. Slimbouwen is based on three principles (Slimbouwen, 2015): (1) Industrialisation of the building process, (2) Flexible and lifespan lasting building, (3) Reduce the environmental impacts.

Looking at the potential economic impacts of applying circular practices in the built environment, Figure 12, shows that the industry sector of which the building sector is part, contributes most to the opportunities of a CE in the Netherlands: € 5,3 million out of the total € 7,3 million (Rietveld et al., 2013). Circular building practices thus have the potential to be a profitable economic activity.

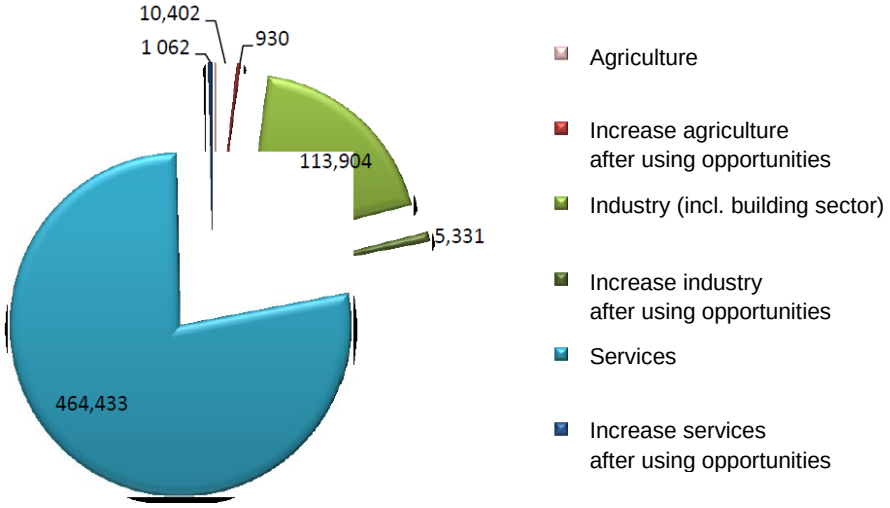


Figure 12 – Division of Dutch GDP per sector in 2010 and the share of potential growth in GDP via growth of CE (Rietveld et al., 2013).

2.3.7 Conclusion for CE in the building sector

In the building sector many different stakeholders (of which a large amount of SME's in the Dutch situation) are involved in creating complex objects: buildings have long lifetimes and it is difficult to predict their whole lifecycle. Many important decisions about their functioning are made in the initiating stage which establishes what changes can be made. The Dutch building sector experienced economic downturn between 2008 and 2014, resulting in increased competition and lower mobility rates among both households and companies in moving housing.

These economic trends allow for new possibilities for circular practices to emerge, combined with the fact that the built environment has the potential for improvement here since it is one of the top contributors to environmental problems like resource use, energy use and CO_2 emissions. An obstacle for implementing CE is the **low rate of innovation** in the sector: short-term planning, fragmentation, a low rate of cooperation and the presence of blocking industry organisations all contribute to resistance to change. This is why **practical tools and examples are needed** to show the industry the way towards implementing CE. Options for circular building practices have been identified and some pioneering practices are present.

3. Integrating visions, learning, actor networks and business models within system innovations: a literature review

In this chapter a review of various theories and concepts that can be found in literature around system innovation will be presented. After an introduction to the theories in 3.1, the relevance of this perspective to Industrial Ecology will be shown in 3.2. This chapter furthermore explores visions in sustainable development and systemic innovation in 3.3, learning of actors in 3.4, networks and network theories in 3.5, before going into more practical concepts of business models in 3.6. In section 3.7 overall conclusions will be drawn based on the purpose of creating a conceptual framework to investigate case studies.

3.1 Introduction

Chapter 1 mentioned that for establishing CE a broad perspective is needed, that takes into account multiple levels of application, networks of stakeholders, sectors and fields of research that should collaborate (Yuan et al., 2006). This system perspective on innovation is not new. It is based on ecosystems thinking, where everything is interconnected and related (Ellen MacArthur Foundation, 2013). System thinking assumes that parts should be considered in their context, and systems should be considered based on the parts they consist of. A transition towards CE aims for changing the underlying principles of the system with its processes and artefacts. Innovation theory based on this systems perspective is an interdisciplinary research field, where various concepts can be explored. This chapter presents a review of concepts that are part of systemic innovations aimed at shaping a sustainable future.

3.2 Visions

In transition management and system innovations towards sustainability, visions of the future are termed an important element (Borup, Brown, Konrad, & van Lente, 2006; Kemp, Schot, & Hoogma, 1998; Quist & Vergragt, 2006; Quist, 2007; Rotmans, Kemp, van Asselt, 2001; Smith, Stirling, & Berkhout, 2005). Future visions are assumed to provide coordination of different actor groups and communities, forming an orientation for joint action and bridge different boundaries and levels of organisation (Borup et al., 2006; Quist, 2007). Analysing these visions and their dynamics is a key element in understanding change in the scientific and technological realm. Examples of future visions can be found in society in various forms. They range from mission statements of big corporations to the 'vision for sustainable consumption' by the World Business Council for Sustainable Development (WBCSD, 2011), providing guidance and direction. Quist (2007) distinguishes between different types of visions:

- Desirable positive visions, sketching a bright image of the future, like WBCSD's vision on sustainable consumption or the sustainable development concept presented by the Brundtland commission (WCED, 1987)
- Undesirable negative visions, that are pessimistic in their future visions with examples like the report 'Limits to Growth' (Meadows & Club of Rome, 1972) and the climate change projections presented by IPCC (IPCC, 2014).

Quist (2007) moreover mentions the fact that visions can also become or be contested. Contested or controversial visions are reflected in society since they generate debate between actors with opposing visions. Examples of such visions with opposing positions are the future of nuclear energy or genetically modified foods (Quist, 2007). Visions on the other hand can also gain acceptance, as illustrated by the developments around CE (see section 2.1.1). The CE paradigm in itself can be considered a (desirable) future vision on a macro level. This can be traced back to EMF's own statement about the organisation (Ellen MacArthur Foundation, 2013, p. 111):

> *"The Ellen MacArthur Foundation was established in 2010 with the aim of inspiring a generation to re-think, re-design and build a positive future through the **vision** of a regenerative, circular economy, and focuses on three areas to help accelerate the transition towards it."*

EMF explicitly mentions the circular economy as a positive future vision that can provide guidance in creating a regenerative (closed-loop) system. The vision moreover is elaborated upon as a future where values, innovation and drive will help utilising the power of regenerative processes and creating prosperity without threatening future opportunities (Ellen MacArthur Foundation, 2013). For a research in the field of CE it thus makes sense to take a closer look at the scientific concepts on visions and vision development.

3.2.1 Vision concepts

Various scholars have contributed to vision concepts, using different terms, different dimensions and levels of application of visions, correlating to their meaning. These levels at which visions are at play in different ways can be described at the local level of (innovative and entrepreneurial) projects, the intermediate level of sectors and the (national and international) macro level (see also Table 8).

A first contribution from *future studies* will be considered due to its emphasis on developing a framework for investigating the functioning of visions. In this study a vision is defined as "the more or less explicit claim or expression of a future that is idealised in order to mobilise present potential to move into the direction of this future" (van der Helm, 2009, p. 100). The meaning of visions thus depends on three vision aspects (van der Helm, 2009):

1. The future – although the word vision can also point at 'views' or 'perspectives' and these aspects are also part of visions of the future, there is a need to study those visions that make strong claims about the future. Visions in this context do thus refer to something not (yet) existing.
2. The ideal – visions are expected to refer to an idealised future that respects historical and contextual uncertainties. Therefore visions are considered preferred futures instead of likely futures. This implies that the idealised future vision is the only conceivable image of the future.
3. The desire for deliberate change – visions serve an important goal in converging actions into the desired direction as set out by the vision. As opposed to other future study approaches like backcasting that aim at opening up the future (Quist & Vergragt, 2006), visioning essentially closes the future.

Van der Helm (2009) moreover identifies several contexts that hold different vision types. These are related to the origins of the vision, its development and use. An overview of this typology is given in Table 7:

Vision type	Characteristics
Humanistic	Holistic description of an ideal universal society (utopia as a well-known example)
Religious	Urgency of giving meaning to human life in relation to the thereafter
Political	Leadership, (electoral) support and priority setting
Business/organisational	Leadership and convergence
Community	Consensual integration of actors and collective action (actor network tool)
Policy (support)	Network constitution and influencing decision making
Personal	Personal development and giving meaning to one's life

***Table 7** – Different types of visions and their discernible characteristics (van der Helm, 2009).*

Van der Helm (2009) finally provides several elements or themes that help us understand the functioning of visions. The first theme is the introduction of metaphors as an initial step (comparable to the local level in Table 8). An important metaphor for visions for instance is the magnet that shows how we are pulled towards the future (as presented by Fred Polak, n.d. in van der Helm, 2009). The magnet metaphor however does not describe how certain ideas have this magnet effect while others do not. This is why van der Helm (2009) introduces the notion of 'transformational tension' that describes the contrast between what is now and what could be in the future. This contrasting tension between the present situation and the idealised future allows progress into the desired direction. Other metaphors that have been proposed are the compass, the platform or the crowbar that converges energy into the realisation of the otherwise unattainable future (van der Helm, 2009). Metaphors always come at a risk when interpreting them, so additional themes are needed.

As a second layer van der Helm (2009) uses the distinction between explicitness and implicitness of visions. Visions need to be made explicit using images, words or the metaphors described above in order to discuss, reject or accept them (van der Helm, 2009). On the other hand these representations are used for communication but do not reflect the full idea of the vision. This tension between implicit (what is perceived) and explicit (what is emitted) is where a vision and its transformational tension emerge.

A third theme is the statement for change made by a vision that serves an important function in inspiring, directing and motivating people. In this way visions provide the mental framework needed to execute actions in the desired direction that can be evaluated (van der Helm, 2009).

A final theme is the influence of leadership and authority. Van der Helm (2009) argues that the transformational tension should always be supplemented by authoritative tension which calls for looking into the practice of making these ideas authoritative. This could be done in several ways using models related to the visionary persons that carry the ideas like authority based on social position, historical records or large-scale involvement. This theme is of special importance at the intermediate level of (sector) networks. With this final step a framework is developed to influence our thinking (via metaphors for instance), then our behaviour (via authoritative tension) and eventually this results in action or "material reality" (van der Helm, 2009, p. 100) and when this happens at the macro level, visions can indeed mobilise the present potential into the desired future.

In *transition management* the term **'guiding vision'** (Smith et al., 2005) is used relating to the commitment of stakeholders in shared processes of vision definition, vision development and in innovation processes and trajectories that are derived from these shared visions (Quist, 2007; Rotmans, Kemp, van Asselt, 2001). Transition management can be seen as a deliberate attempt to change existing regimes according to a consensus guiding vision (Smith et al., 2005). Moreover, different functions of visions for transitions are described by Smith et al. (2005) given in Table 8:

Function	Explanation
Mapping a 'possibility space'	Visions identify a real of possible alternatives for socio-technical systems providing socio-technical functions.
A heuristic	Visions act as problem-defining tools by showing technical, behavioural and institutional problems that need to be resolved.
A stable frame for target-setting and monitoring progress	Visions stabilise technical and other innovative activity by serving as a common reference point for actors collaborating on its realisation.
A metaphor for building actor-networks	Visions specify relevant actors (including and excluding), acting as symbols that bind together communities of interest and of practice.
A narrative for focusing capital and other resources	Visions become an emblem that is employed in gathering resources from outside an emerging regime's core membership.

Table 8 *– Functions of visions for transitions (Smith et al., 2005).*

When looking at the different levels at which the guiding vision in transition management is used, Quist (2007) describes the generation of transition visions with stakeholders of a broader set of visionaries at the local level. At the intermediate level different sets of visions are made to keep options open. At the macro level the vision as once developed is part of the overall transition vision.

Studies on *technology development* in Germany use the concept of **'Leitbild'** referring to future visions (Dierkes et al., 1992; 1996 in Quist, 2007). This vision concept contains two main elements:

1. Guidance – this first element relates to the generation and direction of shared goals within the innovation and to the provision of orientation towards this goal by linking and synchronising the interaction and learning processes among actors from different backgrounds. It moreover has to do with providing a space and alignment for developing new rules that facilitate the emerging network around the innovation.
2. Image – the image part of the concept consists of the cognitive challenge of generating knowledge required for realising the vision and the mobilisation of actors and resources. It finally provides coordination of interaction and dependencies among different actors and among the overall the network.

In the Leitbild concept Dierkes et al. (1992, as mentioned in Quist, 2007) the importance of a vision champion is stressed. This vision champion can be an individual or a group of individuals coordinating different activities and interactions as presented in both the guidance part and the image part of the concept. Moreover, a balance seems to be needed between bottom-up and top-down coordination (Quist, 2007). A final issue that is mentioned with regard to this vision concept is the emergence of a network where actors interact, and how this interaction influences the vision in turn. The Leitbild concept thus has to deal with this dynamic and mutual influence of the vision development and actor interactions (Grin, 2000 in Quist, 2007; Menéndez & Cabello, 2000).

When looking at the 3 different levels in society, the concept of Dierkes et al. (1992, in Quist, 2007) was applied to the micro level of small-scale technological applications, using the idea of metaphors (Dosi, 1993). These metaphors fulfil the same function as the Leitbild at the level of projects. At the intermediate level of networks, the

original Leitbild concept can be applied, since it explicitly deals with coordinating (emerging) networks. At the macro level of systems Grin and Grunwald (2000) broaden the concept of Leitbild as guiding developments in these systems. As such, they can be described as paradigms (Quist, 2007) facilitating certain directions of development while constraining others. Discussing visions is a prerequisite for change at the macro level (Grin & Grunwald, 2000).

Technology development studies in the UK and in the Netherlands have developed the concept of visions under the name of technological **expectations and promises** (Borup et al., 2006; Geels & Smit, 2000; van de Poel, 2003; van Merkerk & van Lente, 2005). Scholars in this field emphasise the shared character of expectations and promises, based on positive beliefs in technology. Moreover, they focus on rhetorical aspects of expectations and promises and they show the relations at different levels as also outlined in Table 8. This 'nestedness' of expectations and promises is mentioned in these contributions, but different authors interpret these levels in a different way. Based on the contributions of van de Poel (2003) and Quist (2007) the relations between promises, expectations and guiding principles at the regime or macro level this concept will be explained. A (technological) regime with its guiding principle(s) is higher in the hierarchy than expectations and promises (van de Poel, 2003). Promises are supported by several interrelated and nested expectations. Promises and expectations are bounded by a regime with its guiding principle, while emerging promises and expectations may compete with the regime. Emergent promises, supported by their expectations, can become part of a new guiding principle that is competing with existing guiding principles at the macro level. An interesting addition to this conceptualisation is the fact that dynamics between actors may give rise to a self-fulfilling character of expectations and promises (cf. van Lente, 1993 in van de Poel, 2003). These dynamics between actors are also dealt with in the next and final contribution.

A final contribution to be considered is the concept of the *actor world* (Callon, 1986 in Quist, 2007). This is related to individual actors that have their own specific future **vision** they want to achieve. Such an actor world is based on expectations that support an actors' actor world. Every actor can develop an actor world that may conflict with another actors' actor world. Only a few visions in this conceptualisation can become shared among several actors. Such a shared future vision results from agreements among actors when negotiating and interacting (Callon, 1986 in Quist, 2007). When looking at the different levels, Quist (2007) connects the concept of the actor world at the local level to individual actors having established their own actor worlds. At the intermediate level of networks actors agree upon a shared future scenario. This means different actor networks can support different scenarios that might be competing (Quist, 2007). At the macro level future visions are part of the actor world.

3.2.2 Comparison and conclusion on visions

Vision Concept	Local level	Intermediate level	Macro level
The functioning of future visions (van der Helm, 2009)	Visions as metaphors (influencing thinking via the vision's image)	Leadership, authority and explicitness (influencing behaviour via guidance)	Motivation, inspiration and direction (changing reality via orientation)
Guiding Vision (Rotmans et al., 2001)	Generation of transition visions with stakeholders or visionaries	Presence of different sets of transition visions to keep options open	Guiding vision as part of the transition vision
Leitbild/guiding vision (Dierkes et al., 1992)	Metaphors	Leitbild/guiding vision	Paradigms
Promises & expectations (van de Poel, 2003; Quist, 2007)	Promises of an innovative project supported by a set of expectations	Promises for new fields supported by a set of expectations	Regime that allows an emerging guiding principle based on promises & expectations to match
Vision within an actor world (Callon, 1986)	Actor world of an individual actor, competing with actor worlds of different actors	Shared scenario is agreed on by a network of actors. Different networks support competing scenarios	Part of the actor world

***Table 9** – Comparison of different vision concepts and their embedding within different levels (based on Quist, 2007).*

The literature review in this section has confirmed the relevance of visions in systemic innovations towards sustainability. A comparison of different vision concepts shows that most of them address emerging technologies or scientific fields. They deal with bottom-up processes that cannot be controlled from a top-down perspective. Many of the concepts make a distinction between different levels. This nested structure of the vision concept is presented in Table 9 (see previous page) where the embedding of the different concepts becomes clear.

It was found that the paradigm of the CE itself can be considered a vision on the macro level. On the lower levels different sets of promises supported by expectations are now competing, reflected by the search for ways to implement the CE. Among the promises of a CE are for instance savings in net materials costs and reduced price volatility and supply risks. CE moreover promises local job creation, alongside greater innovation and greater resilience and a contribution to climate change mitigation and fossil fuel independence (Ellen MacArthur Foundation, 2013). When looking at the CE and vision concepts, the concept of future visions as developed by van der Helm (2009) can best be used for analysing visions at an operational level due to its focus on the actual functioning of visions. This framework provides useful themes as handles for analysing visions in the case studies central in this thesis. This framework moreover can be adapted to a suitable form for this research in the conceptual framework to be developed in Chapter 4.

Usage of the vision concept:
Drawing on the review above, the vision concept provides useful themes for a conceptual framework to be developed in Chapter 4 with elements for a case analysis in Chapter 5. The vision concept here for integrates the functioning of visions as presented by van der Helm (2009) with some elements provided by Quist, (2007):

- **Vision image** including (1) potential metaphors used here and (2) the explicitness of the vision in words or images (van der Helm, 2009).
- **Vision guidance** in (1) clear collective goals, (2) presence of alternative rule sets, (3) leadership and authority (van der Helm, 2009; Quist, 2007).
- **Vision orientation** via motivation, inspiration and direction (van der Helm, 2009).

3.3 Learning

Another key element in systemic innovations is learning by actors and parties involved. It is assumed that learning results in a change in the cognitive and mental framework of stakeholders (Quist, 2007). This is an important condition for change, especially in the area of sustainability where the change needed requires learning by stakeholders. Learning however does not guarantee the change foreseen (Grin & Graaf, 1996). Learning about CE and sustainability thus does not per se result in the actual changes in activities that support its transition.

3.3.1 Concepts of learning

Learning always starts at the individual level where new information is assimilated, based on past experiences and via a feedback-stimulus applied in subsequent actions (Hall, 1993). However, when looking at cooperation between parties in a supply chain, the learning concept can best be applied at the level of organisations or groups of actors (Quist, 2007). This learning on group level has been researched in many different disciplines. A characterisation of learning according to these disciplines results in conceptualisations for learning in social contexts, the political realm, organisational contributions and government or policy-oriented learning (van de Kerkhof & Wieczorek, 2005). Next to these different disciplines another distinction can be made between 'levels' of learning. In this respect the terms first order learning and higher order learning are used (Brown, Vergragt, Green, & Berchicci, 2003; Quist, 2007). For first order learning new insights are obtained about options for a particular problem and context. Higher order learning has to do with problem definitions, norms, values, convictions and goals of actors. Higher order learning manifests itself in a radical change in mental frameworks, interpretation of observations, problem-solving approaches and thus behaviour of stakeholders (Brown & Vergragt, 2008). Higher order learning occurs via processes of self-evaluation and reflection. This type of learning is needed to implement radical new (sustainable) solutions and it supports change processes (Quist, 2007).

A first concept of learning to consider is learning in *innovation studies* as proposed by Kamp (2002). This type of learning can be located in niche experiments, test markets or development projects and it distinguishes between four major types of learning. First order learning in this concept happens via learning-by-searching and learning-by-doing (as categorised by Quist, 2007). In search oriented learning actors focus on the 'why' question of a particular problem. This happens for instance around R&D where one searches for new knowledge in a systematic way. With a focus on learning by doing a (group of) stakeholder(s) learns how problems can be solved since the focus is on achieving knowledge to produce. Higher order learning in this concept involves learning-by-using and learning-by-interacting (Quist, 2007). Via the using component, it is learned what is to be done for a given problem since users learn how to cope with a particular innovation. In the final type of learning as described by Kamp (2002), interaction is central and an example of this type of learning is by producers when learning from their users via interaction.

In *organisational studies*, the concept of learning is applied to organisations, which are supposed to have relatively homogeneous mental frameworks (Quist, 2007). Here the levels of learning are called single-loop learning and double-loop learning. Singe-loop learning is explained as learning within the boundaries of accepted routines (Quist, 2007). Double-loop learning requires the creation of "new routines that were based on a different conception of the universe" (Argyris, 2003, p. 1179). Linstone (1999 in Brown & Vergragt, 2008) uses a typology of how individuals in an organisation learn, based on technological, societal and individual aspects. He moreover stresses the importance of integrating perspectives of actors as to broaden the range of options for an enhanced understanding of the problem (Lindstone, 1999 in Brown & Vergragt, 2008).

The domain of *policy studies*, also deals with the learning concept. This is important here due to the heterogeneous nature of actors in this field. The existence of advocacy coalitions already reveals the differences between actor groups in policy domains. In these coalitions actors cooperate around certain problems, while they have completely different mental frameworks (Sabatier & Jenkins-Smith, 1999). This coincides with the interaction type of learning as proposed by Kamp (2002). The coalitions that are achieved are in this context described by the term congruence (Grin & Graaf, 1996). Grin and Graaf (1996) describe congruence as actors taking a joined position, while value systems (at the higher order of learning) differ completely. This congruence is different from consensus because congruence means agreements on many assumptions, but not full agreement on all aspects of a problem (Quist, 2007). First order learning in the policy domain thus deals with these assumptions or secondary aspects, while higher order learning requires changes in the underlying core beliefs. Fischer (1995 in Brown & Vergragt, 2008) presents a multi-level concept for learning within public policy according to four levels:

1. Technical – the level of costs, benefits, tools for and outcomes of policy implementation targeted at a specific objective (or set of objectives).
2. Contextual – the level of problem definitions based on interpretation frameworks.
3. Systemic – the level of goalsetting related to societal needs.
4. Ideological – the level of fundamental beliefs about the world.

When looking at the domain of *social and behavioural sciences*, scholars refer to higher order learning as interactive learning (van Mierlo, 2002), communities of practice (Wenger, 1998 in Garmendia & Stagl, 2010) or generative learning in organisations or teams (Senge, 1990). Senge (1990) discusses five 'disciplines' of learning:

1. Personal mastery – continually deepening and clarifying our personal vision, focusing energies and seeing reality objectively.
2. Mental models – deeply rooted assumptions that influence how we understand the world and act based upon this understanding.
3. Building shared vision – discovering shared pictures of the future that stimulate enrolment and commitment.
4. Team learning – the capacity of team members to suspend assumptions and enter into thinking together, starting with dialogue.
5. Systems thinking – integrating the other four disciplines.

In these disciplines it was noted that the first two aspects relate to individual learning or first order learning. The higher order learning occurs when visions are collectively developed. It furthermore is stressed that this interactive learning is difficult to achieve (van Mierlo, 2002).

Scholars in the field of sustainability transitions and *strategic management* also deal with higher order learning as consisting of three interrelated mental shifts (Brown et al., 2003):

1. A shift in the framing of the problem and the perceived solution.
2. A shift in the initial approaches to solving the problem, and in assessing choices between desirable, but competing objectives.
3. A shift in the relationship among the participants in the experiment that includes a mutual convergence of goals and problem definitions. These shifts can occur both among the participants and their networks as among a broader societal context.

Next to this conceptualisation Brown et al. (2003) moreover present two types of higher order learning. These two different types involve learning among participants involved in an experiment and learning correlating to diffusing the outcomes of the experiment. The second type of learning of further diffusion in society is concluded to be a very important, yet very complicated process (Brown et al., 2003). Brown et al. (2003; 2008) conclude that a sense of urgency (e.g. reputation or financial stakes) is the most effective driver for higher order learning since it forces a trial and error process that is central to learning. Within organisations, Brown and Vergragt (2008) argue that this sense of urgency is formed by threats to the success of the organisation such as failures or unexpected situations. This trial and error process consequently leads actors to re-assess in an increasingly higher order: firstly a reassessment of tools, then the problem definition and thirdly the interpretive frames and theories (Brown & Vergragt, 2008). In a relating area of research, Wynne (1995) describes higher order learning as collective value learning. This explicitly deals with the difficulty that Brown et al. (2003) pointed out in involving society at large.

Building on the difficulty of diffusing learning outcomes and the lack of a way to study the learning processes in innovative experiments, Brown and Vergragt (2008) developed a framework to monitor and map learning processes. This framework is built on the different levels of analysis as developed by Grin and van der Graaf (1996) and Fischer (1995 in Brown & Vergragt, 2008). In their framework, Brown and Vergragt (2008) describe (1) the level of problem solving according to pre-determined goals by means of e.g. risk analysis, (2) the level of problem definition regarding specific coupling of the problem to technology-society (3) the level of dominant interpretive and cognitive frames (of making sense of observations), (4) the level of worldviews. They apply their framework to the case of developing a zero-energy building and conclude that higher order learning indeed took place, mostly at the second level of problem definitions and to some extent also at the level of interpretive frames. Some of the key factors that contribute to actor learning are clear goals and boundaries for the project, agreement among actors about the vision, values and process of the project and intense interaction of actors with commitment (Brown & Vergragt, 2008). Learning moreover can be analysed both at the individual and at the team level, where the team formation turned out to be an important learning aspect in the case as analysed by Brown and Vergragt (2008). In this way this conceptualisation is related to the theory on social learning as developed by Robinson (2003).

This social learning concept can also be found in recent contributions in transition management. Social learning is seen here as a process via which actors deal with uncertainty and complexity (Schäpke, Omann, Mock, & Wittmayer, 2013; Wittmayer et al., 2013). The concept bridges the individual and the collective level of learning in its interpretation of first and higher order learning (Wittmayer et al., 2013). First order learning can contribute to empowerment because of acquisition of new skills by actors enlarging their set of capabilities. Second order learning may result in changes in values, assumptions and worldviews allowing actors to discover new possibilities to meet (sustainable) needs (Schäpke & Rauschmayer 2011 in Wittmayer et al., 2013). This conceptualisation of social learning was turned into a framework by Garmendia and Stagl (2010) to analyse learning processes in case studies. This framework uses three dimensions or levels of social learning, visualised alongside three axes (Garmendia & Stagl, 2010). The first axis is the behavioural mode where social learning includes more than the acquisition of new facts, but focuses especially on values and assumptions by inducing changes in “frames of reference” (Garmendia & Stagl, 2010, p. 1716). Social learning moreover goes beyond the individual level to groups, organisations and institutions which implies gaining the skill of systems thinking, including uncertainties and complexities of these systems (Garmendia & Stagl, 2010).

3.3.2 Comparison and conclusions for learning

The literature review here revealed that learning by stakeholders is important in system innovations towards sustainability. It is a condition for change, but does not directly lead to achieving the change intended. Different concepts for learning were found based in different disciplines resulting in a heterogeneous overview of the concept. Some common aspects are present however, such as the need to look at the group or team level to analyse learning processes. The different concepts alongside a distinction between lower and higher levels of learning are presented in Table 10.

Learning Concept	Discipline	First order learning	Higher order learning
Innovational learning (Kamp, 2002)	Innovation studies	Learning-by-searching Learning-by-doing	Learning-by-using Learning-by-interacting
Organisational learning (Argyris, 2003)	Organisational studies	Single-loop learning	Double-loop learning
Policy-oriented learning (Sabatier & Jenkins-Smith, 1999)	Policy research	Changes in assumptions to reach congruence	Changes in policy core beliefs to reach consen-sus, conceptual learning
Generative learning (Senge, 1990)	Management and psychology	Individual learning	Generative learning using shared visions, system thinking, open dialogue
Learning in socio-technical experiments (Brown et al., 2003; Brown & Vergragt, 2008)	Sustainability transitions & strategic management	Problem solving	Reassessing problem definition, interpretive frames, worldview
Social learning (Robinson, 2003) Collective value learning (Wynne, 1995)	Sustainability transitions (within society at large)	-	Collective learning about values

Table 10 *– Comparison of different learning concepts, their origins and levels (elaborated based on Quist, 2007).*

Concluding about the applicability of learning for this research, the concept proposed by Brown et al. (2003) and defined by Brown and Vergragt (2008) seems interesting since it combines different concepts, allowing embedding in a conceptual framework. Another possibility is its focus on BSTE's (Brown et al., 2003). These BSTE's are used to connect learning concepts to social experiments with a predefined scope in participating actors, time and resources. The case studies around circular building practices resemble these BSTE's due to their bounded and experimental character. Both the experiments of Brown et al. (2003) and the case studies in this thesis focus on the introduction of concrete solutions in projects with a relatively short time span. Brown et al. (2003) distinguish between diffusion of learning outcomes in broader networks and society which allows for usage when developing a tool. The concepts of learning in BSTE's moreover presents clear categories for analysing cases. These different categories can also be placed into a conceptual framework to be developed in the next chapter.

Usage of the learning concept:

The conceptual framework to be develop will focus on *higher order learning* since this type of learning is involved in change processes that are central in this thesis. These processes moreover occur among a group of actors, just like forms of higher order learning. Based on the review above, the conceptual framework and resulting case analysis will use the learning concept in the following way, integrating the frameworks of Brown et al. (2003) and Brown and Vergragt (2008):

- In terms of a **shift in defining or framing problems** and a perceived coupling (of solutions) to technology or society (Brown & Vergragt, 2008).
- In terms of a **shift in problem solving approaches** and shifting priorities (Brown et al. 2003).
- In terms of the level of dominant interpretive and cognitive frames; **joint learning** and shifting joint opinions among the actors involved (Brown & Vergragt, 2008).

3.4 Networks

Innovation always requires coordination of actors and their relationships, especially when aiming for closing material (and energy) loops in a transition to a CE. This coordination and the linkages between parties are not only to be made in the technological system, but especially in the social system (Gimenez & Tachizawa, 2012; Seuring & Müller, 2008). Organisations, firms or individual actors are linked to each other by a set of relationships, defined as a social network (Boons & Baas, 1997; Gordon & McCann, 2000; Granovetter, 1985). For a change in the linkages in the system it is important to know how these networks work. Network theories have emerged in several scientific fields to understand relationships between actors and their influence on actor behaviour and the other way around (e.g. Callon, 1986; Gordon & McCann, 2000; Granovetter, 1985). Just like visions and learning, networks also work at different levels. The micro level can be used to study relationship between individual actors, while the intermediate level focuses on networks of relationships between individuals within groups or organisations (Quist, 2007).

In sociology, innovation studies and business studies, network theories focus on the relationships among different types of actors. Actors in these studies can be conceived as (groups of) organisations as well as individuals (Quist, 2007). Although the focus of these studies is on the first type of organisations, individuals can be key actors in a network. The focus on heterogeneous actors is most relevant in exploring collaboration in circular supply chains in the built environment. The supply chains itself can be regarded a special network type whereas the focus on CE in these supply chains allows to analyse the complexity of these networks (Sisco, Chorn, & Pruzan-Jorgensen, 2010). This relates to complex problems as a central focus, which cannot be resolved without collaboration, knowledge of stakeholders and networks (Smith, Ansett, & Erez, 2011).

3.4.1 Network theories

This section deals with several network theories as developed in innovation studies, sociology and business studies. The approaches to be reviewed are:

1. Actor network theory
2. Industrial network theory
3. Social network theory
4. Network pictures
5. Sustainable supply chain management theory

Actor Network Theory (ANT), also known as the sociology of translation, is a network theory developed to study innovation processes. It offers a methodology to reconstruct a social-technical change process through which new ideas do (or do not) become reality. According to ANT, all innovations have to deal with a heterogeneous set/network of actors with aligned interests (Walsham & Sahay, 1999 in Vernay, 2013). This actor-network "defines identity [of actors], the roles they should play, the nature of the bounds that unite them, their respective sizes and the history in which they participate" (Callon, 1986, p. 24).

Central in ANT is the reflection of every form of change in the network. Actors that enter a network or change position in a network affect both the technology and the network. And vice versa: technology is able to change the network (Quist, 2007). Two important elements in this theory are enrolment and translation. Enrolment is about becoming a member of a network. The notion of translation refers to all the work, negotiations and changes within the innovation via which a certain actor influences another actor (Callon, 1986). The aim of translation is to achieve a stable network configuration where roles of actors are agreed upon. After this translation, actors start working together on the achievement of their shared vision and goals. Translation according to Callon (1986) consists of three steps: (1) to speak for others in defining or distributing roles, enrolling actors that are needed in the network; (2) to be vital for the actors in the network by creating "strategic points" or "obligatory passageways" (Callon, 1986, p. 27) for an innovation; (3) to displace both physically and socially via reports, documents, papers or symposia that also move materials and money. The concept of ANT thus assumes that little differences exist between human actors and non-human actors. This has been criticised since artefacts that influence the network are considered an actor, while a social actor that cannot directly influence the network is not considered an actor here (Quist, 2007).

Callon et al. (1992) later on broadened ANT into the so called techno-economic network. In this concept a heterogeneous actor set collectively develops and diffuses innovations, interacting and organising the relationships between scientific research and the marketplace (Callon, Laredo, Rabeharisoa, Gonard, & Leray, 1992). What is different in this concept is the combination of development and diffusion and the introduction of institutions in the network (Quist, 2007). It moreover adds poles to the network and a degree of irreversibility, strengthening and giving orientation to the network. The poles as added by Callon et al. (1992) were adapted and applied to evaluate the embedding of PV in housing in the Netherlands by van Mierlo (2002). In this evaluation the poles of (1) research and technology development, (2) product development, (3) use by consumers and organisational customers and (4) government and society were used.

In *Industrial network theory* networks are depicted as the web of contacts that exists between suppliers, producers and customers in industry. The industrial network theory started from two main assumptions (Håkansson, 1987; Oerlemans, 1996):

1. Technical innovation is in general the outcome of cooperation between businesses and other actors in a network like customers, suppliers and non-market relationships.
2. Businesses are embedded in industrial networks and change in these networks affects the behaviour of businesses and the other way around.

In this way, networks can involve firms producing both complementary and competing products or services. Since it is based on industrial relationships, resources and activities relating to the exchange and processing of resources are central. The industrial network theory therefore distinguishes between three main elements (Håkansson, 1987): actors (1) that perform activities and use or control (critical) resources; activities (2), to combine, develop exchange or create resources. Two types of activities can be discerned: transformation activities, if an activity is in full control of a certain actor and transaction activities, if an activity involves other actors; resources (3), that can be analysed according to five categories: material inputs, financial capital, technology, labour and marketing.

Industrial network theory moreover sees three functions for networks (based on Quist, 2007): (1) contribution to the development of knowledge among actors; (2) coordination of exchanges of resources; (3) contribution to mobilising resources. The outcome of this network concept and its dynamics are thus influenced by the actors involved and their relationships, the structure of the network, the combinations of resources and activities in the network and power distribution (based on Quist, 2007).

The *social network model* as developed by Granovetter (1985) started primarily as a critique of the neo-classical, opportunistic and rational approach to institutions. The social network model argues that more order can be found within interfirm interactions and less order within intrafirm interactions than assumed by rational economic models (Granovetter, 1985). This model is based on interpersonal relationships that crucially depend on trust and informality which are seen as potential strengths. Strong social interactions based on trust are more likely to happen within businesses, resulting in more order within interfirm interactions (Gordon & McCann, 2000). The strength of relationships in this model is referred to as the 'embeddedness' of the social network. Social embedding means sharing norms, institutions and sets of assumptions among a group of actors. In relationships among individuals with decision-making power in a group of different organisations, the existence of trust relationships means that the individual or collective actions of the group differ from the behaviour associated with rational economic mechanisms. Gordon and McCann (2000) define three key features of this trust-based behaviour:

1. Firms in the social network are willing to undertake risky cooperatives and joint-ventures without fear of opportunism;
2. Firms are willing to reorganise their relationships without fear of reprisals;
3. Firms are willing to act as a group in support of common mutually beneficial goals.

When applying the social network theory to industrial clusters it is assumed that such clusters de reflect not only economic responses to the patterns of available options and opportunities, but also a relatively high level of social integration and embeddedness (Gordon & McCann, 2000).

Network Pictures have been understood as the representations of views of a company's position in a network (Ford, Håkansson, Snehota, & Gadde, 2002). These views are composed of several 'pictures' since different companies and individuals will have different pictures of the characteristics, content and extent of the network. Based on this conceptualisation, Mason and Spring (2011) observe that a network picture is a *static* picture of an understanding held by individuals at a certain point in time. Moreover, they notice that network pictures are a *technique* when applied by managers. This has to do with the fact that a network picture from one individual can provide useful information, but if network pictures are gathered from a number of individuals a more comprehensive network picture will be established. Managers thus assimilate several network pictures into their own network picture (Henneberg, Mouzas, & Naudé, 2006). These combined network pictures then shape decision making. In this way, network pictures do not just reflect reality, they also intervene in reality (Callon, 1998 in Mason & Spring, 2011).

Just like the vision concept, the network pictures have been applied to different levels (of management in this case). Several scholars used network pictures at these different levels. Henneberg et al. (2006) for instance suggest that network pictures constitute an overview of the position of firms in the network (meso level). Ford et al. (2002) give an example of IKEA that looks more into the strategic level of the entire industry (macro level). An overview of network picture within the different levels is presented in Table 11:

Level of management & research using network pictures	Key issues
Industries as networks (macro level) (Ford et al., 2002)	Networks, as configurations of actors that carry out value activities form the environment they are part of. Focus on structures, processes and evolution.
Firms in the network (meso level) (Henneberg et al., 2006)	Firm's strategic behaviour in networks can be analysed via the position and roles they play in focal nets. Positions come about via business relationships. Essential elements are the capability to identify, evaluate, construct and maintain positions and relationships.
Relationship portfolios (local level)	Business is a core of resources and activities. Strategic issue is which of these activities are carried out internally and which through different types of exchange relationships.
Exchange relationships (micro level) (Leek & Mason, 2010)	Individual customer/supplier relationships are the basic unit of analysis. Capability of creating, managing and concluding important relationships is a core resource for a business.

Table 11 *– Four levels of using network pictures within network management (Leek & Mason, 2010).*

Network pictures in this way could thus be a useful tool for managers to identify and explain several types of problems and to assist in decision making. The method is quite complex and time-consuming though, so the use of network pictures needs some explanation and clarification before being recommended as a tool to managers (Leek & Mason, 2010). Another complication of network pictures is that they are in no way prescriptive. With different objectives for using network pictures, different methods can be used and different information will be collected. Moreover, the dynamic nature of relationships means that monitoring network pictures over time would be required to reveal changes necessary. This is why Leek and Mason (2010) mention the need for in- depth, longitudinal research to explore the application of network pictures.

In *supply chain management* (SCM) the network encompasses all stakeholders around transformations of goods from raw materials through to the end user and the associated information flows (Seuring & Müller, 2008). The management part relates to the integration of activities via improved relationships with partners in the supply chain to achieve a competitive advantage (Seuring & Müller, 2008). These relationships and the collaboration are central in this thesis and can be regarded as part of supply chain management. Supply chain management that is focused on sustainability or closing material loops holds different names in literature (Fahimnia, Sarkis, & Davarzani, 2015), but the concept can be considered as integrating environmental concerns into supply chains (Zhu, Geng, & Lai, 2010). In practical terms it is about reducing consumption of material, water and energy in the whole supply chain via collaboration with suppliers and customers (Zhu et al., 2010). Although the concept of SCM for sustainability is relatively new for many organisations (Zhu et al., 2010), the concept emerged in the 1990's according to literature reviews (Fahimnia et al., 2015; Gimenez & Tachizawa, 2012; Joseph Sarkis, Zhu, & Lai, 2011; Seuring & Müller, 2008).

These literature reviews present some interesting results for the topic of this thesis on circular supply chain collaboration. Gimenez and Tachizawa (2012) indicate two approaches to extend sustainability along the supply chain: assessment and collaboration. Their overview concludes that assessment of suppliers alone is not sufficient and that businesses need to engage with stakeholders in their supply networks in collaborative practices to improve their sustainability (Gimenez & Tachizawa, 2012). Two types of enablers for extending sustainability to suppliers are found: internal factors such as the availability of resources or senior management support and external factors like clarity objectives in the relationship between actors (Gimenez & Tachizawa, 2012). Gimenez and Tachizawa (2012) finally pinpoint a need to look at the characteristics that strengthen these enablers in a supply chain relationship. Seuring and Müller (2008) come to the same conclusion as Gimenez and Tachizawa (2012) in their need for cooperation: "Overall, there seems to be a need for cooperation among a wider range of companies along the supply chain than is usually discussed in conventional supply chain management literature" (Seuring & Müller, 2008, p. 1705). Moreover they conclude that only few case studies on sustainable SCM collected data from several or even all stages of the supply chain (Seuring & Müller, 2008), where the focus on CE in supply chains could fill this urgent need. Sustainable SCM according to Seuring and Müller (2008) finally deals with a wider set of performance objectives, taking the environmental, economic and social dimensions of sustainability into account. This links to the triple bottom line approach (Elkington, 1997) that will be described in the next section on business models.

Where the literature reviews above point to some gaps in current research about SCM and sustainability/ circularity that this thesis proposes to close, other scholars contributed to new approaches of managing networks (of supply chains). Svendsen and Laberge (2005) for instance stress the importance of the convenor role in addressing complex sustainability issues in networks. This convenor can help a multi-stakeholder network to make use of its resources, intelligence and energy for generating novel solutions and system innovation that cannot be achieved by individual actors or organisations (Svendsen & Laberge, 2005). Around the role of this convenor Svendsen & Laberge (2005) describe a different management approach that considers three factors:

1. Ways of thinking (mind-sets): the convenor has an important role in establishing links between network members and developing strong relationships based on **trust**. Next to trust, developing shared language, interpretation and vocabulary is essential, which related to the shared **vision** development as described in 3.2. A final important factor is collective **learning** from a diverse network to make use of its collective intelligence.
2. Ways of being (behaviours): the convenor manages the network via the identification of urgent stakeholder issues and when needed negotiates between competing issues. The role moreover involves **consulting** those that might be affected by actions of others in the network. When bringing actors together the convenor has to show leadership over managing and **considering the larger system** in such a way that value can be added to both the organisation and its social and ecological environment. He moreover takes care of the process of **convening** in for example distributing information or finding neutral working spaces.
3. Ways of engaging (processes): the processes required to build a sustainable stakeholder network involve three phases. The first phase of **outreach** aims at defining goals, guiding principles and network norms, clarifying roles and communication methods. Within the second phase **collective learning** (Argyris, 2003) is central focused around e.g. clarifying common ground, constructing shared meanings and building trust. In the final **joint action** phase clear goals have to be set together with a shared vision for the network and an action plan.

This definition of the convenor resembles what Ansett (2006) terms the **boundary spanner**. The role of this boundary spanner is defined as "gathering critical information, obtaining feedback and perceptions from the external environment through their stakeholder networks and then interpreting and translating that information back into their organisation" (Ansett, 2006, p. 39). Ansett (2006) observes a growing need for boundary spanners when dealing with a holistic approach to sustainability issues. Next to these boundary spanners or convenors, some more practical oriented business literature describes general approaches around sustainable supply chains including equity, transparency, mutual benefits, setting expectations, joint standards and implementation, monitoring and evaluation and capacity building (Albani & Henderson, 2014; McManus & Tennyson, 2008; Sisco et al., 2010; Tennyson, 2003).

When looking at the specific topic of *supply chain collaboration,* several scholars contributed to a conceptual understanding of this phenomenon (Barratt, 2004; Horvath, 2001; Stank, Keller, & Daugherty, 2001; Zang, Hofer, & Adam, 2004). Collaboration is a broad term and applied to the supply chain different forms of potential supply chain

collaboration can be conceived. Two main types of collaboration are vertical collaboration (e.g. with suppliers and customers) and horizontal collaboration (e.g. with competitors and other organisations) (Barratt, 2004). Whereas the examples above are types of external collaboration, internal collaboration is another category that has the potential to enable internal integration (Stank et al., 2001). In his conceptual understanding of supply chain collaboration Barratt (2004) distinguishes three broad categories of elements:

1. Cultural elements - a first cultural element is **trust**, which has been studied extensively in the field of inter-organisational relationships, but not so much in SCM (Smeltzer, 1997 in Barratt, 2004). **Mutuality** is another element since mutual benefits and trust-based relationships allow for mutual risk sharing (Gordon & McCann, 2000). **Information exchange** is another essential element where in particular quality and transparency of information flows can enhance (or hinder) collaboration (Barratt, 2004; Lee & Whang, 2000). A final cultural factor is the combination between **openness and communication**. Clear lines of communication contribute to information sharing and the creation of shared understandings (Stank et al., 2001). Openness and honesty have the potential to develop trust and commitment (Stank et al., 2001; Popp, 2000 in Barrett, 2004).
2. Collaboration elements – collaboration needs **cross-functional activities** enabling the exchange of information within or between organisations, just like the development of trust. To overcome 'functional friction' (Barratt & Green, 2001 in Barratt, 2004) of crossing functional boundaries, **process alignment** is needed, supported by senior management. Moreover **joint decision making** is an important element just like shared **performance standards** for the supply chain to improve overall performance (Barratt, 2004; Lambert & Pohlen, 2001).
3. Strategic elements - successful supply chain collaboration also depends on the degree of **intra-organisational support.** This determines the degree of process alignment amongst senior management and other parts of the organisation (Ireland & Bruce, 2000). Moreover, **corporate focus** needs to shift to collaborative initiatives instead of a focus on shareholders (Sabath & Fontanella, 2002 in Barratt, 2004). Another strategic element is the **business model** where the business case for collaboration needs to be developed (Horvath, 2001; Ireland & Bruce, 2000). Finally, the **role of technology** needs to be defined, since supply chain collaboration is too often focused on technology and this can become a barrier for collaboration (Ireland & Bruce, 2000).

3.4.2 Conclusion on networks

The search for network concepts in this section revealed that knowing how actors interact in a network is essential when aiming for system innovations. Innovation always requires coordination of actors and their relationships. Different theories on networks, originating from sociology, innovation studies and business studies were found.

Concluding about the applicability of networks in a conceptual framework (see Chapter 4) and case analysis, the industrial network theory seems promising. Since the aim of the CE is about resources that need to be closed in material loops, the industrial network theory explicitly deals with these exchanges of resources within the network. This model however, is quite rational in its description of relationships, which might be completed with aspects of the social network theory and supply chain management and in particular supply chain collaboration.

The literature review on supply chain management moreover revealed that supply chains can be regarded a special type of network around material and information flows. The relevance of this research lies in its focus on collaboration and its lifecycle perspective due to the focus on CE. The relevance is moreover determined by its combination of a broader set of performance criteria that include the environment and society. This broader perspective on value creation and delivery will be described in the next section on business models.

Usage of network theories and collaboration aspects:
Based on the review above, the conceptual framework to be developed in Chapter 4 will use network formation and collaboration in the following way, integrating the industrial network theory with aspects of supply chain collaboration:

- **Network composition**
- Description of **resources and activities** in the network
- **Actors involved and their relationships** in terms of (1) strategic elements like corporate focus, (2) collaboration elements like process alignment or joint decision making, (3) cultural elements like trust, information exchange, openness and mutuality (Barratt, 2004).

3.5 Business Models

For the paradigm shift needed for a CE, business model (BM) redesign is considered key in strengthening the delivery of environmental and social values while delivering economic sustainability at the same time (Bocken et al., 2013; Porter & Kramer, 2011; Stubbs & Cocklin, 2008). Business models can be understood as a device for framing, influencing and shaping both collective and individual action (Mason & Spring, 2011). This action directed towards developing a CE, is based on Circular Business Models (CBMs) where new ideas that combine social, economic and ecological benefits are linked to value creation (Boons & Lüdeke-Freund, 2012; Boons, Montalvo, Quist, & Wagner, 2013; Lüdeke-Freund, 2009; Stubbs & Cocklin, 2008). Hence, CBMs can show firms their way towards new circular ways of doing business. Several theories on business models have emerged; this section provides an overview, including a definition of a business model and a circular business model to be used in this research.

3.5.1 Business model concepts

Literature presents a diversity of perspectives and definitions of a business model (BM). Some scholars describe business models in a more holistic way as "the blueprint of an organization's business logic" (Lüdeke-Freund, 2009, p. 3) "how a firm conducts business" (Zott & Amit, 2010, p. 222) or "how a business creates and delivers value to customers" (Teece, 2010, p. 173). Others provide a way to structure a business model alongside a series of elements of which the structure developed by Osterwalder and Pigneur (Osterwalder, Pigneur, & Tucci, 2005; Osterwalder & Pigneur, 2010) is most widely accepted. Next to their structure, literature on business models also shows a more consolidated perspective of the components of a BM around the central element: the value proposition (Bocken, Short, Rana, & Evans, 2014; Boons & Lüdeke-Freund, 2012; Boons et al., 2013; Frankenberger, Weiblen, Csik, & Gassmann, 2013; Richardson, 2008; Zott & Amit, 2010). All scholars use structures that encompass similar elements, presented in different classifications. Most traditional literature on business models can be traced back to three elements of value proposition, value creation and delivery and value capture (Richardson, 2008) as also presented in Table 12. In Table 12 moreover the different ontologies that are used in literature are compared to each other based on the framework of Richardson (2008):

1. Value proposition: What the business delivers to customers and why they are willing to pay for it.
2. Value creation and delivery: How the value proposition is created and delivered to customers.
3. Value capture: Why the value proposition is created or how the value is captured.

Richardson, 2008:	Value Proposition	Value Creation & Delivery	Value Capture
Chesbrough, 2010	Value Proposition	Market Segment, Structure of the Value Chain, Position within the Value Network	Revenue Mechanisms, Competitive Strategy
Osterwalder & Pigneur, 2010	Value Proposition	Key Activities, Key Resources, Key Partners, Customer Segments, Channels, Customer Relationships	Cost Structure, Revenue Streams
Teece, 2010	Create value for customers	Entice payments	Convert payments to profits
Zott & Amit, 2010	Content: selection of activities that are performed	Structure: the way activities are linked	Governance: who performs the activities and captures value
Boons & Luedeke-Freund, 2013	Value Proposition	Supply Chain Customer Interface	Financial Model
Frankenberger et al., 2013	What? – the value proposition	How and who? – activities, resources, capabilities, pro-cesses and customer segments	Why? – revenue model
Mason & Spring, 2011	Market Offering – artefacts, access, activities and value	Technology – consisting of product, process, core and infrastructure	Network Architecture – consisting of markets and standards, transactions, capabilities & relationships

***Table 12** – Comparison of business model classifications.*

Based on this overview of literature on business models the following definition of a BM will be used:

A business model describes the way value is created, delivered and captured by a business

The model as proposed by Mason and Spring (2011) seems useful as basis for analysis since it integrates the theory *behind* business models. In this way it allows for linkages between the concepts described for networks due to its interfirm perspective. Moreover, this model looks especially into the multi-level applications of business models that are lost in most other concepts (Mason & Spring, 2011). Since these multi-level perspectives were explicitly described in the sections before on learning and visions, these concepts could also become part of this business model concept when looking at a transition. This is why this model will be explained in some more detail.

As depicted in Figure 13, the BM concept of Mason and Spring (2011) consists of three main elements: (1) technology, (2) market offering and (3) network architecture. Technology can be understood as the knowledge and usage of tools, systems, methods, techniques for products or organisations (Kremer, 1993 in Mason & Spring, 2011). While the focus of most innovation studies is on product technologies, Mason and Spring (2011) stress the importance of three other types of technology: process, core and infrastructure. Process technologies are used to deliver services or manufacture products. Core technologies underlie particular product technologies and significantly influence identification of an organisation in its innovations (Teece, 2010). Infrastructural technologies enable connections of which the internet, shipping systems and telephone networks are examples. When looking at the technological dimension as a whole it becomes clear that control over these aspects differs among different businesses in the network (Mason & Spring, 2011). Hence, the factors that determine the technological element of a BM entail both internal and external actors.

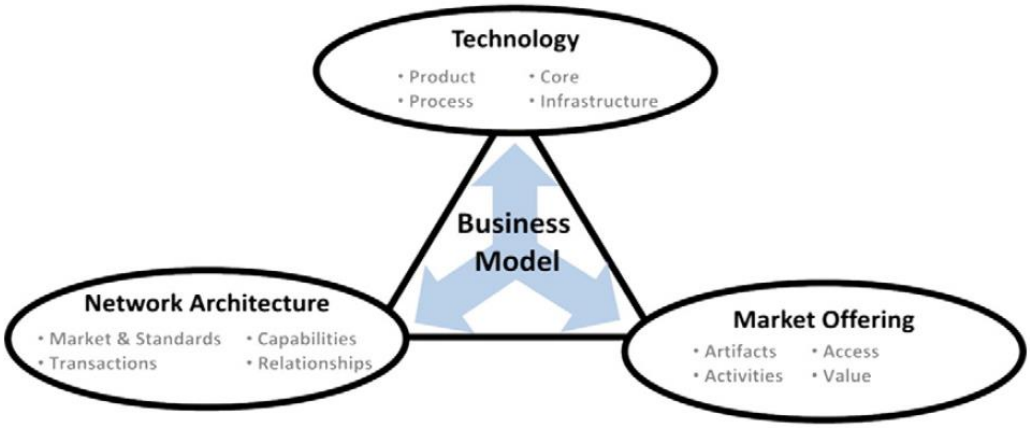


Figure 13 *– Business model concept according to Mason and Spring (2011).*

The market offering captures the value proposition with its roles of products and services in BMs. In this model it especially concerns the nature of interaction between producer and consumer. The value element of the market offering is close to the definition of value given in the theory overview above. It emphasises the benefits derived from an exchange by a customer. The artefact is the central element that is exchanged in many traditional BMs, even though service-oriented BMs are becoming more important. In these new types of business models, the artefact is strongly related to the final elements of the market offering: access and activity. Within access-based BMs the provider retains ownership of the capacities of the value-creation (Gadrey, 2000 in Mason & Spring, 2011). Activities finally, are what businesses perform for their customer when delivering a service.

Network architecture refers to the "architecture of the business network" (Mason & Spring, 2011, p.4) with relationships between a firm and the organisations that are involved in its transactions. In the network element, capabilities are defined as the knowledge that is both maintained and developed by a business (Mason & Spring, 2011). Capabilities consist of direct and indirect capabilities. Based on direct capabilities, roles within the network can be defined. Indirect capabilities relate to an important aspect for CE: how a firm can access and use the capabilities of other organisations in the network (Leek & Mason, 2010). The ease with which companies can access these capabilities of other firms is amongst others shaped by the existence of markets and standards. These two are interrelated since changing markets involve emerging standards (Langlois, 2004 in Mason & Spring, 2011).

Transactions occur when goods or services are exchanged and this is also the place where money (and profits) are made. In traditional BMs, the transaction is often quite a simple activity. Access-oriented and performance-based BMs however, developed more complex transaction structures (Baldwin, 2008; Baldwin & Clark, 2002 in Mason & Spring, 2011). The final element of relationships between firms is especially important in innovations indicating that transactions are often enabled by interaction. This stresses the importance of the non-financial part of an exchange (Mason & Spring, 2011).

3.5.2 Business models and CE

In the previous section some traditional BM characterisations were already mentioned as opposed to new types of business models. These 'new' BMs have the ability to link to the development of CE by making the conceptual principles of CE work in practice. BMs namely bridge sustainable innovations with operational levels of business strategies (Boons et al., 2013). This is most clearly reflected in the value proposition where economic, social and environmental values are to be balanced, based on the triple bottom line approach as developed by Elkington (1997). This perspective of multiple value creation asks for assessing the utility of value and the consistency with needs of customers (Boons et al., 2013). This can be done using Business Model Innovation to fundamentally change the (BM) system towards a sustainable and circular BM. Business Model Innovation hence urges a firm to reconceptualise its purpose and redefine its perception of value (Bocken et al., 2014). The structure of a BM finally makes sustainable innovation possible since it urges firms to consider the bigger system of which they are part, aiming for shared value creation with a positive contribution to the firm, the environment and society (Bocken et al., 2013; Boons et al., 2013; Elkington, 1997; Porter & Kramer, 2011). A circular BM thus need to consider how value is created for all stakeholders (Zott & Amit, 2010), including society and the environment. As such, **collaboration across an extended stakeholder network is an essential element** in creating and delivering value in a sustainable way (Bocken, Rana, & Short, 2015). A conceptual visualisation of this sustainable business model framework is presented in Figure 14.

Value Proposition	Value Creation & Delivery	Value Capture
What value is provided and to whom?	***How is value provided?***	***How does the firm capture (monetised) value?***
1. Product or service **2.** Customer segments and relationships **3.** Value for customer, society and environment	**4.** Activities **5.** Resources **6.** Distribution channels **7.** Partners and suppliers **8.** Technology and product features	**9.** Cost structure and revenue streams **10.** Growth strategy or ethos **11.** Value capture for key actors including society and environment

Figure 14 *– Conceptual framework for a sustainable business model (based on Bocken et al., 2015).*

The multiple value creation perspective that is central in Figure 14 is closely related to a trend in preventing the creation of negative externalities. Externalities are economic, social or environmental costs or benefits that a firm inflicts on an otherwise uninvolved party that did not choose to experience these costs or benefits (Buchanan, 1962 in Lodder, Huffenreuter, Braungart, & den Held, 2014; van Bergen et al., 2014). The trend fits in the paradigm shift to CE since it is supported by pressure to fundamentally change the societal system (Lodder et al., 2014). The need for businesses to take a closer look at their broader societal impact is explained by the 'True Value' Methodology of KPMG (van Bergen et al., 2014) in their description of a "method to understand and quantify the externalities and the likelihood they will affect the company's earning capability and risk profile in the future […].Ultimately, we need a standardised approach to measure societal value creation" (van Bergen et al., 2014, p. 5).

In this way, the final aim of a circular business is not to reduce the negative impacts of their activities (this is termed eco-efficiency), but to increase their positive impacts on the ecology, economy and society as a whole, introducing eco-effectivity (Ellen MacArthur Foundation, 2013; McDonough & Braungart, 2002). McDonough and Braungart (1992-2013 in Lodder et al., 2014) translated this into the Triple Top Line (TLL) approach as opposed to Ellington's triple bottom line. Whereas the TTL approach is based on a mutual beneficial relationship of ecological and economic systems, eliminating the concept of waste as in the essence of CE. Based on this literature review and following the definitions of a BM and the concept of CE (Chapter 2) a circular business model can be defined as:

A circular business model describes the way a business creates, delivers and captures value at every chain in the system with and within closed material loops.

Achieving circularity in BMs can be done in various ways. Bocken et al. (2014) developed a categorisation of sustainable business model archetypes. Their aim of sustainable BMs combined with the possibilities of value creation within a CE as developed by EMF (2013), leads to the following propositions for CBMs:

Technological			Social			Organisational		
Optimise material & energy efficiency	Create value from waste	Substitution with renewables	Functiona-lity, not ownership	Adopt a stewardship role	Slow consump-tion	Co-creation	Repurpose for society/ environ-ment	Develop scale-up solutions

***Table 13** – Sustainable business model archetypes (based on Bocken et al., 2014; Plan C, 2015).*

Together the BM archetypes in the table above can be used as a guiding tool to identify circular business opportunities. Since the archetypes are categorised in three different fields, some of the archetypes should be combined with others for a complete CBM (Bocken et al., 2014). This categorisation does not imply that archetypes from all different fields need to be applied, but it reveals the focus of an archetype. The categories used are based on common innovation categories that enable sustainable innovation (Boons & Lüdeke-Freund, 2012). The innovation in this case is the transition to CE: technological innovations enable the establishment of cycles of technical and biological materials, organisational innovations enable a holistic approach to implement an alternative paradigm (Stubbs & Cocklin, 2008 in: Boons & Lüdeke-Freund, 2012) and social innovations enable social value creation and maximising social profit (Boons & Lüdeke-Freund, 2012).

3.5.3 Conclusion on business models

This overview revealed that BMs are powerful mechanisms to show firms their way towards circular business practices. BMs namely bridge systemic sustainable innovations with the operational level of strategies. In BM literature this is most clearly reflected in the value proposition where economic, social and environmental values are to be balanced for a sustainable BM. Several theories on BMs have emerged, that all evolve around three aspects: the value proposition, value creation and delivery and the value capture.

In conclusion, the conceptual model as proposed by Mason and Spring (2011) seems promising as a base for analysis since it integrates the theory behind business models. In this way it allows for linkages between concepts. Moreover, this model looks especially into multi-level applications of BMs. Since these multi-level perspectives were explicitly described in the sections on learning and visions, these concepts could also become part of this business model concept when looking at a transition. This conceptualisation however is not directly linked to the establishment of CE or CBMs and that is why the possibilities of the sustainable business model archetypes of Bocken et al. (2014) and the principles of the TTL approach (Lodder et al., 2014) with a focus on increasing positive impacts could be added to the concept of Mason and Spring (2011).

Usage of business models literature:
Based on the review above the business model will be used in the conceptual framework (see Chapter 4) in the following way, using general business model theories and strategies for sustainable business models:

- **Value creation, delivery and caption** (financial, social and environmental).
- **Innovation** in the business model - based on sustainable business model archetypes.
- **Collaboration** as part of the business model.
- **Future improvement**: reflection on the implementation of the initial ambition regarding value creation.

3.6 Conclusion

This chapter provided a review of different theories and concepts related to the transition to a CE for the built environment: visions, learning and networks. It moreover explored theories around business models as practical building blocks to be used in a conceptual framework that integrates systemic transitions and the investigation of actual cases of circular building practices. This conceptual framework will be developed in the next chapter.

4. Conceptual framework and Research Methodology

Based on the outcomes of the literature review, this chapter deals with the questio how this can be combined in a conceptual framework and research methodology. Therefore this chapter will present the conceptual framework to be used in section 4.1. The research methodology is developed in section 4.2.

4.1 Conceptual framework

The conceptual framework to be used will be presented based on the following findings from Chapter 2 and 3:

The Circular Economy concept and its applicability:

- The concept of CE provides interesting opportunities; the concept however faces some major barriers that currently inhibit the implementation in mainstream (building) business. Concepts related to transition theory and system innovations towards sustainability can be used to overcome these barriers.
- In these transition theories multiple interrelated levels of application, networks of stakeholders, sectors and fields of research are taken into account that should collaborate. The three main levels include the local level of projects, the intermediate level of sectors and the macro level of (inter)national collaboration.

Vision concepts and their contribution:

- Visions are important enablers in emerging processes and they manifest themselves at the three different levels. In understanding the functioning of visions one can look at the vision's image (via metaphors and explicitness), then at vision guidance (via shared goals, alternative rule sets and authoritative tension) and eventually at orientation provided by the vision via motivation, inspiration and direction.
- The paradigm of the CE can be considered a vision on the macro level, backed up by different sets of promises and expectations that can be competing ones.

Learning processes and their contribution:

- Learning by stakeholders is important in system innovations towards sustainability. Especially higher order learning is an important factor, yet it is difficult to achieve.
- When analysing higher order learning one has to look at the presence of drivers like a sense of urgency and it links to visions in enhancing this type of learning via visioning exercises. Higher order learning relates to networks since extending ideas among similar initiatives/experiments is key in inducing higher order learning.

Networks and their applicability:

- Knowing how actors interact in a network is essential when aiming for system innovations.
- Supply chains are regarded as a special type of network involving material and information flows, established around a particular (building) project.
- These supply chains can be analysed alongside actors, activities and resources, but due to the topic of collaboration additional elements like joint decision making, performance standards, support, trust, mutuality and openness and communication can be added.

Integration of business models:

- Business models can be included in a conceptual framework since they bridge theoretical levels with operational levels. They can also be integrated within a multi-level perspective and include a broad perspective on value creation that integrates impacts on society and the environment.
- In conceptualisations of business models links to other concepts can be made, since the concept combines network structures with practices and technologies and value creation within a certain market offering.
- Two main typologies of business models can be made. One is based on the central element of value (value proposition, delivery and capture) while the other includes technology, networks and market offering.

When conceptualising the four different main concepts reviewed in Chapter 3, the following diagram can be derived (Figure 15 on the next page):

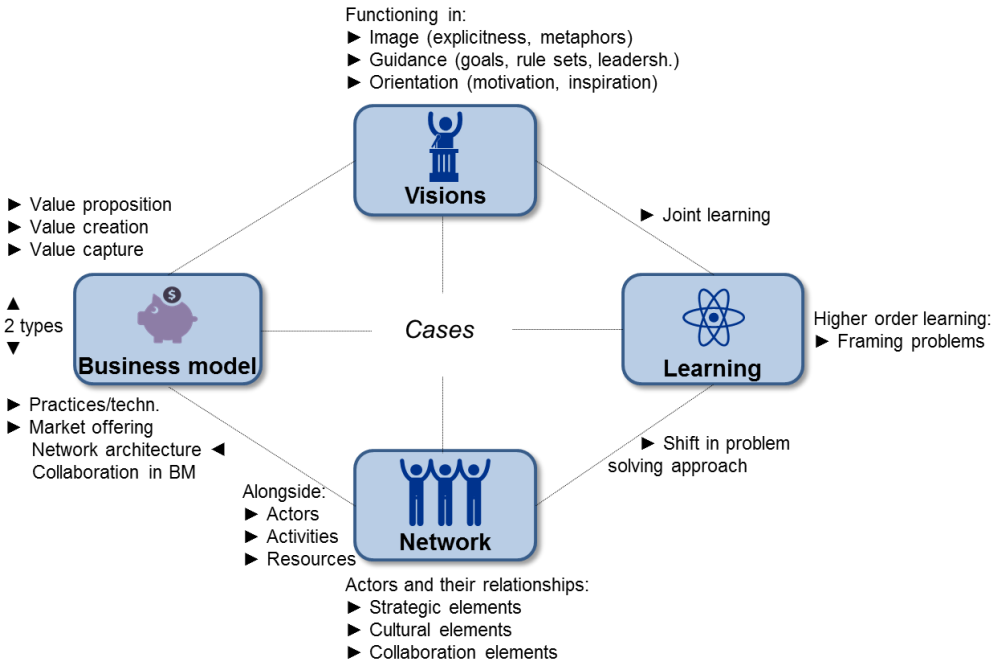


Figure 15 *– Conceptual framework for circular supply chain collaboration.*

Figure 15 shows the way the main concepts are related to each other, including the elements of analysis that were chosen and defined in the literature review in Chapter 3. For especially the network, learning and vision concept choices were made considering the application of the discussed concepts. These choices result in a focus on the elements that are positioned next to the blocks of the four main concepts in Figure 15. The framework and elements used will be explained next.

4.1.1 The vision concept in the conceptual framework

The literature review for vision concepts provided three interesting elements, based on the functioning of visions by van der Helm (2009) and the analysis by Quist (2007). These elements show an increasing influence of visions, starting with the actual content or the vision's image. This vision image looks at metaphors used and the way the vision bridges the tension between such a metaphor and explicitness in words or images. The vision guidance element firstly analyses the presence of clear and shared goals (based on Quist, 2007). It also looks into the presence of alternative rule sets (Quist, 2007) and leadership that guides the vision (van der Helm, 2007). The vision in this way is related to learning processes since guidance and orientation can steer actors to jointly change perspectives (higher order learning). The vision concept and the learning concept moreover relate to each other since learning in the context of innovation projects can benefit from visioning exercises (Brown et al., 2003). The concepts of learning and networks are linked since learning also takes place when actors extend ideas among similar initiatives or experiments.

4.1.2 The learning concept in the conceptual framework

For the learning concept the literature review in Chapter 3 revealed three types of higher order learning to be integrated in the conceptual framework. The first type of learning to be analysed in the cases relates to defining or framing problems and their coupling to technology or society (Brown and Vergragt, 2008). The second type of higher order learning analyses shifting problem solving approaches (Brown et al., 2003). These are linked to the network approach since these different approaches relate to integration of different disciplines in the supply chain as explained by Barratt (2004) in his collaboration elements. The third type of learning analyses shifting joint opinions of actors involved (Brown & Vergragt, 2008). These newly established joint interpretive frames of actors in turn are related to the vision concept where visioning exercises can result in such shared interpretive frames. The types of learning and their connections to visions and the network are visualised in Figure 15. The BM and vision concept are linked in their strategic position in business practices around collaboration (based on the framework of Barratt, 2004).

4.1.3 The network theories and collaboration aspects in the conceptual framework

The conclusion in the Chapter 3 on network concepts combines aspects from the industrial network theory and supply chain collaboration as depicted in the conceptual framework in Figure 15. The industrial network theory analyses the

actors in the network (the composition) together with their activities and resources. This theory links to the business model concept of Mason and Spring (2011) who explicitly mention the network architecture as part of their model (see Figure 13). The industrial network theory is complemented with three elements that determine the relationships between actors: strategic, collaboration and cultural elements (Barratt, 2004). For the strategic elements, Barratt (2004) mentions BMs that should embed collaboration, linking this level to BM concepts. Moreover these strategic elements deal with corporate focus, which is a translation of a vision on a firm level. In this way the vision and business model concepts can be linked to the network concept. The collaboration elements link to industrial network theory in processes and functional activities that enable exchanges of information and other resources. Network and learning concepts are linked since learning takes place when actors extend ideas among similar initiatives or when actors integrate the supply chain they are part of. The cultural elements lastly deal with aspects on the individual actor level. These elements need to be established to result in a collaborative supply chain network.

4.1.4 Business model theories in the conceptual framework

For the business model concept in fact two main typologies were discussed in the literature review in Chapter 3 that can still be applied. The way these two typologies relate to each other needs some further refinement in this section. The first typology around value proposition, delivery and capture (Richardson, 2008) is a useful concept, because integrating multiple value creation is an essential element for circular ways of doing business. Hence value creation, delivery and capture are first elements to be analysed in the cases.

The second typology of Mason and Spring (2011) looks more into the theories and concepts behind BMs. This model allows integration in the other concepts that were discussed. The network architecture is an explicit link to the network concept, while the market offering can easily contain the value proposition focused on multiple value creation as presented by Richardson (2008). The technology part needs to be adapted from the meaning that Mason and Spring (2011) ascribe to this element. This is due to circular building practices, where technology is not the main focus, but it can rather be described as a combination of practices and processes that involve technology. In this way another link can be established between the network conceptualisation alongside actors, activities and resources and the concept of Mason and Spring (2011). Actors are an important part of the network architecture, while the practices involve the activities and resources of the industrial network theory. One can also analyse the relation between collaboration and BMs here. The market offering is an additional element of the business model where value creation along the triple bottom line (Elkington, 1997) can be added. The business model and vision concept are mostly linked to each other in their strategic position in business practices around collaboration (based on the framework of Barratt, 2004). All these links can be analysed in the cases along the sustainable business model archetypes of Bocken et al. (2014). They moreover allow for a reflection on the value created and how this can be improved.

4.2 Methodology

Before diving into the reasons for selecting the methodology and the initial design of the case study research, the distinctive characteristics of the case study method will firstly be explained in this section to gain a better understanding of this research methodology. Case studies are an alternative to more traditional approaches of description such as correlational or quantitative descriptions and they emphasise the perspective of the participant as the central aspect in the process (Zucker, 2009). The strategy distinguishes itself from other methods in its attempt to study (1) an actual phenomenon in a physical context, where (2) the boundary between this context and the specific phenomenon are not clearly defined (Yin, 1981). Different case study types can be distinguished (Swiercz, n.d.; Yin, 1981; Guba & Lincoln, 1981 in Zucker, 2009):

- Factual or descriptive cases – that tell the story of a certain phenomenon or situation and in this way only transfer information to the reader of the case study research.
- Explanatory cases – that put the writer of the case in the position of an expert that makes the difficult subject under study comprehensible to the reader.
- Exploratory cases – that explore a new terrain.

Another classification of case studies is given by Swiercz (n.d.) according to the purpose of describing (1) company or industry profiles, (2) decision-making episodes, (3) theoretical explanations, (4) ethical and legal confrontations.

4.2.1 Purpose and rationale for case study

Several reasons can be given for choosing the case study as a method for this research. The method firstly allows for an **integration of practice and theory** that occur and develop simultaneously (Swiercz, n.d.; Zucker, 2009). For an emergent phenomenon such as CE in the building sector this is an advantage, since it makes for an investigation of actual cases while at the same time refining a conceptual framework to be used in this emergent field. Related to this first reason is the opportunity to generate new knowledge. The case study provides an opportunity to observe complex phenomena, interpreting these observations and turn them into a new and **original thought** (Swierz, n.d.).

Case studies are also suited to deal with unstructured data coming from a **dynamic and ambiguous** organisational process (Swierz, n.d.). Since circularity in the built environment was only established in a few (pilot) projects, these dynamics and ambiguities will arise when investigating the domain of CE in the (Dutch) building sector. The case study method at the organisational level can moreover result in the implementation of a transition which in this case is the emergent transition to a CE in the Dutch built environment. In this way the impact of the method manifests itself in moving the description of a certain phenomenon **to intervention** (Zucker, 2009). This is of importance for the ambition of KPMG Sustainability to support clients to bring circular ambitions into practice.

When looking at the type of case study and its purpose, it can be stated that this thesis focuses on an **exploratory** study since it deals with the emergent field of CE applied to the built environment. With this focus it contains some elements of the description of an **industry profile** (the building industry) directed to the specific purpose of CE. The main purpose however also lies in the **theoretical explanations** of the case study research.

4.2.2 Case study design

A first step in the case study design is defining the unit of analysis. In this thesis research the unit of analysis is a (commercial) **building project** that involves the application of principles of the circular economy with a focus on the collaboration between the actors in the project. Subunits can be identified in the project, such as the organisations within the collaboration and the individuals/actors representing these organisations.

Next is the choice between a single case study and the investigation of multiple cases. Due to the experimental nature of circular building practices, it is not certain that only a single case study will be representative or serves a longitudinal purpose as defined as justifiable aspects for choosing this method by (Yin, 2009). This does not favour a single case study. This argument is strengthened by the notion that evidence from multiple-case study research is judged more compelling, thus making the overall research more robust (Herriott & Firestone, 1983 in Swierz, n.d.). One moreover chooses a multiple case study approach according to Zucker (2009 based on Yin, 2009) when it (1) predicts a similar result or (2) produces contrasting results but for predictable reasons (based on theory). Due to the robustness of the results, the focus on the phenomenon of CE in the building sector and the possibility to select cases with a slightly different focus that is relevant in the field of CE, the **multiple-case study method** was chosen.

Another aspect that needs to be defined in the case study design is the holistic versus the embedded nature of case studies (Yin, 2009). Embedded case studies focus on several units of analysis, while a holistic case study deals one unit of analysis. The cases in this thesis will be analysed at the individual level of team members as well as at the level of organisations. This makes for an **embedded** multiple-case study design. In this study design several stages can be identified according to their activities and aim. A general overview is given in Figure 16 (Yin, 2009) and the different stages will be described according to insights from Zucker (2009) and Yin (2009):

- Stage 1 – define and design: after the initial theory development, cases are selected (see 4.2.4 Selection of cases) and data collection protocols are developed that support the description of experience. In this research the data collection protocol involves creating interview questions and a way to deal with the collected data that keeps track on methodological, theoretical and observational notions.
- Stage 2 – prepare, collect and analyse: in this stage interviews will be executed for the selected case studies followed by a first analysis of the data. Per case the outcomes are linked to the conceptual framework. This first analysis is about getting a more abstract notion of the results and their relationships. Zucker (2009) mentions the activities of noting relationships between variables, assembling a coherent understanding of the results, building a logical reasoning behind it within a chain of evidence and making conceptual coherence (Zucker, 2009).

- Stage 3 – analyse and conclude: this stage deals with an analysis of the results overall, the implications of the results for the theoretic part and general conclusions. One has to be careful when dealing with the broader implications of case studies since generalisation is usually limited in case study research (Zucker, 2009). Yin (1981) however argues that *theoretical* generalisation is to the domain of case study research what statistical generalisation is to the traditional experimental research. When working on a cross-case analysis, Yin (1981) describes two main methods: the case-survey approach and a case-comparison approach. The case-survey approach however requires a vast amount of cases to be investigated and the examination is often quite large. In this research the **cross-case analysis** will be a better suited method since it searches for a common explanation based on several cases. The main thing to preserve in this phase is the chain of evidence. This chain links certain pieces of evidence explicitly, shifting between data collection and within-case analysis to cross-case comparison and even overall conclusions and theory refinement (Yin, 1981).

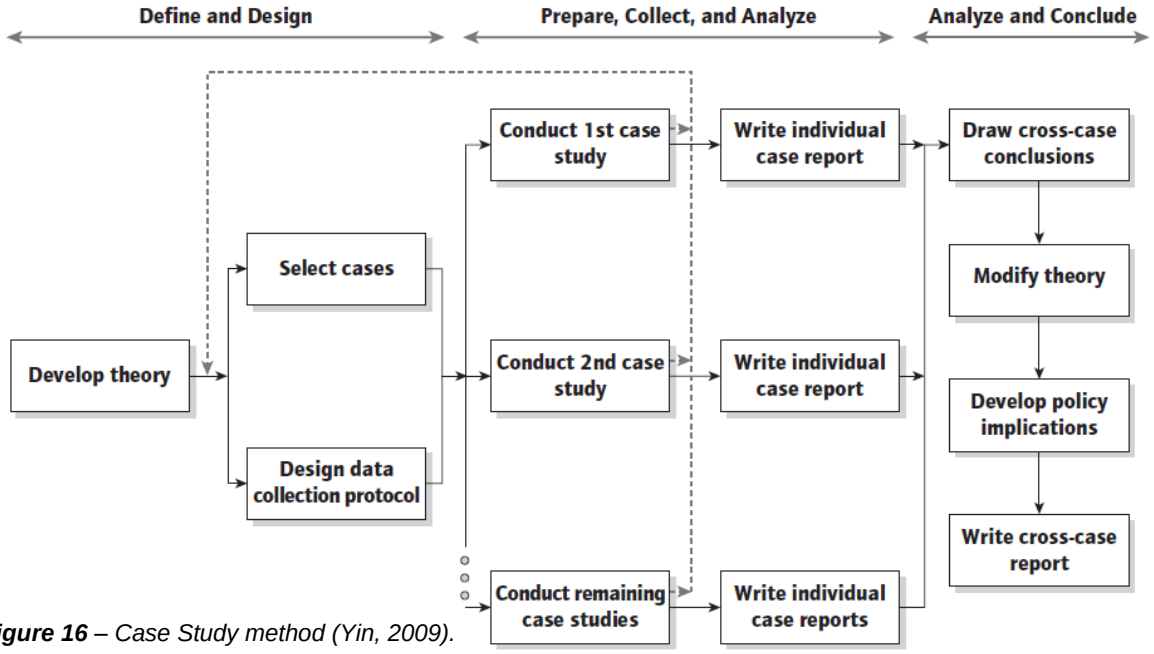


Figure 16 *– Case Study method (Yin, 2009).*

4.2.3 Data collection

The data collected in this thesis is of primary nature, derived from cases via reports of collaborating organisations and experiences from actors in the cases. Six stakeholders per case are approached for an interview to obtain this data. Examples of these interviewed stakeholders are general contractors, architects, developers and clients (see Appendix A for an overview of interviewed stakeholders). Next to this, secondary data was used in the case writing via sources like (newspaper) articles, web pages, summaries and books to frame the issues. Lastly, academic literature has been used for the development of a conceptual framework and as input for the tool development process.

4.2.4 Selection of cases and reporting

Case studies in the domain of CE and the built environment are selected based on their position in the real estate lifecycle. Circular building involves circular design principles at the start of the lifecycle of a building. Circular building also looks at the end-of-life of a building around demolition where materials should be captured in order to re-use, or recycle them again. This is why the case studies should involve projects that apply circular practices in different lifecycle stages: a newly built project, a renovation project and a project that demolishes a building in a circular way.

The case studies therefore firstly include Park 20|20 in Hoofddorp, that was newly built based on C2C principles (Park20|20, 2015a). A second case is the renovation of Alliander in Duiven, where a complex of existing buildings was renovated with the ambition of 80% circularity of resources (VW Vastgoed, 2015). And thirdly, the Heerema head office building in Leiden, that was the first BREEAM-NL certified demolished office building (Delta Development Group, 2014). The cases and their location (all in the Netherlands) are depicted in Figure 17 on the next page and will be introduced in Chapter 5.

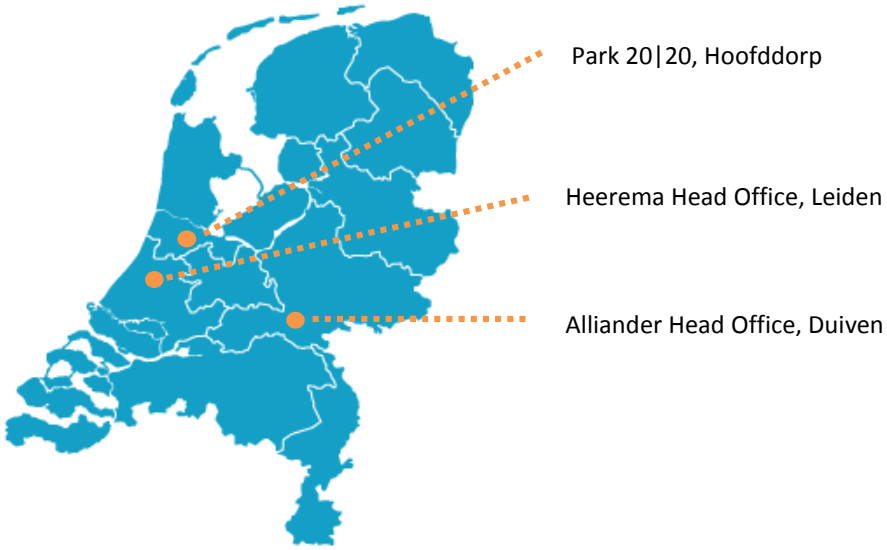


Figure 17 *– Location of the 3 case studies*

With regard to the case description in Chapter 5, these are organised in the following way:

1. Introduction of the case and background regarding the vision and ambitions and the technical ways to implement these.
2. A description of the process along the stages of the real estate lifecycle (see Figure 18 that is based on Figure 10) including a timeline of the process and a description of the project organisation.
3. An analysis of the case in terms of (1) actor network and collaboration, (2) vision aspects, (3) higher order learning, (4) business model aspects.
4. Conclusions and discussion on the supply chain collaboration involved, linking back to the conceptual framework of Figure 15.

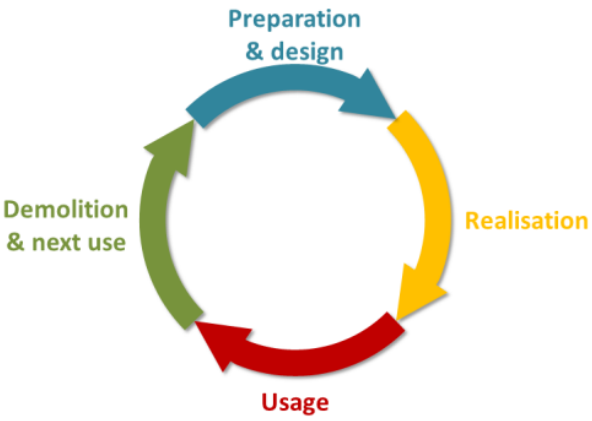


Figure 18 *– The real estate lifecycle.*

5. Innovative Circular Building Projects in the Netherlands: Circular Supply Chain Collaboration by Case Results

The three circular building projects that were selected in this thesis will be explained along their supply chain collaboration in this chapter. This analysis is based on the four main concepts in the conceptual framework of visions, learning processes, actor networks and collaboration & business models. Section 5.1 describes the case results for Park 2020, section 5.2 shows the result for the renovation of five existing office buildings for Alliander and the Heerema Head Office case results will be described in section 5.3.

5.1 Park 20|20 – Newly built Cradle to Cradle® inspired business park



Figure 20 *– Masterplan Park20|20 (DTZ Zadelhof, 2014a).*



Figure 19 *– Park20|20 (Arizona State University, 2015).*

5.1.1 Introduction

Park 20|20 is an offices park in Hoofddorp, the Netherlands (Park20|20, 2015a). It is based on the Cradle to Cradle® (C2C) philosophy of McDonough and Braungart (2002). The masterplan provides an offices area with closed cycles of water, waste and energy and sustainable buildings based on flexible working (Agentschap NL, 2012; Mak, 2013). The site combines facilities to support this office environment like sport centres, hotel and catering industry and a kindergarten. Most innovative in the building and development process of Park 20|20 is its inclusion of the end-of-use options of buildings right from the start. All materials in the buildings established have their resources passports (Damen, 2012). This allows for tracking the materials and their corresponding residual value. Moreover, where possible, suppliers of these materials still own the materials, urging them to come up with high quality solutions that can easily be disassembled. In this way material value can be regained at the end-of-life of a building. Examples of these materials or components are the LED light system, solar panels and office equipment (van den Broek, 2015). All suppliers moreover have to pass C2C criteria that are strict on toxicity of materials. The combination of natural (or at least non-toxic) materials and a human centred design approach make for a healthy indoor climate that supports the activities of employees. Finally facility management is an important factor in the park concept: facility managers guard the working of the total system by managing water, waste and energy cycles and greenery (Bekkering, 2012).

Vision

The vision of Park 20|20 is to develop the first full-service C2C inspired business park (Zachariasse, 2015). Buildings are created based on a human centred design approach to realise productive, clean and inspiring work environments (Park20|20, 2015a). This is linked to the C2C vision of reframing design as a positive force looking for opportunities instead of minimising damage and negative impacts (Park20|20, 2015a; van Tuijl, 2015). C2C in the built environment aims to increase value and stimulates innovation in all use phases of buildings. It evolves around three main principles: (1) waste equals nutrients, so buildings have to be designed to be disassembled to reuse their materials or safely return them to soil, (2) use renewable energy for the activities that need this energy in a built construct, (3) celebrate diversity by adapting designs to the unique characteristics of a place (Park20|20, 2015a). This diversity in turn evolves around three types of diversity: biodiversity, cultural diversity and diversity in design (Zachariasse, 2015).

C2C at Park 20|20 is translated into the vision of a building that can be the disassembled at the end of its usage phase or functional lifetime. All material value will be released again since it was only **temporarily stored in a building that acts as a material bank**. This aspect of the vision will also be central in the analysis of the vision in section 5.1.4. This vision is further developed into several starting points (McDonough & Braungart, 2011). The first of these focus points is 'Harmony and Interdependence' with the aim of Park 20|20 to be a life-supporting system in harmony with energy flows and living beings. Healthy interiors are another aim for the park, actively supporting the well-being and health of all occupants. The park moreover focuses on materials as nutrients. This is done by using processes and products that can safely return to soil or to industrial sites for reuse at highest quality levels. The park site moreover uses renewable energy in quantities that meet or exceed the project's needs. Finally continuous improvement is aimed for: as Park 20|20 is completed over time, it will increase its ambitions (McDonough & Braungart, 2011).

> *"The aim is to create buildings that function as material banks (…) and to get to a 100% C2C building. It goes as far as that within 50 years we would be able to remove the park without leaving anything behind."* – Grosfeld, 2015.

Project specifications

The project involves the following main characteristics:

Project factor	Project data
Size	11,4 ha
Programme	• 89.000 m2 for a total of 13 office of which the following 7 are established: 1. Bosch Siemens Huishoudappatuur (BSH) 2. FOX Vakanties 3. FIFPro 4. Delta's own Experience Centre 5. Bluewater Energy Services 6. Plantronics 7. NOW Building – multi tenant office building • 3.700 m2 facilities: Park café, green houses, sporting facilities, dry cleaners, super market, kindergarten, biological and technological pavilion • 1.400 parking places
Budget	Investment value: € 300 million
BREEM-NL score	Basically BREEAM Excellent (although buildings were built after each other and have been certified separately)

***Table 14** – Project specifications Park 20|20 (Mak, 2013; Park20|20, 2015b).*

Several technical solutions and innovations have been applied at the park site. The energy system is an integrated thermal energy storage system that is used by all buildings – allowing for efficient heat and cold cycles (Mak, 2013). The thermal energy can be used for low temperature floor heating and cooling. Additionally a part of the electricity demand is supplied by renewable energy sources like PV panels and some wind energy (Park 20|20 C.V., 2011). The park moreover uses a central water system where rain water is used for sanitary purposes and where a helophyte filter system filters grey water (Park20|20, 2015b). Green roofs and green (indoor) walls have been applied. The roofs allow for additional water storage while the green walls improve the work environment for employees and make sustainability visible in the buildings (Grosfeld, 2015). The park uses as much as possible C2C certified materials. This indicates that the design could be disassembled and all individual parts of products are scanned throughout the whole supply chain on toxicity (Zachariasse, 2015). Part of the C2C certification also deals with recycled content: around 75% of all concrete and steel applied in the buildings is recycled (Mak, 2013). Moreover, 30% flooring material is saved by using hollow SlimLine floors (Park 20|20 C.V., 2011). Park management finally plays an important role: they make sure as many 'waste' cycles will be closed or actually reused again (Park20|20, 2015b).

5.1.2 Process and project description



The process development of Park 20|20 can be traced back to 2000 when the three initiating parties – Delta Development Group, Reggeborgh Group and VolkerWessels – worked on the redevelopment of the Fokker aircraft factory close to Schiphol. They developed a plan for this location with logistics and offices (Bekkering, 2012). It was noted that demand for logistics was increasing while demand for offices decreased because the office market was saturated (Zachariasse, 2015). At the same time the municipality of Haarlemmermeer discussed the possibilities of shrinking the total area of offices in the region. The three developing parties at the Fokker location decided to ask the municipality for an exchange: if the offices area at the Fokker location could completely be turned into logistics, they would claim the location South of the Hoofddorp station for offices development (Bekkering, 2012). This became the park site where a special concept had to be realised. From that moment on Delta Development Group started to brainstorm about concepts to apply at this site.

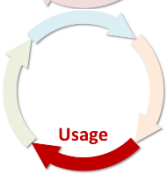
Around 2004, Delta Development Group wanted to collaborate with an American architect in a tender for Microsoft. They got in contact with C2C founder William McDonough and his architectural practice after watching the documentary 'Afval is voedsel' (Zachariasse, 2015; Bekkering, 2012). Although they did not win the collective tender for Microsoft, at that point Coert Zachariasse and his Delta Development Group were inspired by the C2C concept and committed to make this work in the Park 20|20 area:

> *"So then we break back into our own world, into our own office and Coert [Zachariasse] into his back garden and in his back garden he wrote the whole concept of Park 20|20. And then he got Bill [McDonough] on the line and said: this is what I would like to do"* – O. Zachariasse, 2015.

After the masterplan was finished and the local government supported the project, Zachariasse went to McDonough in Charlottesville (USA) at the beginning of 2008. He had one burning question for the founder of C2C: how to bring this concept into practice (Bekkering, 2012). It turned out even McDonough had to admit the ambition level of the masterplan had never been realised before: what Zachariasse wanted basically was not possible (de Kort, 2013). It was then decided to start and see how far they could get the concept in reality. One of the issues was the implementation of reversed logistics where suppliers need to take back their products at the end-of-life of a building (Bekkering, 2012). This incorporation of the functional lifetime is one of the aspects the C2C certificate covers, so Delta together with general contractor IBB Kondor put together a list of potential C2C suppliers and subcontractors (Grosfeld, 2015; van Steijn, 2015). To these firms they explained the C2C concept and they challenged them to come up with products that came close to it (Agentschap NL, 2012). Then they started testing these products together with McDonough Braungart Design Chemistry (MDBC), a company jointly owned by McDonough and Braungart (Bekkering, 2012). Based on the test results Delta and IBB Kondor had a clear proposal to the parties that (almost) met the C2C criteria: joining the Park 20|20 innovation programme when continuing their innovation and certifying according to the C2C criteria. This innovation programme in turn provides them a position as preferred supplier and it offers opportunities to develop knowledge, new business models and partnerships. At this moment 28 companies are part of this innovation program (Agentschap NL, 2012). These developments are quite demanding however:

> *"The process is more complicated, but it will deliver so much more in the end (..) You see people getting enthusiastic when you get them out of their traditional thinking patterns by persisting it is possible and it delivers additional value"* – C. Zachariasse in Mak, 2013.





From the first meeting in 2008 onwards, McDonough was intimately involved as lead architect in the design of the masterplan and all buildings. Together with a Dutch architectural firm and in collaboration with all other building disciplines (here: developer, general contractor, building installations advisor, interior designer and technical installations) the design for the park and its buildings was finished in 2010. After this preparatory phase that lasted from the negotiations in 2000 until the publication of a vision booklet in 2010, the realisation could begin. On April 29, 2010 the development of the first building officially started (Park 20|20 C.V., 2010a). The client of this first building was household appliance manufacturer Bosch Siemens. After this first building five additional offices were built for private clients together with pavilions, Delta's office, a park café, an experience centre and the overarching park development as described in Table 15. At this moment the park is in use while some buildings are still in development. Facility managers are involved in the usage phase around park management.

Time period	Activities
Preparatory phase	
Around 2000	Start of negotiation of parties Delta, VolkerWessels and Reggeborgh Groep with Municipality of Haarlemmermeer about the current location.
2004	Delta meets William McDonough in a collective tender – start of C2C development within masterplan (Park20|20, 2015a).
End of 2007	Declaration of intent between Park 20|20 C.V. and municipality cv to develop C2C offices park (Wessels, 2013).
Beginning of 2008	Meeting between Delta and William McDonough in Charlottesville to make an agreement about implementation and design (de Kort, 2013).
	Establishment of list of 75 suppliers and sub-contractors that could (potentially) meet C2C criteria; request to develop innovative products.
2009	Scan of indicated products for C2C criteria with the firm MDBC.
2009	Proposal for suppliers and contractors: joining the innovation program when they would go for C2C certification. This led to a pool of 28 suppliers.
Beginning of 2010	Publication of a vision booklet (McDonough & Braungart, 2011)
Realisation phase	
April 2010 – November 2011	Realising the Bosch Siemens building (Park 20|20 C.V., 2010b).
April 2010 – December 2011	Building parking garages (Park 20|20 C.V., 2010a)
January 2011 – December 2012	Building central systems like thermal energy storage (Park 20|20 C.V., 2010a)
March 2011 – June 2012	Realising the FOX Vakanties building (Park 20|20 C.V., 2010c).
October 2011 – May 2012	Building of biological and technical pavilion, park café, office Delta and Experience Centre (Park 20|20 C.V., 2010c).
End 2011 – December 2012	Realising the FIFPro building (Park 20|20 C.V., 2010d).
April 2013 – November 2014	Realising the Bluewater building.
May 2015 – current	Start building Plantronics Head Quarters (7th client at the park) (Park20|20, 2015a)
July 2015	Design for NOW building: multi-tenant office building.

***Table 15** – Timeline of the development of Park20\|20 (based on Bekkering, 2012 - except indications).*

Project description

The project organisation for Park 20|20 in the realisation phase consisted of an overall limited partnership between Delta Development Group, Reggeborgh and VolkerWessels. Buildings are developed out of this partnership under a maintaining private company, called Park 20|20 C.V. (van den Broek, 2015). Per building a dedicated construction team (or 'bouwteam' – see also section 2.3.1) worked on the building development. In this construction team, Delta led the overall development, McDonough took the lead in the design and the general contractor led the realisation. The construction team in this case consists of the following disciplines: developer, architect, general contractor, building installations advisor, interior designer(s) and the installation company (Zachariasse, 2015). All these parties in the team are involved in weekly meetings. The 'construction team model' is used quite regularly in the building industry, but the scale at which this team worked together – both in terms of different disciplines involved and in terms of the project scale and duration – can be called innovative. The constellation of the team changed only slightly per building. The installation company and installation advisor were added later on, but apart from that all team members worked together from day one of the development (Zachariasse, 2015).

Per office building a different tenant was found and a six week workshop series was held with these clients. Aim of this workshop is to get to know clients and their requirements and the other way around: to get clients acquainted with the C2C principles. This is an important innovation in the building process, where *common language* between client and construction team is created. In this phase no contracts are signed, it is based on a simple letter of intent (Zachariasse, 2015). Besides the buildings, the central circulatory systems (also used metaphorically) had to be realised. Examples of these systems are thermal energy storage or water filters. For these aspects separate organisations were set up. Energy services are delivered by a separate limited partnership while park management is handled by an individual Services Ltd. The overall project organisation is depicted in Figure 21.

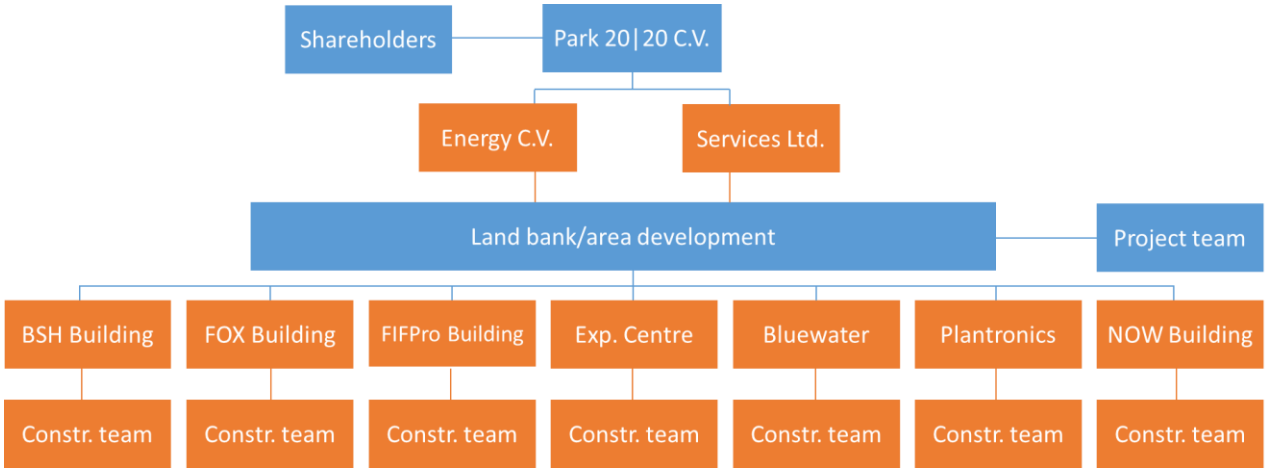


***Figure 21** – Project structure of Park 20|20 (based on van den Broek, 2015).*

Another central element in the project organisation was the usage of a BIM model (see 2.3.6). This evolved over time and started only from the development of the Bluewater building (around 2013). The construction team from then on was organised around this BIM model with even one central room in the office of the general contractor (Zachariasse, 2015). In this way the different parts of the team worked in the same room on the same model. This is essential when implementing the vision where one needs to be able to track all materials in the building. BIM is gaining ground in the building sector, but the application via a 'BIM room' is different from regular building practices.

5.1.3 Analysis: actor network and collaboration

The actor network and collaboration around Park 20|20 will be analysed according to the network composition, a description of resources and activities in the network and the actors involved and their relationships.

Network composition

Park 20|20 brings together a broad range of stakeholders as depicted in Figure 22. The network is as diverse as combining research institutes, governmental actors and private actors among which investors, the construction team, clients, software developers and suppliers. This composition ensures connecting knowledge from different fields. Figure 22 moreover reveals most actors are active in the overall park development (not marked with a star in Figure 22). In the construction team only the interior designers switched per building and this relates to the different clients per building with their own demands for their interiors. Furthermore some suppliers provided materials only per building, while others (e.g. Royal Mosa) provided materials for multiple buildings. Next to this main division, the different subcategories of the network will be explained subsequently.

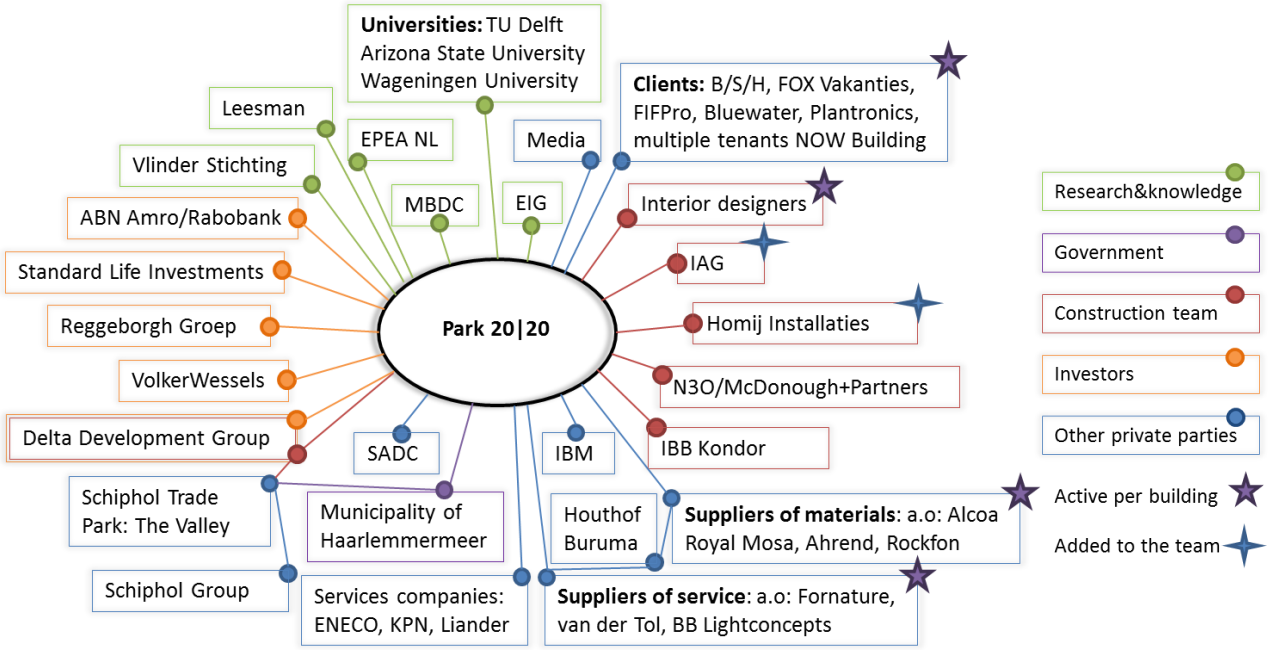


***Figure 22** – Overview of actor network around Park 20|20.*

Research and knowledge actors are involved via collaboration of Park 20|20 with several universities. Arizona State University is involved in assessing the influence of the built environment on employee productivity (van den Broek, 2015). Research agencies MBDC (see process description in 5.1.2), EPEA and Eco Intelligent Growth (EIG) are involved in implementing the C2C concept. They assisted in material tests, certification, material passports and training sessions for suppliers at the park. The experiences of EPEA led to a European research assignment under Horizon 2020 to improve the material passport system (van Tuijl, 2015). The Vlinder Stichting is involved in research around endangered species of butterflies that are now protected at the park (Zachariasse, 2015). Finally research institute Leesman is involved at the park development to measure the impact of C2C buildings on people and productivity.

It was noted that relatively little government actors are active at Park 20|20. The main governmental actor is the municipality of Haarlemmermeer. This seems to be related to the fact that it is a pioneering *private* development.

The actors in the construction team are the ones actually realising the masterplan and involve IBB Kondor as general contractor, Delta Development Group, the combination of N3O and McDonough and Partners as architects. From 2011 onwards, installation advisor IAG and installation company Homij were added to the team and the team moreover contains different interior designers per building. The developer plays a double role since they are also involved in the Park 20|20 C.V. of investing companies. The investing parties bare the biggest risks and among them is VolkerWessels – a concern of contractors of which contractor IBB Kondor and installation firm Homij are also part.

Finally quite some other private parties are involved with two main groups: suppliers of materials and services and clients. IBM is moreover involved in establishing software for tracking materials and 'wise' buildings that anticipate demand for heating or cooling based on weather data and for instance (Zachariasse, 2015). Houthof Buruma is a legal advisor, assisting suppliers in new business models (Zachariasse, 2015). Lastly the Park 20|20 C.V. led to a development called Schiphol Trade Park: The Valley .This is a collaboration between Schiphol Area Development Company (SADC), the municipality of Haarlemmermeer and Delta. This Valley will provide a hub where the Netherlands positions itself as a Circular Economy hotspot in the context of the Dutch EU chairmanship in 2016. This spin-off project mobilises actors from both the public side (e.g. ministries) and the private side (e.g. big corporates and start-ups in the field of CE).

The actor groups are moreover plotted along the real estate lifecycle as explained in section 4.2.4. On the inside of this cycle actors are placed that traditionally already participate in this phase of the real estate lifecycle and on the outside the innovations in the process are visible: these actor groups have been added to the different phases for integration of the supply chain. This overview shows that the process innovated in the preparation & design phase, realisation phase and in the usage phase (Figure 23).

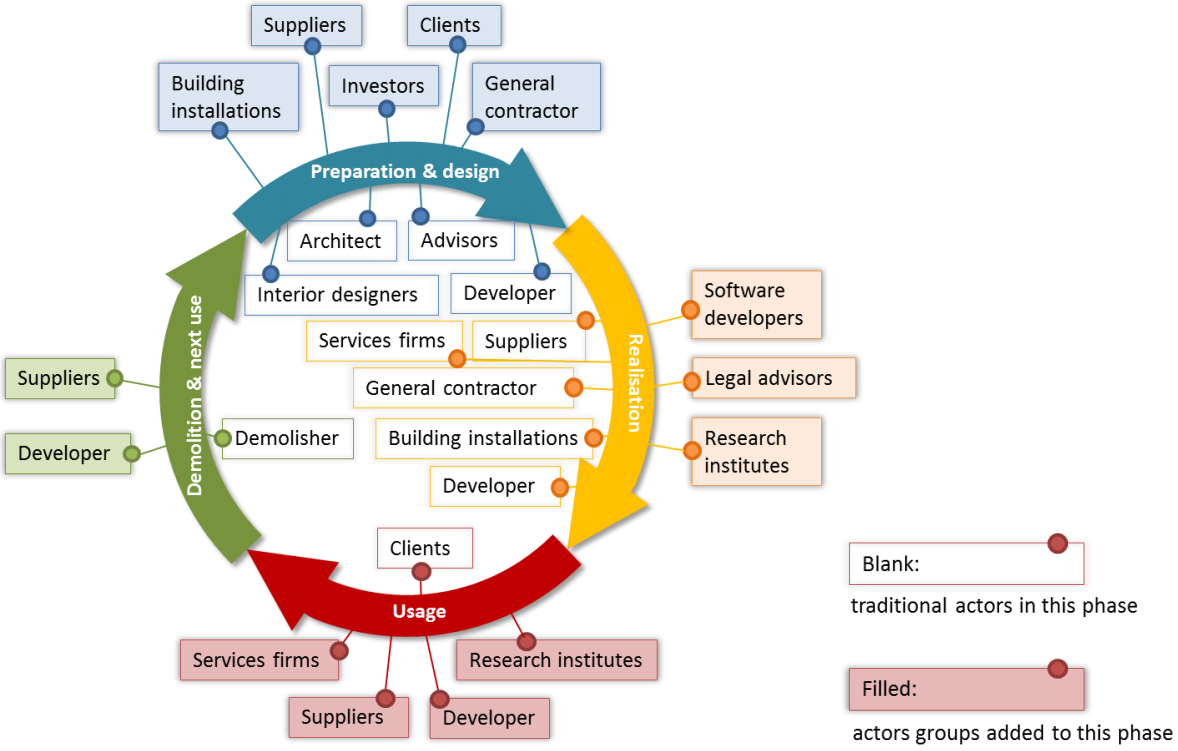


Figure 23 *– Actor groups at Park 20|20 plotted along real estate lifecycle.*

Resources and activities

Based on the industrial network theory two elements in the network are analysed: activities and resources. The most important activity to secure supply chain collaboration is the active **connecting role** of the developer. Developers traditionally already connect different parts of the supply chain, but in this project even suppliers were involved from the start to realise collaboration and innovation. Delta Development Group describes its own role as 'turnkey deliverer' (Zachariasse, 2015). This means they do not only develop office buildings, but provide integral projects with tailor-made interiors. In practice this also means that the developer gets all parties together. These are informal trajectories, resulting in formal trajectories. Connections however develop informally:

> *"One makes a whole supply chain come together. Let's look at steel: from steel suppliers till demolishers, with contractor and sub-contractors, so involve the whole chain. It's remarkable these parties don't get together themselves, but since we initiate, this happens. And then you find out they don't know each other's business models. And the possibilities that emerge when you talk to each other and look at overlap of the different parties these are eye-openers (…) and it starts with communicating and connecting."* – van den Broek, 2015.

Via this new set-up of the preparatory phase where the developer brings the supply chain together, the role of supplying parties and sub-contractors becomes more important. These parties are now actively working on their products, innovating to reach C2C criteria and monitoring their supply chains in turn since this new approach requires transparency. At the same time this means the general contractor sees his traditional purchasing role diminishing since all suppliers are already involved from the start. This has an influence on the general contractor:

> *"If you would implement the vision that is created, we will only be responsible for supplying screws, scaffolding and coordinating the preparation, execution and guidance of the process."* – Warmerdam, 2015.

Next are resources and these can be analysed according to five categories: material inputs, financial capital, technology, knowledge and labour. The material inputs for Park consist of mostly C2C certified materials. This means they have additional benefits in creating a healthy indoor climate for instance. Otaining knowledge about these (user) benefits however requires additional costs. This is demonstrated by Park 20|20 now actively monitoring the impacts of using C2C products (van den Broek, 2015; van Tuijl, 2015). Secondly, financial capital is centred around the three investing parties Delta, VolkerWessels and Reggeborgh Groep. Banks like ABN Amro and Rabobank financed different projects and Standard Life Investments bought some of the buildings (Zachariasse, 2015). Main technologies of importance here (next to standard building technologies) are BIM and software to track the materials in the buildings as developed by IBM. The most important knowledge developed deals with materials and the way they are used. C2C tests and certifications increased material knowledge. The project also contributed to ways to use these materials via design for disassembly. Labour in the park development involves preparational labour around developing the vision, the masterplan and building designs. Moreover the building activities itself are among the labour resources.

Actors and their relationships

Actors involved and their relationships are analysed in terms of (1) strategic elements like corporate focus, (2) collaboration elements like process alignment and (3) cultural elements like trust, information exchange, openness and mutuality. These elements all contribute to successful supply chain collaboration (Barratt, 2004).

> *"And sometimes you collectively turn a complete other way than you initially thought the project would take you. That is collaboration."* – Grosfeld, 2015.

Strategic elements:

A first element in this category is intra-organisational support which is described as the degree of process alignment among both senior management and other parts of the organisation (Ireland & Bruce, 2000). At Park 20|20 it can be analysed that this intra-organisational support was certainly present within the developing party Delta. Delta's CEO actively pursues the C2C goals and aligns his whole organisation and supply chain according to these goals. He moreover communicates regularly with CEO's of the other investing parties VolkerWessels and Reggeborgh. This enables quick decision making at senior level and alignment of vision and action. For other parties in the supply chain, intra-organisational support was not directly present since management of these parties was not

fully convinced from the start. This could change over time however (Kragtwijk & Warmerdam, 2015). This also leads to corporate focus, which was again certainly in favour of collaborating initiatives at Delta. Other parties involved also changed their focus towards collaboration in the supply chain as illustrated by general contractor IBB Kondor:

> *"Because we are working for some years over there in Hoofddorp, you see the whole firm is going into that direction, into working according to that philosophy."* – Kragtwijk, 2015.

Another strategic element is the role of technology that needs to be defined in the collaboration. This was done here via BIM. Using this software required team members to make arrangements on how to use it, since this collaborative digital environment can provide enormous benefits when everyone uses it in exactly the same way (van Steijn, 2015). On a strategic level finally collaboration was also part of the vision: collaboration was an essential part for a C2C park.

Collaboration elements:

Collaboration needs cross-functional activities that enable the exchange of information within or between organisations. In Park 20|20 these activities were present in normal project team meetings, but also in sounding board groups (van den Broek, 2015). These additional sessions facilitated information exchange even more. EPEA moreover provided a training for construction team members and suppliers to foster alignment and empower them to make the right decisions. The setting for collaboration was thus provided, but some team members mentioned they were not used effectively. Not all parties shared their information – especially considering issues in the collaboration itself. Joint decision making and process alignment are subsequent collaboration elements which were present at Park 20|20. All different construction team parties were put together from the very beginning and could (at times) speak to clients directly. This facilitated process alignment and joint decision making in the right way.

> *"We [building installation expert Homij] could have direct contact with clients (in this project). That is new for a sub-contractor, which worked very well."* – van Steijn, 2015.

Performance standards and contracts are last elements to consider here. These standards were present in the C2C concept. This C2C ambition was translated into contracts for both clients and construction team. They thus had to sign to realise the C2C ambition (van den Broek, 2015). Apart from this ambition, no innovative contracting was used. Standard building contracts were applied, but improvements can be made by using DB(F)MO contracts (see 2.3.5).

> *"You always consider installing a more expensive element with a lifespan of 20 years and what this will save you in maintenance costs. So DBFMO contracts, maybe the financing part isn't even necessary, force you even more to consider maintenance at the start around designing installations."* – van Steijn, 2015.

Cultural elements:

Culture is an important aspect of supply chain collaboration and involves amongst others trust. All interviewed actors confirmed trust was present. This was established via various ways. One way was to remove uncertainty by promising all parties involved to realise all buildings together. Especially in times of crisis, this certainty for new assignments opened up room for stress free working and made parties willing to invest more (Zachariasse, 2015). Trust also came into being because of the selection procedure: everyone in the team wants to solve the problem and not create problems for others (Kragtwijk & Warmerdam, 2015). Trust is also important at senior level among the investing parties in the Park 20|20 C.V. The three CEO's of these parties have a history of working together, strengthening the trust in this project (Zachariasse, 2015). Some of the ways to establish trust also link to other cultural elements. The transparent process was named and the clear concept of where the project wants to go. Others mentioned the respect for each other. Openness, transparency and clear and short lines of communication were present (Zachariasse, 2015). A final element is mutuality. Mutual benefits and risks were shared: suppliers and other actors took their responsibility when it considered their product or service (van den Broek. 2015).

> *"The real thing is that you stick with your pick. You pick the person and write it up: for better or for worse. It's like a marriage. All the way through to the end. And of course you are going to hit times where you look at each other and… But you just stick with it. So the team dynamics formed themselves throughout the process."* – O. Zachariasse, 2015.

5.1.4 Analysis: vision aspects

Vision aspects are analysed according to (1) vision image (2) vision guidance and (3) vision orientation via motivation, inspiration and direction (van der Helm, 2009).

Vision image

The image of the vision of Park 20|20 has been analysed in terms of metaphors used and explicitness (van der Helm, 2009). The 'building as a material bank' (as explained in 5.1.1) served as an important metaphor in Park 20|20. This metaphor implies not only technological change around materials, it moreover implies economic and organisational changes. The economic model behind this metaphor should focus on creating and maintaining value, whereas the organisational structure of the supply chain has to facilitate this value maintenance. The vision moreover was made explicit by the publication of a vision booklet 'toward a Cradle to Cradle Park 20|20' (McDonough & Braungart, 2011). Story telling around this booklet was used. The booklet describes the vision and names implementation strategies per element of the vision. The booklet was handed out to management of potential collaboration partners by Delta with the story that they could pass on the booklet to the implementation parts of their organisation. These parts could actively use the implementation strategies named in the booklet. Park 20|20 moreover translated the vision into a roadmap that sketches where the park wants to be in 2020 upon completion and how this can be translated into clear and operable goals (van Tuijl, 2015). The vision thus had two main influencing roles: (1) it aligned actors in the supply chain around the park and (2) the vision also created awareness in the supply chain (McDonough & Braungart, 2011; van Kasteren, 2013). In this way this aspect of the vision is linked to learning processes around problem perception that will be explained in the next section (5.1.5).

Vision guidance

Vision guidance is analysed in (1) clear collective goals, (2) presence of alternative rule sets and (3) leadership (van der Helm, 2009; Quist, 2007).

Collective goals:

The vision of Park 20|20 offers a clear normative goal for actors involved with its vision of a building that can completely be removed. Within this shared goal however, it can be noted that not all actors shared the way the vision was put into reality. The fact that suppliers would still own materials when moving towards implementation of the vision was not shared among contractors for instance. For some suppliers high additional costs were involved. This is why the general concept was an explicit collective goal that could be discussed, resulting in interpretations on ways to implement and finance this (van Steijn, 2015; van Tuijl, 2015; Kragtwijk & Warmerdam, 2015). Collective goals thus guided the actors in their collaboration process.

Alternative rule sets:

The vision contains various alternative rule sets, like changes in our attitude towards complete depreciation of materials, changes in tendering processes and requirements of clients, changes in the supply chain, changes in roles of certain actors, changes in business models and ownership and changes in design paradigms. The vision mainly fundamentally changes our view upon material value. It requires alternative sets of rules around ownership of resources, temporally stored in the built object. These new rule sets in turn have an influence on behaviour and guide decisions; this also relates to forms of higher order learning as will be explained in the next section.

Leadership:

In the Park 20|20 project the vision could be described as authoritative since it was carried by visionary people in the form of William McDonough (C2C initiator) and Delta's CEO:

> *"Coert (Zachariasse) as influenced by William McDonough is without doubt a visionary man and the main source of inspiration for Park 20|20."* – Kragtwijk & Warmerdam, 2015.

Their essential role in the visioning process was confirmed by five out of six interviewees. The way these two people create this 'authoritative tension' (van der Helm, 2009) is different. It can be argued that McDonough derives his

leadership from historical records as he initiated the C2C concept and built C2C projects already. Zachariasse on the other hand firstly has the position within Delta to derive his leadership from. His leadership secondly draws on his large-scale involvement in the process. For a developing party in an economic downturn it indeed takes guts and leadership to just pursue in the realisation of a vision. This is a direct example of influencing behaviour via guidance.

Vision orientation

Vision orientation includes the vision's provision of motivation, inspiration and direction. The vision of Park 20|20 certainly served a motivational purpose. Other actors in the construction team were attracted by the enthusiasm of Delta and McDonough and started the ambitious project. Motivation was mainly visible in the fact that a team was built of enthusiastic people that wanted to be part of the design of the future. Motivation was also established at clients by means of a six week workshop on their requirements and how these link to C2C. Clients in this way need to buy into the vision of a C2C building (Zachariasse, 2015). Inspiration was present as well since participating actors believed that realising the vision was possible. This inspiration however needed time to establish:

> *"It is going to take your general contractor or your construction company approximately three years to understand what it is you are trying to do."* – O. Zachariasse, 2015.

The vision of the park moreover provided direction for actors involved on what to do. Different disciplines used the vision in their activities. The developer used the vision to select its collaboration partners like research institutes, material suppliers and service providers (Zachariasse, 2015). For the technical oriented parties like an installations advisor or constructor, the vision was used to make choices about materials to use that keep their value and can be demounted easily. Parties that are more focused on the economics (e.g. investor or bank) used the vision to investigate the consequences for the supply chain, business models and investment strategies. The vision moreover led to carrying out assessments based on the assumptions in the vision about healthy interiors or productivity of employees (Zachariasse, 2015). In this way the vision did not only direct the interactions of the actors involved directly, but also outside of this construction team in directing investment practices or research programmes, giving material reality to the vision. This is also related to higher order learning that will be described in the section below.

5.1.5 Analysis: learning

Based on Brown et al. (2003) and Brown and Vergragt (2008) this analysis focuses on higher order learning in terms of (1) a shift in defining or framing problems and their perceived coupling to technology/society; (2) a shift in problem solving approaches and shifting priorities; (3) changing dominant interpretive frames: shifting joint opinions among actors involved. Next to these aspects of higher order learning, first order learning certainly occurred among the individual actors. Examples of this first order learning are for instance additional knowledge about certain materials (Kragtwijk & Warmerdam, 2015), or circular value propositions that can be applied (van Tuijl, 2015).

Higher order learning: framing the problem

The Park 20|20 project created awareness among actors in the Dutch building sector about environmental impacts of buildings and their components. The C2C certification procedure (see section 5.1.2) revealed the environmental impact for instance. Before, the building sector related sustainability of their materials and products to recyclability or lifespan for instance, but they left the impacts of their supply chain and those that occur at the end-of-life of a building outside their problem boundaries (Kragtwijk & Warmerdam, 2015; van Steijn, 2015; Zachariasse, 2015). So this is a major example of shifting the framing of the problem at hand. It is also related to the vision aspect of influencing thinking as explained previously. Another shift in framing the problem and its perceived solution is the opportunities of the C2C approach that became apparent. Starting from a team of mainly traditional thinkers that see sustainability as expensive, this shifted to a driven team looking for innovative and financially sound solutions. This is reflected in stakeholders focussing on value creation instead of profit maximisation: they now see the contribution of reusing materials (van Steijn, 2015).

> *"I learned a lot and became aware of our impact. We used to do projects based on what was out there and now you basically look at value creation. Are the resources you use recycled? And if you apply plastics: is it recycled or virgin? So this is about awareness of the process."* – van Steijn, 2015.

Higher order learning: shifting problem solving solutions

The project revealed that working with circular principles requires a multidisciplinary approach involving all different disciplines in the team from the very beginning of the project (Zachariasse, 2015). This can be considered a shift in problem solving approach. The team experimented with this approach, so improvements were named: even more knowledge of all disciplines can be integrated upfront. Actors moreover mentioned they learned to look in a different way to their designs and broaden their scope. Whereas in the past they only represented their own discipline in collective meetings they now also started to think about exploitation costs (Kragtwijk & Warmerdam, 2015). This can be considered a shift in priorities since it means actors are now willing to invest more initially to save costs on the long term. This is visualised in Figure 24, where two approaches are plotted that try to create environmental benefits. The eco-efficiency approach is the traditional approach towards sustainability of diminishing negative impacts. This approach can show impacts in the beginning – the steep increase at the start – but it will never reach a 100% sustainable situation. Eco-effectiveness on the other hand is aimed for in the park development. This approach initially needs investment, visualised by the initial 'dip' in the eco-efficient pathway in Figure 24. Time and money need to be invested here to learn what it is to do the right things (Zachariasse, 2015). Zachariasse (2015) moreover explains how the learning process secured the steep increase in this eco-efficient approach: when actors were working on the second building in the park it came together. At that point the process was optimised via BIM and production costs were lowered, while the quality of the buildings outperformed the market. This difference is wat Delta Development Group and McDonough + Partners call market leadership.

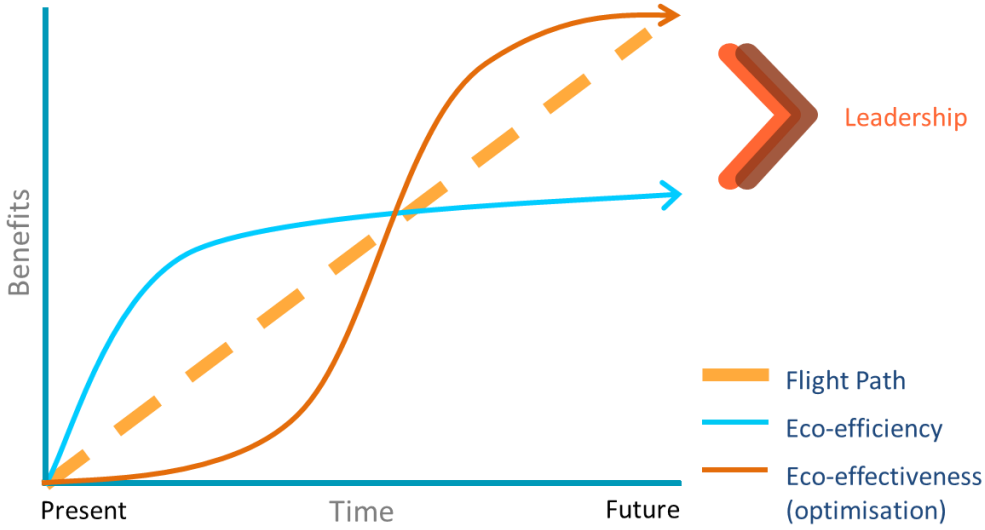


Figure 24 – Eco-efficiency versus eco-effectiveness (William McDonough + Partners, n.d.)

Higher order learning: joint learning and joint opinions

At the third level of dominant interpretive frames actors learned as well. They all mention interpretations change drastically. This shows agreement or at least congruence was reached in the team about pursuing the goals of the C2C concept. In this way this type of learning partly overlaps with vision aspects of influencing behaviour. The learning that was achieved can best be illustrated with an example from the general contractor mentioning the C2C philosophy is now part of their DNA (Kragtwijk & Warmerdam, 2015). When they visit other contractors they notice that they think differently and others do not understand why they are working on designs that can be disassembled for instance. This joint learning is moreover embedded in the innovation program of Park 20|20 for suppliers and service providers. Learning from each other and innovating collectively are important themes in this program.

"So we all started at square one and learned together and grew together" – O. Zachariasse, 2015.

5.1.6 Analysis: Business Model

Based on the review of BM concepts in Chapter 3 the business model of Park 20|20 is analysed according to (1) value creation, delivery and capture; (2) BM innovation; (3) collaboration as part of the BM; (4) a reflection on the implementation of the initial ambition with regard to value creation as a future improvement of the BM.

Introduction: value creation, delivery and caption

Central in the value creation of Park 20|20 are high quality office buildings with low energy costs (environmental and economic value) and a healthy indoor climate (social and economic value). Over time the value of the building as a material bank is secured since Delta owns the buildings and the materials that are stored in there, whenever suppliers have no tack back mechanisms. The *expected residual value* of the materials is part of the balance sheet of Delta (van Kasteren, 2013) which is completely new in the building sector.

"It's about turning negative remaining value of a building into positive one." – Zachariasse in de Kort, 2013.

Value creation is the main activity for the developer, as opposed to traditional profit creation as depicted in Figure 25. This figure shows the trajectory from underlying values, via several steps, to value creation. In this way the development starts from quality instead of quantity. The developer thus creates and captures value, but for clients in the offices value is created as well. Although the rent for the offices is around € 100.000 per year above average, clients can earn this back via savings on employee absence. Because of a healthy indoor climate and green surroundings it is expected that this can contribute considerably. This relates to high employee costs are high within many organisations. Even if employee absence can be reduced by only 1%, this can save a company up to € 300.000 per year (Wessels, 2013). When comparing to the extra costs for rent this still results in net savings for clients at the park that on top enjoy healthy employees. This hypothetic example is backed-up moreover by findings of the World Green Building Council, presenting the following typical division for business operating costs: 90% staff costs in salaries and benefits, 9% rental costs for buildings and 1% energy costs (Alker, Malanca, Pottage, & O'Brien, 2014).

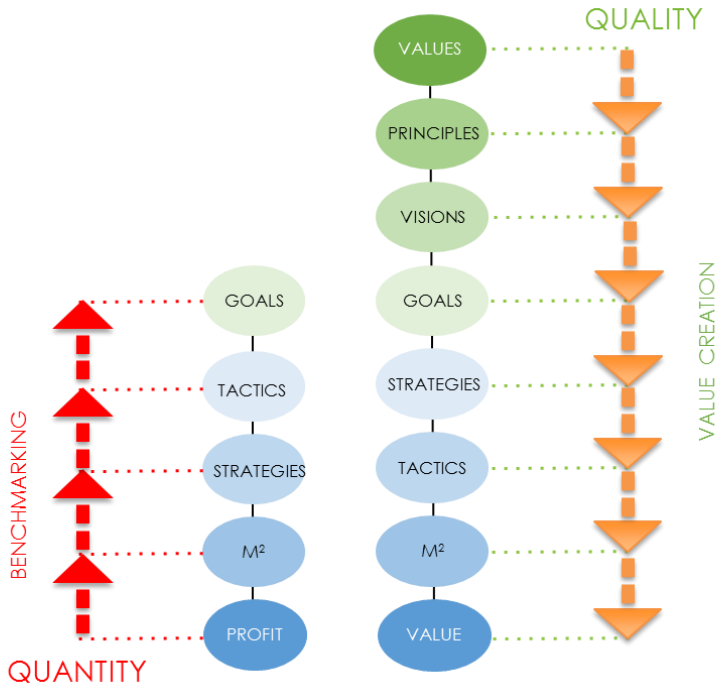


Figure 25 *– Comparing traditional development to value creation (From Values to Value™ and concept McDonough Innovation, LLC, 2015).*

The developer uses different scenarios to capture value. Whenever the building can be rented to a next client without significant additional investments, the building will maintain its highest value. In a second scenario the building can be stripped to the main construction elements to be reused in a new function. This requires a building designed for flexibility since only then you can capture value covering for the costs of renovating (de Wit, 2013). The third scenario is related to the second one, without adding the new function. This means dismantling the whole building and reusing all components. The fourth and final scenario is selling the materials as resources. This is only possible when disassembly costs are lower than current standard demolition costs and one possesses a detailed inventory of all the materials. Without this inventory (material passports) you end up with a negative value: demolishing costs – the current situation in the building sector. Park 20|20 thus uses several value caption mechanisms within design and materialisation.

BM Innovation

Based on the introduction above the main BM innovations will be compared to the strategies for CBMs of Chapter 3. This will be done for both the perspective of the developer and the perspective of the supplier that takes an important role in the vision of the building as a material bank.



***Figure 26** – Park 20|20 BM Innovation (based on Zachariasse, 2015).*

For the developer four main innovative circular strategies can be distinguished (Figure 26). The first is about maximising value per square meter (Zachariasse, 2015). This means the developer offers his client a building with less square meters than he initially asked for. The developer then invests half of the money saved for this smaller building back into additional quality while the client can keep the other half. This strategy is an example of maximising material and energy efficiency in the technical business model archetype of Bocken et al. (2014). Within this archetype maximising value per square meter can be described as increasing functionality by reducing the spatial needs of the client and as dematerialisation. The second strategy of the developer is related to maintenance costs. These costs are optimised by using products of service or rental contracts for e.g. lighting or furniture (Zachariasse, 2015). These contracts result in lower maintenance costs per month for clients, because suppliers are now responsible for maintenance. This is an example of one of the social BM archetypes (Bocken et al., 2014): deliver functionality rather than ownership. In Park 20|20 result oriented functionality (pay per use) is used together with use oriented functionality (lease contracts) and product oriented functionality (extended maintenance and warrantees). The third strategy is a focus on people and productivity (Zachariasse, 2015). As explained, the main finding is that a healthy indoor climate via air quality, (green) views or ergonomics, employees will be more productive. This can be considered an example of an organisational BM archetype. The developer repurposes for society by regenerating social values. The fourth and final strategy is the material banking concept itself translated in C2C materials. C2C as an overarching concept focuses on all three technological BM archetypes (Bocken et al., 2014), but the building as a material bank has a special focus on creating value from waste.

Next to these four main strategies another innovation from the developer side considers the way the park incorporates facility management around water, waste and energy to close cycles. The establishment of an Energy C.V. and Services Ltd. (see also Figure 21) is very different from regular building projects. The scale of the project facilitates this structure. The facility managers united in these separate structures were moreover involved from the beginning during the design of the project to secure optimal functioning of the total system at the park (Bekkering, 2012). This can be considered an example of an organisational BM archetype around alternative ownership.

> *"It's much more of a mass customization high quality model instead of a mass production low quality cost model".* – O. Zachariasse, 2015.

For suppliers several strategies can be distinguished for products applied. Van Tuijl (2015) mentions a 'cascade of circular value propositions'. This cascade coincides with the CE business and design strategies in Table 2 and Table 3 in Chapter 2. Looking at the technical strategies, van Tuijl (2015) explains for the lighting system it starts with flex use of materials. This requires products to be designed for disassembly, an example of slowing down resource loops via durable designed products. Next comes lifespan extending maintenance followed by refurbishing, both examples of slowing down resource loops via design for product life extension. Then one moves to component recycling and material recycling as part of design for a technical cycle in closing resource loops. So before you go into what we now call recycling you have completed four circular stories already (van Tuijl, 2015).

Next to these technical practices, the lighting system operationalises this via three business strategies. First is the traditional way: just pay for the lighting system. The second model is called 'pay per lux' which is an example of a performance model slowing down resource loops (see Table 3). Thirdly a contract is offered that guarantees a buy back for the materials. This is an example of strategically closing resource loops via reverse logistics.

Collaboration as part of the business model

Collaboration is not directly part of the BM of Park 20|20: no incentives were used to reward actors if they collaborated well and reached collective goals (Grosfeld, 2015). The project approached it from the other way: targets around C2C were leading and they guided the team in their collaboration (Zachariasse, 2015).

Reflection on used business model

When comparing the implementation of the initial 'positive impact' ambition, quite some value is created. During the project however the complexity of the ambition was discovered (van Tuijl, 2015). Still some possibilities for improving the value creation were thus named as indicated in Table 16:

Technological			Social			Organisational		
Optimise material & energy efficiency	Create value from waste	Substitute with rene-wables	Functiona-lity over ownership	Adopt a steward-ship role	Slow consump-tion	Co-creation	Repurpose for society/ environ-ment	Develop scale-up solutions

***Table 16** – Future improvement areas for the Park 20|20 BM.*

On the technological side, the material banking concept (enabling the creation of value from waste) can be improved. Further research is needed in either monetising future value now or selling the ability to make better informed decisions in the future (Zachariasse, 2015). Moreover the concept needs additional software support. This software has to integrate the changing values of materials over time, different timeframes of materials added to or stripped from the building and changing impacts of materials on people and the environment (van Tuijl, 2015). Park 20|20 is working on this in collaboration with IBM (Zachariasse, 2015). The software also needs to generate different output for different stakeholders having their own informational needs. Lastly it was noted that the current situation around C2C suppliers needs improvement, since still a limited number of suppliers is certified. This leads to a situation with little to no competition, while this is essential when you want to scale these projects (Grosfeld, 2015).

The next improvement considers the organisational side of repurposing for society. The people and productivity values in the designs for Park 20|20 require additional research. The relation between all the measures that have been applied and the actual impact on people and their productivity is now measured at the park. With more understanding of these relations the future designs can improve (Zachariasse, 2015).

A final social improvement relates to adopting a stewardship role. The concept of the park started with radical transparency about environment and social impacts. This is embedded in the C2C certifications, but since still relatively few materials are certified, more value is to be created around this radical transparency.

5.1.7 Conclusions and discussion

Looking at the four different concepts analysed in this case and their contribution to circular supply chain collaboration, it can be concluded that they all had their share at Park 20|20.

The **network** or supply chain is diverse and the project led to follow-up activities in both R&D (research into productivity and building materials) and new developments (The Valley). Actors are organised in the construction team. The most important activity regarding supply chain collaboration is performed by Delta via connecting all parties in the supply chain and stimulating innovation. Resources were mobilised and for material resources C2C products and materials were used. With these C2C products the developer hopes to realise high quality sustainable buildings. Since the project initiated C2C certification, which had to start from zero, the materials can only be sourced from a relatively small pool of suppliers. Looking at actors and their relationships, for the cultural elements in the conceptual framework (see Figure 27), it can be concluded that trust, transparency in information exchange, openness and short lines of communication were present. Trust was established by providing certainty to actors involved to be part of the team for the next building to be built. This lead to a collaborative and stress free working environment. Moreover, the investing parties have a historic reference of working together, facilitating trust. When looking at collaboration elements, these were supported as well via process alignment and joint decision making. For the strategic elements it can be concluded that collaboration was part of the vision. Moreover corporate focus on collaboration (gradually) developed and the BIM technology greatly supported supply chain collaboration.

Learning and vision aspects are related as explained in the previous analysis. The **vision** of Park 20|20 had its influence via the strong metaphor of the building as a material bank (BAMB). The image of the vision was strengthened by its explicitness via a vision booklet and roadmap. The vision booklet was spread by means of storytelling. In this way the vision created awareness of the impacts along the complete supply chain around a building. This can be regarded as **higher order learning** about framing the problem (scope is extended to include the end-of-life and reusing materials). The vision moreover provided guidance via collective goals. The vision was also supported by authoritative tension and provided new rule sets to guide behaviour around a new ownership perspective on materials that are temporarily stored in a building. This relates to joint learning on joint opinions. The vision revealed that a multidisciplinary approach was necessary that puts all actors together at the very start of the project to look for overlap and innovation. The vision lastly provided orientation via motivation and direction. Gradually inspiration grew among the construction team as well. This can be considered higher order learning about problem solving approaches. This problem solving approach can moreover be termed multidisciplinary. All different disciplines are integrated upfront in the project to realise the vision.

With regard to the **business model** it can be concluded that it is based on creating and monetising positive impacts. This was established by creating cascades of circular value propositions. Collaboration however was not directly part of the business model and more improvements can still be made.

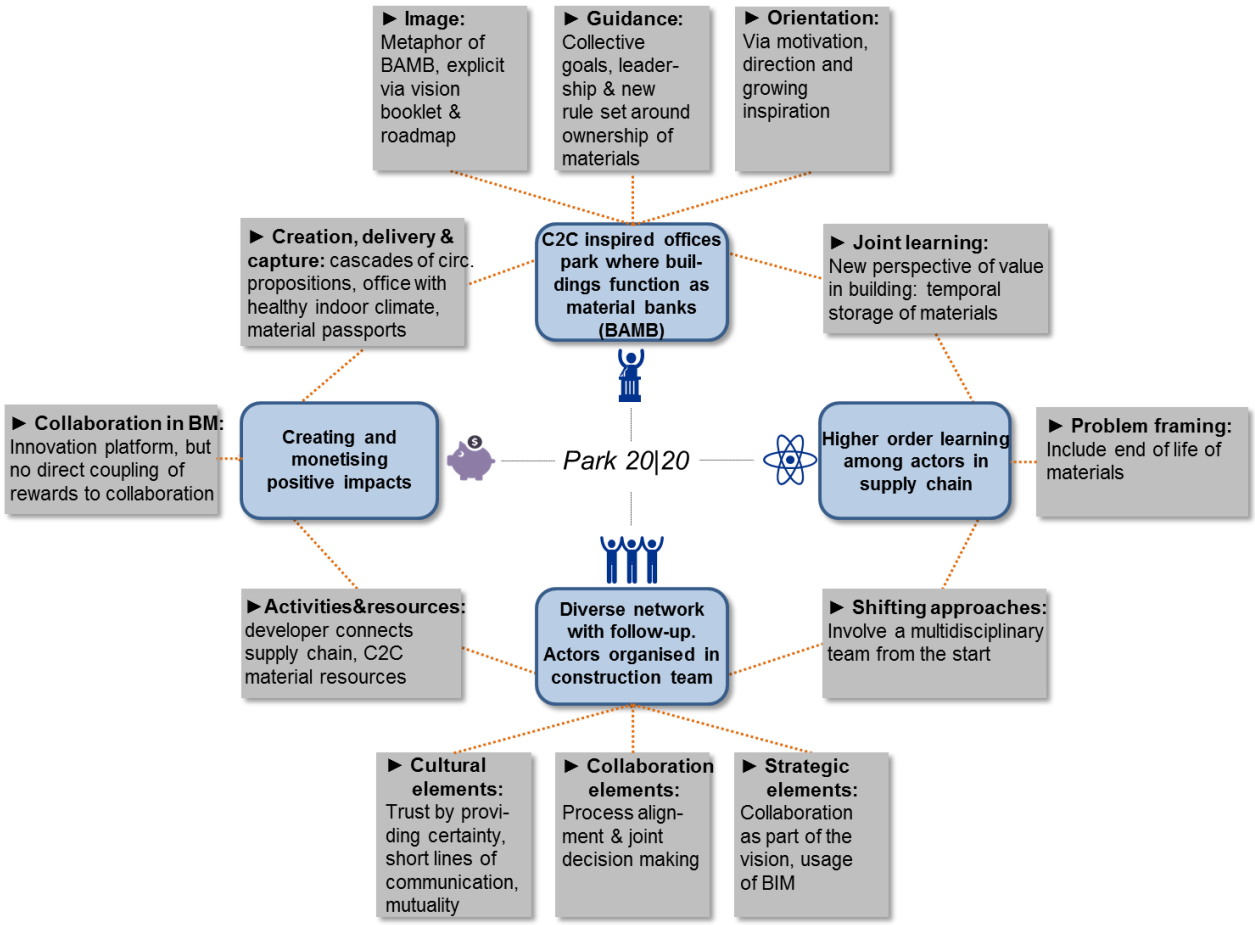


Figure 27 *– Conclusion for supply chain collaboration at Park 20|20.*

5.2 Alliander – Renovation of an existing offices complex



***Figure 28** – Alliander Office (VW Vastgoed, 2015).*



***Figure 29** – Interior Alliander (Fokkema&Partners, 2015).*

5.2.1 Introduction

The energy grid company Alliander showed high ambitions in the creation of its energy producing offices in the eastern part of the Netherlands. It is an almost completely circular renovation project where five existing office buildings were transformed into one sustainable complex (EnergieSprong, 2015). The design for this redevelopment project was established in co-creation with Alliander employees. It resulted in the development of a greenhouse with a 'floating' roof that covers all existing buildings as visualised in Figure 28 and Figure 29. In this way existing buildings were maintained and adapted, leading to one efficient building that benefits economically, aesthetically and from a circular point of view. The complex is CO_2 neutral and self-sufficient in its energy by using only renewable energy sources. The materials used during the renovation were re-used as much as possible.

Vision

In the vision for this project, two main principles are central: **circularity and connection** (Dwars, 2015; van Oppen, 2015). This is derived from Alliander's vision of aiming for a better society in the areas they are connected to (Alliander N.V., 2015; van Zantvoort, 2015). The circularity part is related to the usage of the existing stock and combining existing elements (Niehof, 2015). Waste will be used as a resource again, supply chains will be closed and collaboration will be central (Alliander N.V., 2011a). Connection is important for Alliander since they believe this is key in creating societal impacts and stimulating innovation (Alliander N.V., 2011a). The connection is to be established both within the building (connection between employees) and outside the building (connection with surroundings).

> *"The vision of the project is to realise the existing stock is the basis for the next generations (…) We enlarged the ambitions from the initial assignment and started a dialogue with the surrounding area."* – Dwars, 2015.

These two central themes had to be reflected in three important aspects of the project: the usage of the building, the (realisation of the) building itself and within the surrounding area. This leads to the following six ambitions:

	Circularity	Connection
Usage	1. Sustainable (re) accommodation	**3. Pleasant & suitable work environment**
Building	**2. C2C building and building process**	4. Collaborative building process
Surroundings	**3. Positive energy balance**	**5. Connection with surroundings**

***Table 17** – Ambitions for the project in Duiven (based on Alliander N.V., 2011a).*

During the process (that os explained in section 5.2.2) a selection of four final ambitions for the renovation was made in consultation with participating parties (van Oppen, 2015). These four ambitions are stated in bold in Table 17 and will be explained in some more detail. Regarding circularity, a first ambition is to achieve maximum circularity in the building by reusing as much as possible and by using materials with a closed, ecologically neutral loop (Alliander N.V., 2011a; de Groot, n.d.). This can be reached via C2C principles and a responsible building process. The second circularity ambition is that of a positive energy balance: developing a building and/or area that generates more energy than it needs. This energy needs to be generated in a sustainable way (Alliander N.V., 2011a). Connection is to be realised via the third ambition of a pleasant and suitable work environment. This means creating an accommodation

where alternative workplace strategies can be stimulated. The accommodation should result in a flexible, open and transparent environment focused on trust, knowledge exchange, inspiration and innovation (Alliander N.V., 2011a). The fourth ambition is external connection: Alliander likes to connect with its surroundings and is looking for synergy. Visible measures have to be taken to connect the building and its surroundings (Alliander N.V., 2011b).

Next to these ambitions, one final part of the vision is the **integral approach**: the ambitions have to be balanced in a coherent whole (Emanuel & Rebel, 2015). This integral approach is also part of the process. So on a more abstract level, the vision of Alliander for a technically circular building had to be supported by a circular process and financial model. This aspect is partly based upon the vision of the consulting agency Copper8 that was involved in this process. They see an incentive for collaboration when all three aspects of technical solution(s), process and finances are aligned. They reveal their vision upon the project:

> *"We used the themes circularity and connection. For me personally an additional ambition was to do things differently since you can't create anything sustainable with traditional behaviour"* – van Oppen, 2015.

Project specifications

The project involves the following main specifications:

Project factor	Project data
Floor area of building	25.709 m2 for a total of 1.550 Alliander employees
Programme	• 10.772 m2 offices • 5.487 m2 industrial (labs and workshops) • 5.5333 m2 meeting area and other facilities: education, restaurant
Budget	€ 26 million for (re) development and € 10 million for installations and facilities
BREEM-NL score	BREEAM Outstanding (first Outstanding certificate for a renovation project).

***Table 18** – Project specifications Alliander, Duiven (DGBC, 2015b; Henket, 2014; VW Vastgoed, 2015).*

Looking at the technicalities and innovations at the site in Duiven, numerous solutions have been applied. The most important design aspect applied is the glass atrium that connects the five existing buildings. This creates space and improves the energy performance of the building because large parts of former outer walls now become inner walls (Rau in Henket, 2015). This atrium is made of a steel structure realised by a rollercoaster constructor. Rollercoasters are pre-eminently built for disassembly, using as little material as possible. This saves up to 25% of steel (Henket, 2014). The resulting atrium can be used as meeting space thanks to 'BaOpt': an energy efficient climate system as also used in terminals and swimming pools (Emanuel & Rebel, 2015). Moreover, all additional heat from the office units will be reused in either heating the atrium or it will be stored in a thermal energy well (see below), resulting in 25% of energy savings (de Groot, n.d.). Another energy efficient measure is the application of 'bubbles' with a diameter of 6 to 22 meters in the roof. Air is stored in these bubbles as an insulating layer and the amount of air (and thus insulation value) can be changed according to the weather (de Groot, n.d.).

Another innovation applied is the use of Power over Ethernet (poe). This is a system where alternating current of 220 Volt will be transformed in a central transformer to direct current of 48 Volt. Direct current is needed for all our appliances. Normally every little appliance uses a mini transformer - producing a lot of heat. By using a centralised transformer, the total heat load is decreased while the heat produced in the central transformer can be regained and used again (Henket, 2015). This system moreover allows for using data cables for lighting. In this way only one set of cables is needed for both lighting and data transport. Another result of this innovation is individual climate control: Alliander employees can control their own working environment (e.g. lighting intensity). Employees can be tracked in the building in this system, allowing the facility manager to centralise work and ask employees to work in only three of the five office buildings in the complex if needed (Henket, 2015). This can save additional heating/cooling for the building parts that are not in use. Next to these energy savings mechanisms, the energy itself is generated in a sustainable way using PV panels (a total surface of 11.000 m2) and thermal storage combined with heat pumps (de Groot, n.d.). Duiven moreover makes use of an ESCo (see 2.3.5): consortium partner INNAX is responsible for the energy supply and related maintenance for the coming 15 years (Sijbrandij & Korbee, 2012).

Circularity around materials is crucial on the project site. 90% of the existing buildings is preserved (16.009 m2 of the scope of 17.097 m2 of existing buildings is preserved (Emanuel & Rebel, 2015)) . Since additional surface area was needed besides the existing buildings and the greenhouse, extra floors were added on top of the existing buildings. Altogether these extra floors added 9.610 m2 surface area to reach a total surface area of 25.709 m2 for the new office complex (Emanuel & Rebel, 2015). The structure of the existing buildings had to be able to deal with the additional weight of the added floors. Structural design engineers found a solution in removing some heavily built brick walls and reusing the existing foundation and structure of the buildings (Emanuel & Rebel, 2015):

> *"This might not sound very high tech – it might be low tech – but this perspective on a project certainly is innovative. Especially on a scale like this."* – Rebel, 2015.

Bricks and concrete from the old buildings were reused. These were recycled on site and applied under the parking place. Ceiling tiles from old buildings were collected as well, newly coated and reused. The existing toilet bowls got a second life in the new building and old employee clothing was turned into an insulation material applied in one building (Henket, 2015). Scrap wood was saved from incineration to be used as façade material, collected and sorted by a group of people with a disadvantage on the labour market (Emanuel & Rebel, 2015). Old doors have been reused and materials that could not directly be reused were sorted into 13 separate waste streams and returned to industry again. This was applied to white glass and insulation materials for instance (Henket, 2015). Bituminous roofing was returned to industry, processed into new roof covering and applied on the buildings' roofs (Emanuel & Rebel, 2015).

Rainwater serves as irrigation for plants in the interior and as flushing water for toilets. 40% of the water usage is expected to be supplied by rainwater or grey water (VW Vastgoed, 2015). An internal green wall of 877 m^2 is realised and the project contributes to the Natura2000 area nearby via enlarged water surface for salamanders, bat towers and 'sparrow hotels' (Henket, 2015). EV charging stations are realised and an energy neutral building process was established since the PV panels that were to be applied anyway were already used during building activities (Dwars, 2015). Finally the surrounding firms at the Duiven site have been involved in a so-called Green Alliance. This alliance has to expand the sustainable activities into the total area via e.g. collective PV purchasing.

5.2.2 Process and project description



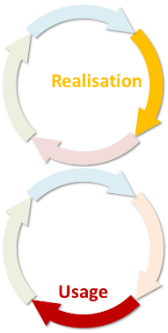
The process of the development started in 2010 when Alliander redeveloped its real estate strategy. One of the outcomes of this trajectory was growth of the location in Duiven from 600 to 1300 employees (van Zantvoort, 2015). In November 2010 Alliander invited external experts to reveal options for doing things differently. This meeting resulted in an advice for an ambitious project. In traditional building projects, it appeared, every phase was separated from other phases. The architect designs a building and then just passes it on to the next person in the chain: the contractor for building it. When something goes wrong, they all blame each other. Alliander wanted to change this.

> *"(Traditionally) you always see the same problems. Blaming each other for flaws that arise and that's actually the fundamental idea of the phrase that guided us throughout the process:' If you always do what you always did, you will get what you always got.' (…) So, we had to do it differently."* – van Zantvoort, 2015.

In order to create support for such an ambitious project and process, many conversations were held within Alliander as an organisation (van Oppen, 2015). These conversations resulted in an ambition document (see vision part in 5.2.1). Alliander hereby established a new way of assigning a project in the building sector: instead of specifying requirements, needs are central - increasing the possibilities to fulfil these needs (van Zantvoort, 2015).

With this ambition document (see Table 17) Alliander went to the market in 2010 and asked for a vision upon this ambition. This open and *collective search* between client and market parties is another innovative aspect for the building sector. In this search Alliander talked to many different disciplines and then realised they had to think in disciplines instead of companies (van Zantvoort, 2015). A list of disciplines needed was established (design, building, installations, maintenance and interior design) and then actual consortia were formed that wanted to participate in the tendering phase. These consortia ranged from big organisations that internally combined all these disciplines to smaller firms looking for collaboration. From the initial twelve consortia in the selection phase, three were selected to further develop and sharpen their vision upon the concept, financial support and process:

> *"It is a love letter where we wrote to Alliander in two A4's how we looked at the assignment."* – Dwars, 2015.



From these three, the consortium VolkerWessels Vastgoed/RAU won the tender and developed their vision into an actual plan for the accommodation based upon an intentional agreement at the start of 2012. The design phase where the consortium prepared the implementation in close cooperation with Alliander, lasted from the start of 2012 until spring 2013 (the project structure of this phase will be explained in the next paragraph). The basic concept of the design however - the greenhouse with overarching roof - was already established in the tendering phase and was developed in all its details during the design phase (Niehof, 2015; Roelofs, 2015). Then the next phase, the realisation of the project, started which lasted until the delivery of the building in September 2015 (see below). The building was officially opened in November 2015. Hereby the usage phase officially started.

Time period		Activities
Preparatory phase		
Start vision forming	November 2010	Inspirational session between Alliander and external experts resulting in functional requirements (van Oppen, 2015).
Requirements definition	Start of 2011 until halfway 2011	Define ambitions by creating internal support and involving Alliander employees in the formulation of the ambitions.
Involve market	June 2011	Asking market for a vision upon the ambition (van Zantvoort, 2015).
Tendering phase		
Selection phase	July 2011-Sept. 2011	Defining ambitions, connecting disciplines in the market resulting in a selection of 3 consortia (Urgenda & Copper8, 2015).
Dialogue with market parties	Sept. 2011-Oct. 2011	Dialogue with 3 selected consortia of market parties to define the request for accommodation, resulting in procurement guidelines. At the same time connecting disciplines in the market
Procuring phase	Oct. 2011-Dec. 2011	After an invitation to submit a tender, this phase aims to award the assignment based on trust between the different disciplines.
Intentional agreement	Dec. 2011-Jan. 2012	Intention to work with the consortium RAU/VolkerWessels Vastgoed; functional, process, and financial aspects of the collaboration are defined in cooperation with this consortium.
Design phase	Jan. 2012-March 2013	Design the building for Alliander in Duiven based on a constant dialogue with Alliander N.V.
Cooperation agreement	Jul. 2012-Sept. 2012	Parallel with the design phase, the development of the collaboration agreement took place.
Realisation phase		
Start	Q2 2013	First activities.
Delivery	September 2015	Building ready for use.
Official opening	November 2015	Official start of usage phase.

Table 19 *– Timeline of the realisation of the project in Duiven (based on Alliander N.V. 2011b - except indications).*

Project description

The project organisation can more or less be described along the three phases indicated in Table 19. For the preparatory phase this organisation involved Alliander itself and consultants from former Squarewise (later on Copper8). These consultants worked on creating support within Alliander for the new (re)development process. Within the tendering phase the project was organised around a core team consisting of three managers within Alliander and of two consultants already involved in the preparatory process (van Oppen, 2015). The core team met with the three different selected consortia both in individual and in plenary sessions (Alliander N.V., 2011c).

Directly after awarding the assignment to the RAU/VolkerWessels Vastgoed consortium (starting from the design phase), the project organisation consisted of a steering group of three Alliander employees and two representatives of the consortium (van Oppen, 2015). The consortium under the VolkerWessels Vastgoed hierarchy met with Alliander once every two weeks (Dwars, 2015; Roelofs, 2015). Moreover, four working groups for the four final themes (see 5.2.1) were present. These working groups consisted of 'experts' from both Alliander and the consortium. For this purpose Alliander gave four employees the opportunity to work *fulltime* on the renovation project by participating in working groups. This is very different from regular buildings where a client is not involved

this intensively. These working groups reported to the project leaders meeting with the project leaders of the different themes. The project leaders meeting reported to the steering group in turn. In the realisation phase moreover an additional construction meeting was added just like an additional working group (Dwars, 2015). The project organisation from the design phase onwards is visualised in Figure 30 below.

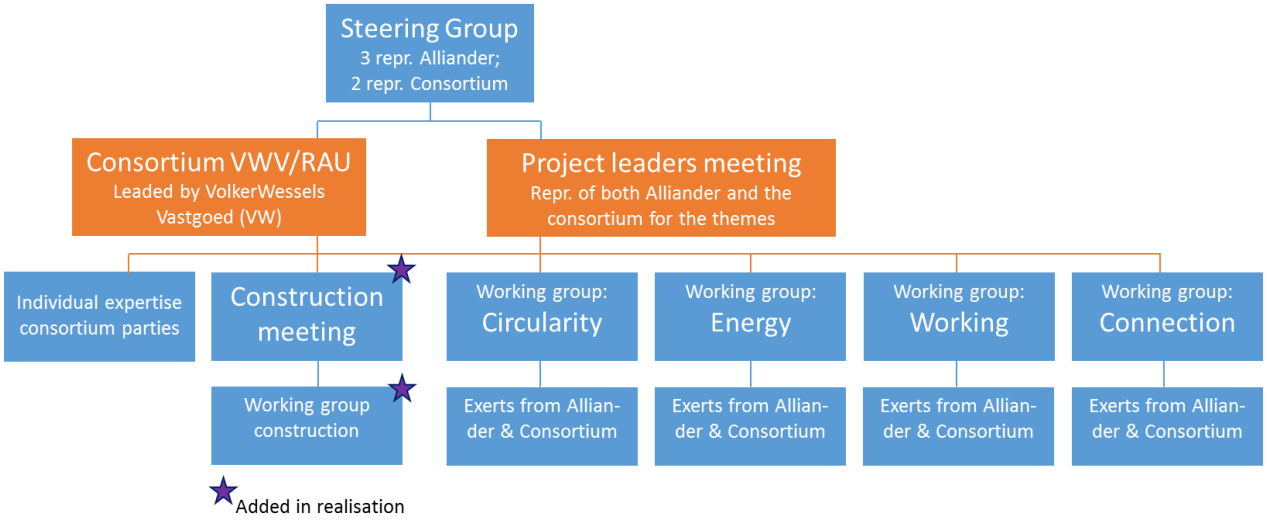


***Figure 30** – Project structure Alliander office from design phase onwards (based on van Oppen, 2015; Dwars, 2015).*

The process and project structure as applied in this case can be considered highly innovative for the building sector. This was confirmed by all interviewees from the consortium (see Appendix C) that mentioned the role of Alliander as essential for setting up the process and developing the ambitions. On the other hand the different consortium partners were named for their essential contributions in developing and realising the renovation. This coincides with the collaboration form often mentioned in this case**: co-creation**.

> *"(Innovative was) the openness and the open and collaborative search. From the tendering phase onwards we just used dialogues to collectively determine the end product of these dialogues."* – Roelofs, 2015.

The collaboration and the project structure were also formally arranged in the type of contract used. In this case a DBMo contract was applied for a period of 15 years (Sijbrandij & Korbee, 2012). This means the consortium is responsible for designing, building, maintaining and partly operating the building. Alliander financed the project and therefore also dealt with some of the operations. The period of 15 years initially was quite a challenge for Alliander since their financial spreadsheets did not cover such extended timeframes. They changed this for this project however to keep up with the long term ambitions for the renovation (van Oppen, 2015).

5.2.3 Analysis: actor network and collaboration

The actor network and collaboration aspects of the renovation project for Alliander are analysed according to network composition, a description of resources and activities in the network and the actors and their relationships.

Network composition

The network around the process of (re)developing the Alliander office (Figure 31) shows quite some diversity. It connects some research institutes, governmental bodies and societal groups as well as private parties. In this way different areas of expertise and knowledge can be combined. The different subcategories of the network as depicted in the legend in Figure 31 will be explained subsequently.

Research and knowledge actors are involved via the provision of expertise as input to the process. The initial inspiration session as mentioned in Table 19 took place at TU Delft involving professors in sustainable building (van Zantvoort, 2015). Moreover knowledge on circularity as provided by studies from Utrecht University and the REBus project was used. This REBus project is set up by public and academic institutions in the UK and the Netherlands and it aims to develop an evidence based understanding of existing circular economy models (Wrap, 2015).

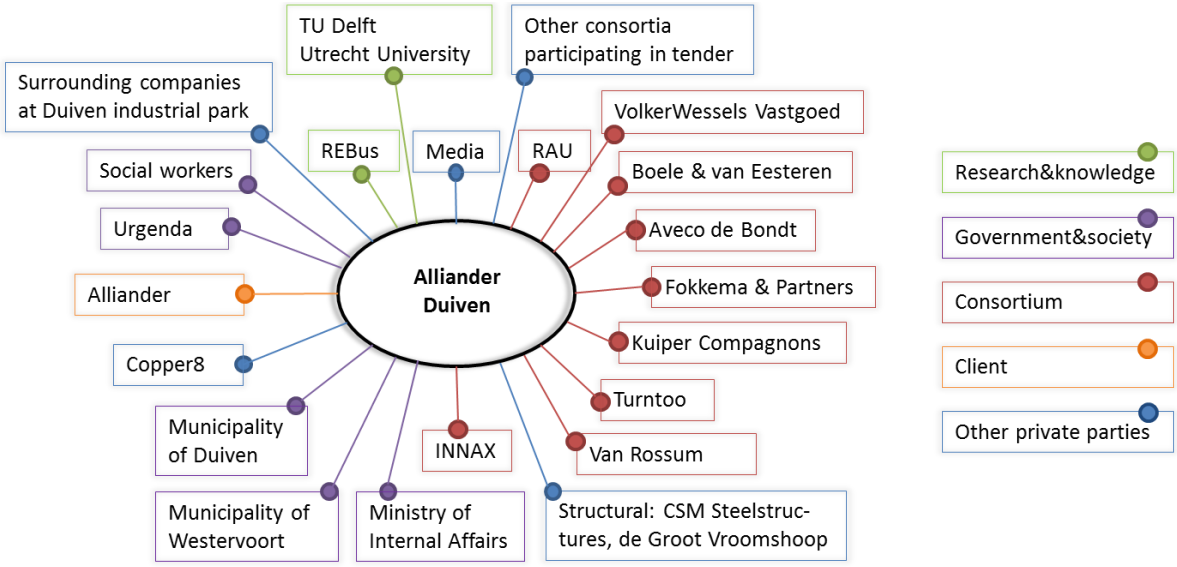


***Figure 31** – Overview of actor network around the renovation of the Alliander offices in Duiven.*

On the governmental side the neighbouring municipalities of Duiven and Westervoort are involved around permits for the project site. At the national level the Ministry of Internal Affairs is involved via two 'Green Deals': Green Deal Circular Purchasing and Green Deal Circular Buildings (van Zantvoort, 2015). These Green Deals are sector based deals to work on concrete results with both public and private parties to increase possibilities for new, sustainable initiatives in society (RVO, 2015b). On the societal side Urgenda can be found as well. Urgenda is a foundation that aims to speed up the transition to a sustainable situation in Netherlands (Urgenda, 2015). Within the Alliander project, Urgenda supports closing resource loops in the area around the new office building (the so-called 'Groene Alliantie'). Finally another societal spin-off of the project is the inclusion of a social workshop around sorting scrap wood (as explained within the project description in 5.2.1).

Next is the consortium that incorporated not only the requested disciplines (design, building, installations, maintenance and interior design), but added additional expertise via the landscape architect (Dwars, 2015). The consortium contained the architect (RAU Architects), developer (VolkerWessels Vastgoed), general contractor (Boele & van Eesteren), building physics and BREEAM (Aveco de Bondt), interior design (Fokkema & Partners), landscape design (Kuiper Compagnons), system innovation (Turntoo), structural design (van Rossum Raadgevende ingenieurs) and building installations (INNAX). This consortium worked in close collaboration with Alliander.

Other private parties encompass the firms involved in the Green Alliance. Examples of these firms are IKEA Duiven, Intratuin Duiven, Makro Duiven and TNT Express Duiven (Groene Allianties, 2012). All these parties committed themselves to achieve sustainable area development, similar to Industrial Symbiosis. Next to the winning consortium, 11 other consortia of private parties were initially involved. Their experiences in the project also created spin-off (van Oppen, 2015). The final group of private organisations contains suppliers of (mainly) structural materials (de Groot Vroomshoop for wooden structures and CSM Steelstructures for steel frames).

Actor groups are also for this case plotted along the real estate lifecycle (see section 2.3.3 and Figure 10 with corresponding colours). On the outside of this cycle the innovations in the process are visible: these actor groups have been added to the different phases for integration in the supply chain. This overview shows that in the Alliander case process innovation happened along all major parts of the building supply chain (Figure 32 on the next page).

Resources and activities

Looking at the activities in the network, the most important activity to secure collaboration was the **facilitating role** of Alliander as a client. Principals of traditional building projects mainly get informed by the general contractor about the possibilities for a new building to come up with specifications of all their requirements. In this case Alliander realised they did not know how to reach what they wanted, leading them to ask the market to collectively look for solutions. This required them to come up with a new project and process structure based on collaboration and trust:

> *"Alliander was the first client for me that dared to dream openly (..): 'we want to go somewhere, we don't know the way yet as we don't know the exact endpoint of our journey, but we want to go'".* – Roelofs, 2015.

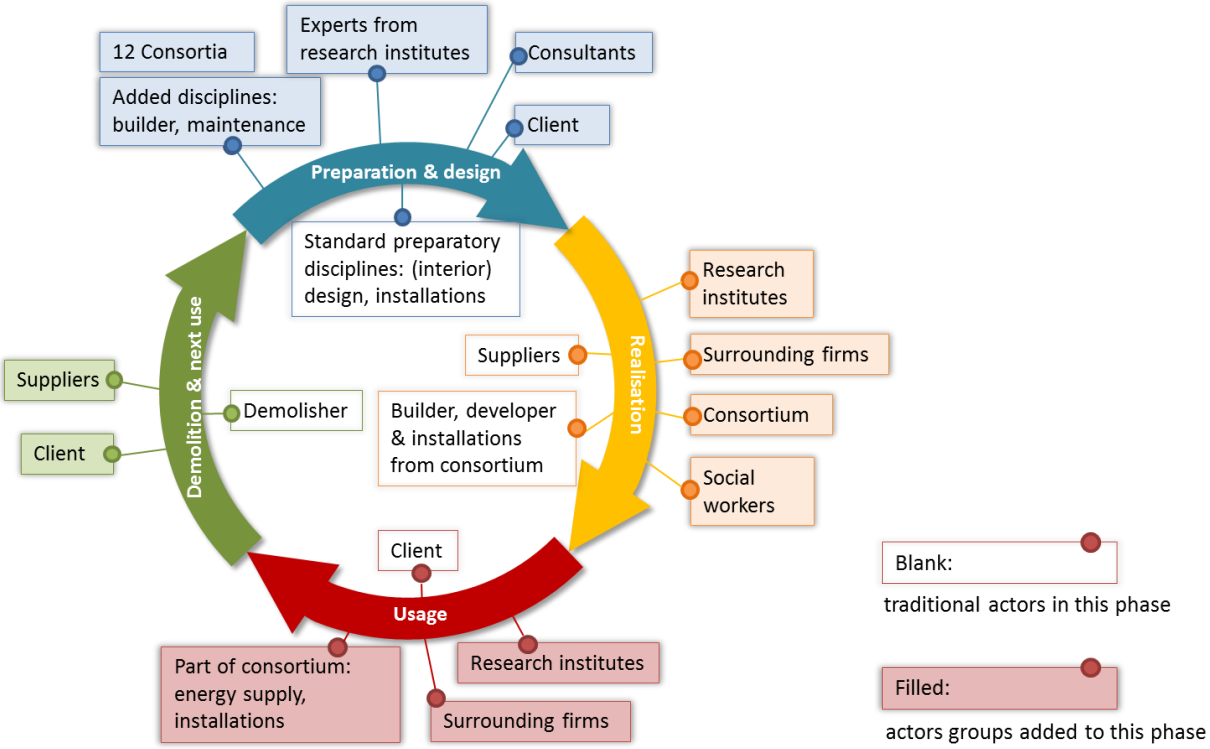


Figure 32 *– Actor groups at Alliander Duiven plotted along real estate lifecycle.*

The assignment and process design also had their influence on the activities within the consortium. The aim of an integral design made the consortium partners strive for the highest ambitions possible within their own discipline while taking the other contributions into account and **balancing** all aspects (Emanuel & Rebel, 2015). This type of collaboration is innovative for the building sector where disciplinary contributions to a design are standard.

Resources are analysed based on material inputs, financial capital, technology, knowledge and labour. 80% of all the material inputs for the Alliander office are circular, meaning they are either recycled directly on site or recycled/reused from elsewhere (van Zantvoort, 2015). This requires a different purchasing process for the general contractor since these material streams are less predictive than traditional materials from suppliers. Financial capital for the project is centred around Alliander as a principal. The main new technologies used are the 48 Volt network and the efficient ventilation system BaOpt as explained in section 5.2.1 (Emanuel & Rebel, 2015). Furthermore reusing and recycling technologies have been applied and this can be considered innovative at this scale. Material passport were used here as well. The most important knowledge developed in this project deals with setting up a co-creative and circular project around new ways of tendering (Copper8 & Urgenda, 2015). Labour involves preparational labour around establising the vision and ambition, designing the building and finally building activities.

Actors and their relationships

The actors involved and their relationships are analysed in (1) strategic elements like corporate focus, (2) collaboration elements like joint decision making, (3) cultural elements like trust, information exchange, openness and mutuality. These elements all contribute to successful supply chain collaboration (Barratt, 2004).

Strategic elements:

At this level firstly the degree of process alignment among senior management and other parts of the organisation is analysed. Within Alliander this intra-organisational support was certainly present since even the advisory board was involved in agreement on the financial approach of the project (van Oppen, 2015). External expertise was hired to create this intra-organisational support via the consulting agency Copper8/Squarewise:

> *"You can never create too much support. Getting a whole organisation on the same page is very relevant. And I also realised that actually realising something tangible inspired people within an organisation. That is the best organisation development trajectory ever."* – van Oppen, 2015.

Intra-organisational support was present at most of the consortium partners as well. This also relates to the fact that the consortium consists of parties that already had experience in sustainable building (Dwars, 2015). Because of this experience, corporate focus is more in favour of collaboration. The role of technology at the strategic level was not directly defined as part of the collaboration. Due to all the reuse of building materials, the project might even be more low-tech than high-tech (Emanuel & Rebel, 2015). The project on the other hand made use of BIM technology to integrate the different disciplines in the design for the building. The project even was awarded a price for the best BIM model (Cobouw, 2014). Finally, on a strategic level collaboration was also embedded in the vision for the project. As explained in section 5.2.1 a vision upon the realisation process was part of the selection criteria. Alliander wanted a collaborative process where all contributions result in an integral design.

Collaboration elements:

Cross-functional activities enabling information exchange between organisations were present in the Alliander case in meetings and workshops via the various groups and teams as visualised in Figure 30. The aim of this aspect of the collaboration was explicitly mentioned by the client Alliander:

> *"So if we keep a high level of collaboration and thus exchange a lot of information and if we keep in dialogue with each other, the consortium is able to work efficiently and effectively."* – van Zantvoort, 2015.

Other important collaboration elements are joint decision making and process alignment. The tendering process was specifically designed for collaboration and alignment, but in joint decision making improvements are possible. This holds especially true for the realisation phase. Here changes in the design were still made while the building process had already started (Dwars, 2015). This resulted in some tension. Performance standards for improvement of the supply chain form another collaboration element. Unique in the Alliander case was the introduction of a contract that described the way the collaboration needed to be established, co-created between client and consortium (van Zantvoort, 2015). These contracts are a final element and Alliander applied a DBMo contract (see 5.2.2). This contract extends the responsibility of the consortium to a larger part of the supply chain compared to traditional contracts.

Cultural elements:

Trust is one of the cultural elements of collaboration and all interviewees confirmed that trust was established within the project. What was special about the establishment of trust in this case was the incorporation of trust within the design of the whole process: the dialogue between Alliander and market parties. Trust starts by showing vulnerability and Alliander initiated this by stating they do not know how to reach their ambition and by asking the market for support (van Oppen, 2015). Some ways to establish trust also link to other cultural elements. Openness and communication were present with a clear communication strategy and strictly organised meetings (Roelofs, 2015; Niehof, 2015). The information exchange was designed to facilitate the collaboration: all actors had access to the same information. Information gathered during an individual dialogue (in the tendering phase) however would never be shared plenary without the permission of the individual consortium (van Oppen, 2015). In the design phase however some consortium partners mentioned that the information exchange was strongly guided by the developer as 'leader' of the consortium. This sometimes constrained other consortium partners in their contact with Alliander. Finally mutuality is an important cultural element. This was achieved in this case by keeping the same players that designed the project also during the realisation and even usage (Dwars, 2015). This is innovative for the building sector and it allows parties to address each other's responsibilities. This is essential in guiding the supply chain collaboration in the right direction:

> *"(Keeping the same players in the team) greatly contributed to the fact that you can demand others to respect their responsibilities and promises even after 1,5 or 2 years."* – Rebel, 2015.

5.2.4 Analysis: vision aspects

Vision aspects are analysed according to (1) vision image, (2) vision guidance and (3) vision orientation via motivation, inspiration and direction (based on van der Helm, 2009).

Vision image

The visions' image has been analysed along metaphors and the explicitness. When looking at metaphors and their influencing role, it can be analysed that two important metaphors are at play. The first one is related to the connection part of the vision and it sees the **building as a catalyst for sustainable area development**. This metaphor implies the building has an iconic value that inspires surrounding firms to co-develop sustainably. The second metaphor is that of **moveable property** as opposed to our current view on real estate as immoveable (Henket, 2015).

> *"Alliander is the worlds' first building organised as a resources depository. For 80% of the resources their origin and usage in the building is known. The building is built for disassembly and uses resources passports so a future purchaser knows the exact amount of the different resources in the building. This secures usability of the resources: in this way they stay resources instead of turning into waste."* – Rau in Henket, 2015.

The metaphor of a building as moveable property is based on the circularity aspect of the vision. This metaphor implies that resources in products keep their status of resource instead of downgrading into waste. In this way they can easily be used in future applications. This metaphor also means waste and recycling companies are no longer needed since they basically identify the characteristics of what has been termed waste and monetise this (Henket, 2015). Since resources keep their identity and value, the identifying activity becomes obsolete in the future.

Next is the explicitness of the vision. The two vision aspects of circularity and connection showed different possibilities for making them explicit. The circularity aspect was turned into an explicit goal of a net energy positive building (it should symbolically produce at least 1 kW per year) using at least 80% circular resources (Dwars, 2015). The connection with the surrounding area was made explicit via the establishment of a foundation 'Groene Allianties', aiming for sustainable area development in Duiven (Groene Allianties, 2012). A final aspect of the vision is its integral approach which is more difficult to make explicit. The overarching roof in the design can be considered a translation of this integral approach. The initial idea of this greenhouse placed over the existing buildings was also described as a 'Eureka moment' for the consortium partners reaching this integral aspect (Niehof, 2015).

Vision guidance

The guidance of the vision is analysed along (1) clear collective goals, (2) presence of alternative rule sets and (3) leadership (van der Helm, 2009; Quist, 2007).

Collective goals:

The circularity goals were shared goals for the consortium. This also relates to their measurable nature (Emanuel & Rebel, 2015). The connection and integral vision aspects are less tangible but the basic idea of the vision was certainly shared (Dwars, 2015; Roelofs, 2015). Actors however mentioned it was more difficult to stick to the vision in the realisation phase (Roelofs, 2015; Niehof, 2015). Here some differences appeared that mainly relate to current practices in the building sector while working from a new collaborative process with ad hoc decisions.

Alternative rule sets:

The vision for the Alliander office contains multiple alternative sets of rules. It mainly changes the tendering process and the way clients reveal their requirements, involve market parties and collaborate with these market parties. It also changes our attitude towards the concept of 'wasting' materials and the role of waste companies. The vision also changes our view upon a building as an isolated object into an iconic complex connected to its environment. The vision requires new design paradigms integrating different disciplines and it requires BMs based on long term value capture of materials. In this way these new rule sets have an influence on behaviour and link to forms higher order learning that will be elaborated in section 5.2.5.

Leadership:

Since the vision is (partly) developed within co-creation between Alliander and the consortium no direct authoritative aspects of the vision can be described:

> *"In that sense it's like team sport where you cannot say 'just leave the keeper' (..) Everyone plays its role in the process and that is reflected in the success stories: it all fits together."*– Emanuel, 2015.

For Alliander as principal however it takes leadership to start a completely different tendering process and just openly state they do not know how to reach their aim. The consortium assisted in implementing this aim even though current purchasing processes for general contractors are not adapted to these new types of circular building. Traditional contracting deals with upfront investments and fixed deliveries so especially for the general contractor and developer it took leadership to follow the vision and to insist in this new way of building (Roelofs, 2015). The vision in this way has two influencing roles here. It supports the consortium in keeping their focus and not falling back into traditional methods (Roelofs, 2015; Emanuel & Rebel, 2015). The vision also influences the collective decision making process (Niehof, 2015). These influences relate to learning processes in the next section.

Vision orientation

Motivation, inspiration and direction are among this vision orientation. The consortium was motivated by the enthusiasm and passion of the Alliander employees (Niehof, 2015). Motivation was reflected in the availability of the tender team to work on the project:

> *"When I emailed on Tuesday afternoon about a collective issue, we had a meeting on Wednesday at the latest. Whether this was at 7AM or at 9PM: everyone attended."* – van Zantvoort, 2015.

Inspiration also developed throughout the process since consortium actors believed realising the vision was possible (Emanuel & Rebel, 2015). During the project ambitions were even raised and internalised. The consortium looked more into possibilities instead of barriers and asked questions like 'why don't we reuse this element?' or 'why do we make an energy neutral building while it can also generate energy?' (van Zantvoort, 2015). The vision thus inspired them to innovate even more. The vision moreover provided direction for actions. It guided the decision making process around material choices and resulted in the development of the Groene Alliantie and involvement in two Green Deals, reaching other actors as well. In this way the vision directed the interactions of the consortium and those of surrounding firms, governments and other principals via their exemplary performance.

5.2.5 Analysis: learning

The analysis of higher order learning will look into (1) a shift in defining or framing problems and a perceived coupling to technology or society; (2) a shift in problem solving approaches and shifting priorities; (3) the level of dominant interpretive and cognitive frames; joint learning and shifting joint opinions among the actors involved. Next to these aspects of higher order learning, first order learning certainly occurred among the individual consortium actors and within Alliander. Examples of this first order learning are for instance additional knowledge about circularity. It appeared to be quite difficult to reach a 100% recycling rate of all materials. Regarding the usage of recycled aluminium the consortium in the end talked to suppliers in Germany and it turned out China is currently purchasing all recycled aluminium. Producers in Europe thus are not able to make products of recycled aluminium since all of this is already reserved for the Chinese market (Emanuel & Rebel, 2015).

Higher order learning: framing the problem

In the consortium a shift in framing the problem was not directly visible. Most of the actors mentioned that they did not change their definition of the problem since the problem definition was already conceived in an abstract way, which increased the solution space. This had to do with the question asked by Alliander. It moreover relates to the experience of consortium partners with circular building practices: some of them were used to shifting their problem definitions and perceived solution. Some others mentioned they did change their problem definition and learned what was going on in different disciplines, increasing their original problem boundaries.

Higher order learning: shifting problem solving solutions

The case certainly revealed a new way to solve the issue of creating a circular building. This new way requires a highly collaborative approach between client and consortium with a multidisciplinary focus. The process (see 5.2.2) facilitated this new way of problem solving, although it was mentioned that other process designs might be possible as well (Emanuel & Rebel, 2015).

"I suspect that you learn about the opportunities collaboration with different disciplines brings. Traditionally you work after each other. I never experienced this way of working so closely together before and with the right people. This is incredibly inspiring." – Niehof, 2015.

In this way actors learned about a new approach based on two main principles: (1) think in disciplines instead of companies and select upfront those disciplines that actually create value for the project and (2) use a process based on a dialogue and personal connection focussing on each other's interests and involving everyone from the preparations until end-of-life options. This is different from traditional building projects where principals might say: 'you are only responsible for placing facades and besides that I don't want to see you.' (Emanuel & Rebel, 2015).

Actors moreover learned to broaden their scope for new ways of (collaborative) working. Whereas they still have the traditional approach in the back of their mind, they learned to continuously challenge themselves to suppress traditional reflexes (van Zantvoort, 2015). This can be termed a shift in priorities since these actors are now willing to invest more time in dialogues in the preparatory phase because they know the added value this brings to the end result. This moreover relates to vision aspect of influencing thinking processes and behaviour.

Higher order learning: joint learning and joint opinions

At the level of dominant interpretive frames some learning took place. Agreement on pursuing the vision was reached, but this was already present from the start since this is where the selection of consortia was based upon. This is also why some interviewed consortium partners mentioned they did not learn here. They already had this open interpretative frame to incorporate new ways of (circular and integral) thinking. When looking at the whole process from the beginning, joint learning can however also be identified in consortia that did not win the assignment in the end. The tendering process learned them about this new approach and they still collaborate (van Oppen, 2015).

5.2.6 Analysis: Business Model

Based on the literature search in Chapter 3 the BM here will be analysed according to (1) an introduction into the value creation, delivery and capture; (2) innovative circular aspects; (3) collaboration as part of the BM; (4) a reflection on the implementation of the initial ambition regarding value creation as a future BM improvement.

Introduction: value creation, delivery and capture

The central value created in Duiven is an almost circular building (environmental and economic value) with an iconic value in the surrounding area (social value with potential environment and economic spin-off). The building moreover connects the Alliander employees (social value). This value is delivered via design principles applied, technical innovations and more low-tech solutions for reuse and recycling. All material value in the project is captured via a resources passport. Alliander moreover tried to capture environmental and social value by means of a green guide as an example to its employees on how to function in the new building. In this way Alliander also showed their commitment towards reaching the net energy productivity of the building.

Looking at the cost structure in the value capture mechanism, Alliander is the main investor. They aim to earn back their investment based on zero energy costs and a higher productivity rate of employees (Dwars, 2015). The mechanism behind this energy bill is a payment scheme between Alliander and the energy supplier: INNAX. INNAX makes sure no energy bill is presented to Alliander since the building should produce energy instead of consuming it for a period of 15 years (Sijbrandij & Korbee, 2012). Whenever the building needs additional energy during this period, the additional costs for providing this energy are on INNAX as part of the consortium.

BM Innovation

The main BM innovations will be compared to the strategies for CBMs of Chapter 3 (Table 13). In the technological category the BM archetype of creating value from waste is applied in several ways. High rates of reuse and recycling have been applied and take back management was put in place via the introduction of the resources passport. Moreover a buy back warrantee was supplied for the assets of the interior (chairs, desks etc.), assuring take back of these products. More value will be created from waste within the Industrial Symbiosis applied to the surrounding industrial site. A final technological BM archetype is substitution with renewables. PV panels are applied

to generate more than the (electrical) energy needs for the building and the thermal energy storage allows for provision of heat in a renewable way.

On the social innovation side the project in Duiven applied examples out of all three main BM archetypes. It encourages sufficiency via the application of an ESCo construction around energy supply and management. The project also has a focus on delivering functionality over ownership via firstly its process structure with a DBMo contract (see also 5.2.3). It secondly applied a result-oriented PSS within the lighting system (pay per use). The project finally uses the archetype of adopting a stewardship role in its effort to contribute to the neighbouring Natura2000 area, protecting biodiversity.

For the organisational category lastly the largest contribution of the project to BM innovation can be noted: its focus on co-creation. Its highly collaborative approach and incorporation of all relevant expertise right from the start can be considered highly innovative for the building sector.

Collaboration as part of the business model

Although most of the innovation focuses on the collaborative approach, collaboration was not explicitly embedded within the BM. Whereas collaboration was certainly present in the process design, it was not coupled to economic incentives which would also guard the collaboration in financially difficult times (van Oppen, 2015). This aspect was thus also named as an improvement of the used business model which is the focus of the next section.

Reflection on used business model

When reflecting on the actual implementation of the initial ambition it is to be noted that quite some value is created on all aspects of CBM archetypes. During the project however possibilities for improving the value creation became apparent. These are located in all three categories of BM innovation as depicted in Table 20:

Technological			Social			Organisational		
Optimise material & energy efficiency	Create value from waste	Substitute with rene-wables	Functiona-lity over ownership	Adopt a steward-ship role	Slow consump-tion	Co-creation	Repurpose for society/ environ-ment	Develop scale-up solutions

***Table 20** – Future improvement areas for the BM of Alliander in Duiven.*

On the technological side a first improvement is an optimisation of the energy efficiency performance of the building. This can be done by conditioning only certain parts of the building when less people are present (on Wednesdays or Fridays) and getting everyone to work in these acclimatised parts (van Zantvoort, 2015). Within the archetype of creating value from waste the Industrial Symbiosis development can be improved by realising even more follow-up of the project in the area (Niehof, 2015; Emanuel & Rebel, 2015).

On the social side, functionality can be improved via even more responsibility for the consortium and suppliers. Since Alliander is still the main investor, currently no actual incentives exists for suppliers to deliver the best materials and guarding their performance and maintenance. This only holds for the ESCo as described above. This responsibility can be regarded an organisational BM aspect around co-creation. In the ideal situation ownership of resources is secured together with the material passports:

> *"If we would leave here in 25 years, we just hand in an invoice and get money for the materials and energy generated and people will come to remove the building because they own these resources. We did not reach this image. So with regard to ownership of materials additional steps have to be taken."* – Emanuel, 2015.

A final point of improvement for the co-creation archetype is to incorporate collaboration in the BM used. This could be done by coupling circularity ambitions to financial rewards (van Oppen, 2015). This incentivises all parties to aim for the optimum synergy and realise a circular building. To make the BM a shared BM among all parties involved in the supply chain, parties have to be collectively responsible for the result and have to sign that if they do not reach the ambitions they collectively have to arrange and pay for the missing qualities/measures. In this way collaboration and the aim of a circular building and supply chain can be safeguarded within the BM for a project.

5.2.7 Conclusions and discussion

Looking at the four concepts analysed in this section related to the conceptual framework, it can be concluded that they all contributed to it with a focus on the vision aspects and network/collaboration. The project is based on a vision of circularity and connection and uses an integral approach. The collaboration type is based on consortia of different building disciplines.

The project involves a diverse actor **network** with spin-off effects in other consortia that took part in the first tendering phase. The most important activity to secure the collaboration is the facilitating role of Alliander as client in an innovative collaborative tendering process. With high circularity ambitions and a focus on reuse and recycling, more than 80% of all material resources are circular. Looking at the cultural elements in the network (see Figure 33 on the next page) the conclusion can be drawn that trust, transparency and clearly organised communication structures were present. Trust was established by Alliander in their open question to the market to support them in realising their ambition. This vulnerability is innovative for the building sector. Another 'innovation' for the building sector is to keep the same players in the team from the first preparations until realisation and even usage, leading to mutuality. Cultural elements in this way thus guided the supply chain collaboration and realisation of the ambitions. For the collaboration elements (see Figure 33) Alliander facilitated cross-functional activities in its new process design with different working groups that combine expertise from Alliander employees and the consortium. For the strategic elements, Alliander even made this vision of a collaborative process part of their tendering selection criteria. Alliander moreover put effort in establishing intra-organisational support by hiring a consultant to create this support within all parties involved in the project.

The **vision** for the project in Duiven applied metaphors of the building as a catalyst for sustainable area development and that of the building as moveable property (instead of immovable property). The vision in this supported actors to keep innovating in the process and it guided in collective decision making processes. This can be considered **higher order learning** about problem solving solutions since actors learned to broaden their scope for new ways of (collaborative) working. The vision also provided guidance via shared circularity goals and the establishment of a foundation to connect the sustainability goals also to the surrounding area. The vision was not directly supported by authoritative tension (van der Helm, 2009) due to the co-creative aspect, but with this focus the vision provided alternative rule sets by changing the tendering process. This is related to higher order learning where actors learned the benefits of this new approach that is based on: (1) thinking in disciplines instead of companies and select upfront those disciplines that actually create value for the project and (2) using a process based on a dialogue and personal connection focused on each other's interests. The vision finally provided orientation via motivation, inspiration and direction. In fact, actors were already selected on these aspects so not much higher order learning took place on joint learning/joint opinions (those were already in favour of collaboration and innovations).

For the **business model** it can be concluded that the value creation entails an almost circular building in its materials and energy use that will connect the employees working inside. It moreover has an iconic value involving the surrounding area in its sustainability goals. The project applied both technological, social and organisational BM archetypes, but it also provides room for improvement. This is related to the fact that Alliander is still the main investor, so no actual incentives exists for suppliers to deliver the best materials and to guard their performance and maintenance. The most important improvement would be the incorporation of collaboration within the BM (this will then become a shared BM). This could be done by coupling the collective sustainability/circularity ambitions to financial rewards to incentivise all parties to aim for the optimum synergy.

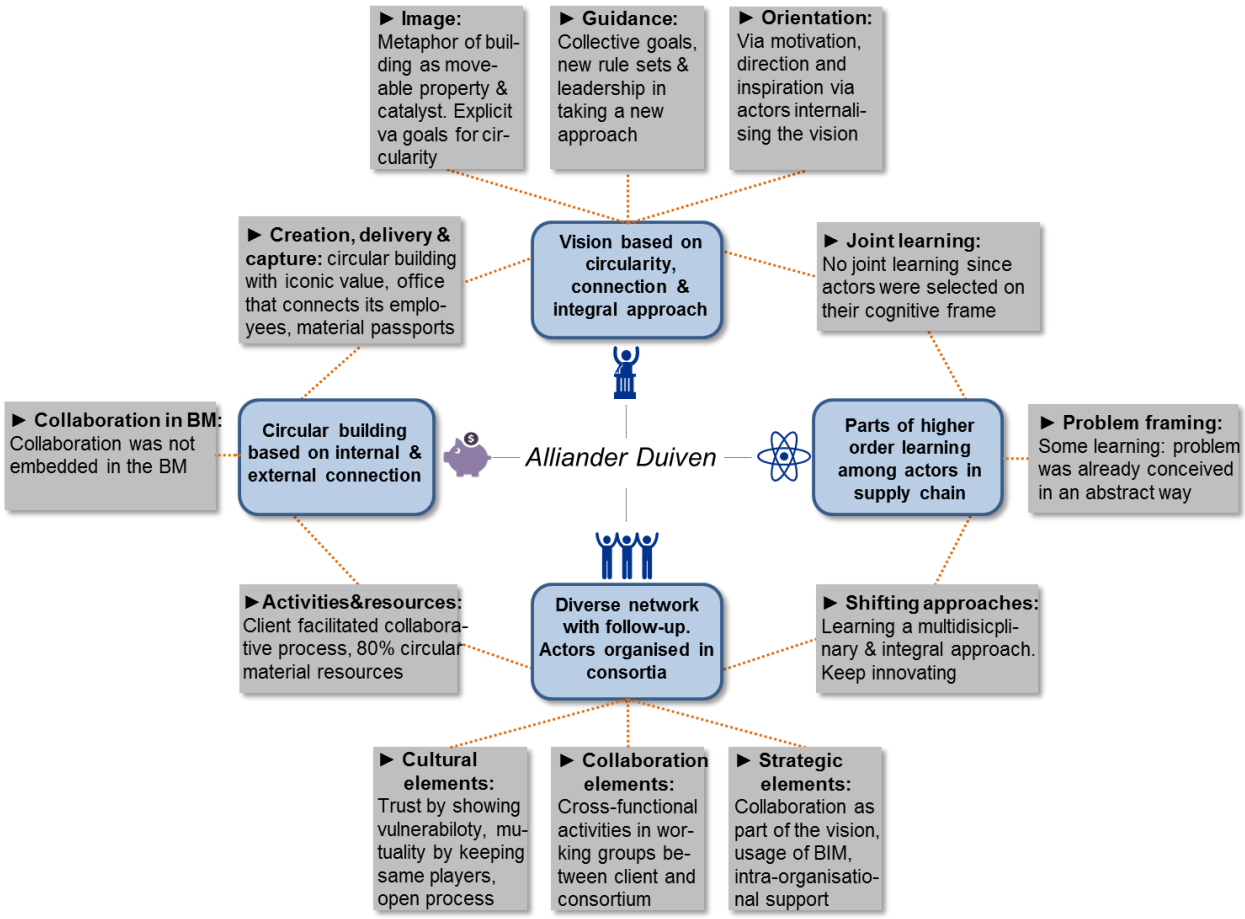


Figure 33 *– Conclusion for supply chain collaboration at Alliander offices, Duiven.*

5.3 Heerema Head Office – First BREEAM certified demolition



Figure 35 *– Heerema Head Office (HMC, 2015)*



Figure 34 *– Interior Heerema Head Office (van Ee, 2015).*

5.3.1 Introduction

The Heerema building in Leiden is the head office of Heerema (HMC), a marine contractor in the international offshore oil and gas industry. This head office is located in the city centre of Leiden. The site is connected to an offices location, a mixed zone for commercial activities & housing and to the Leiden Central Station area (van Zuilekom, 2013). The building site has the shape of a triangle and the building itself is developed in an L-shape (see Figure 34). All floors have a mini-plaza where employees can meet informally or receive guests. The building has nine stories office space and the lower three floors contain a meeting centre, the Plaza, with a restaurant, sports facilities and a congress centrum (BREEAM, 2013). Before realising the new office building, the old abandoned HMC office building at the site was demolished, certified via the first BREEAM demolition certificate (BREEAM, 2013).

Vision

The vision of the new office is closely related to requirements of HMC as a client. HMC wanted an office for the coming 20 years, based on **team working and connection** between different departments (van Zuilekom, 2013):

> *"Basis for the building is informal contact and communication. Communication is essential for us: to foreign offices and vessels, but also internal communication around projects. We have to find ways to contact each other more easily. That is the underlying vision."* – Siera, 2015.

Moreover sustainable ambitions were added, mainly because of the influence of Delta Development Group as a sustainable developer (Diepenhorst, 2015; Hoeben, 2015). This started with the demolition of the abandoned building. Delta wanted to contribute to the development of BREEAM-NL: sustainable demolition and disassembly (BREEAM-NL, 2013). In this sub-category of the BREEAM certificate the aim for the demolition project was to obtain a Very Good rating (the middle level – see 2.3.4). For the building itself BREEAM ambitions were used as well. Based on the first designs the Very Good level was within easy reach as agreed in 2011. During the development HMC showed its 'winner's mentality' (Diepenhorst, 2015) and ambitions were raised to reach the Excellent level.

Project specifications

The project for HMC involves the following main data and specifications:

Project factor	Project data
Floor area of building	21.000 m2 for a total of 1.250 HMC employees (Vondellaan47, 2013) (with capacity to facilitate potential growth up to 1.600 employees).
Programme	• 16.969 m2 offices area and meeting spaces. • Ca. 3.000 m2 additional floor area (circulation space and storage). • Facilities: restaurant, gym, congress centre, offshore simulation platform. • Separate parking area: ca. 575 parking places.
Investment value	€ 60 million (DTZ Zadelhof, 2014b).
BREEM-NL score	BREEAM Demolition certificate and BREEAM Excellent for the entire building (BREEAM, 2013).

***Table 21** – Project specifications Heerema Head Office Leiden.*

Regarding technical specifications, several sustainable solutions have been applied. The building is positioned in a sustainable way with an optimal orientation. The facades that face south are made of bricks. These closed facades block solar heat, making for an efficient use of the climate system (Vondellaan47, 2015). The north facades are formed by glass curtain walls that facilitate daylight accession into the building. Thermal energy storage is applied to decrease the energy needs (BREEAM, 2013). This system uses cold groundwater to cool the building in summer while the water that is heated during this cooling is stored in a warm well to use for heating during winter. The parking areas make use of a LED lighting system reducing electricity needs considerably. Energy needs are further reduced via well-insulated walls and the usage of solar boilers that heat hot tap water (BREEAM, 2013).

Vegetation and greenery are moreover applied in and around the building. The facades of the car park consist of green walls and the roof of the Plaza is covered with a herbal garden. This green roof functions as a water buffer and moreover offers an attractive view to the employees (Vondellaan47, 2015). Around 40 trees and bushes that existed at the building site have been removed to new locations in the region (BREEAM, 2013).

A final specification is the demolition and sanitation of the building site. Waste streams from the old building were collected separately and reused or recycled. Wood collected during demolition in this way feeds back into the wood industry, steel feeds back into a steel plant and all concrete waste is used for road fill (van Es, 2015).

5.3.2 Process and project description



The process description dates back to 2006 when Heerema moved from Vondellaan 47 to Vondellaan 55. At that time the firm only counted 450 employees (Siera, 2015). The offshore industry experienced growth since that date due to increasing oil prices. HMC thus grew their staff and at a certain point the climate system could not facilitate this growing amount of employees anymore. Temporal space was rented in neighbouring office buildings, but a final solution still had to be found. Around that same time (2006-2007) the owner of the former HMC office at Vondellaan

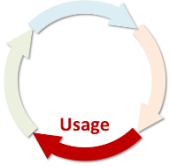
47 contacted Delta Development Group to look for opportunities for this building site. Delta Development Group advised this owner (not be confused with client HMC) to demolish the building since the building was in such a bad shape that renovating would be greenwashing (Diepenhorst, 2015). When HMC started its official search for a new office (location), Delta saw the opportunity of bringing HMC 'back to its roots' (van Zuilekom, 2013) by sustainably demolishing the old office and rebuilding a new one at the site where HMC once started their business. In this way HMC did not leave another office building abandoned. The development could moreover contribute to a pilot project of the Dutch Green Building Council (DGBC – the organisation behind BREEAM) in sustainable demolition. HMC considered several locations for its new office at that time and decided to choose Leiden over Rotterdam due to contacts with local government and the advantages this could offer (Siera, 2015). HMC still had two options in Leiden, but the proposal of Delta Development Group to bring them back to their original site convinced them.

Time period	Activities
Preparatory phase	
2006	HMC moves from Vondellaan 47 to Vondellaan 55.
2006-2007	Owner of Vondellaan 47 contacts Delta Development Group for options.
2011	HMC announces plans for new office building.
2011	HMC chooses proposal by Delta Development Group to move back to a new office building at their original site: Vondellaan 47.
October 2011	Start process design including collaboration and contract. Start design phase.
Realisation phase	
July 2013	Start demolition.
October 2013	Start first building activities.
September 2015	Delivery of the new building
November 2015	HMC moves to the new building (Vondellaan 47): start of the usage phase.

***Table 22** – Timeline of the realisation of the demolition and renovation project for Heerema.*







At the end of 2011 the project for the demolition and redevelopment kicked off by establishing the collaboration and the contracts between the participating parties. Around this time the design phase moreover started. This design phase lasted until halfway 2013 including arrangements around building permits. The sustainable demolition started in July 2013. In fact this sustainable demolition meant that all activities at the site needed to be reported: the demolisher had one employee working fulltime on this reporting process. The aim of this reporting was to obtain a Very Good certificate, but the demolition tool and criteria were still developed at that time. When the documents were judged, the demolition was awarded a 'Pass' level because the DGBC changed the rules during the process (van Es, 2015). This was reported and the judgement was changed to Very Good since this corresponded to the guidelines as set at the beginning of the project. After this demolition the actual building process could start which lasted from October 2013 until September 2015. HMC moved to the new building as the start of the usage phase in November 2015. With this usage phase the BREEAM certification for the building will be awarded which will most likely indeed achieve the Excellent rating.

Project description

The project description is given for the realisation phase since before this phase no actual project design existed. In this preparatory phase HMC, Beelen Sloopwerken and Delta Development Group were the main actors that found each other in their plans for redeveloping the original HMC site.

In the realisation phase the project was organised in a traditional construction team (see also 5.1.2). This means the general contractor coordinates and leads the design and realisation of the project (the operations meeting in Figure 36). The general contractor in turn reports to the developer who connects the client (HMC) and the executing parties. In this way the developer is central in the project design (see Figure 36). On the one hand the developer together with Lendering & Partners (L&P) coordinated the construction team, consisting of general contractor, director, architect, installations advisor and building physics advisor, while on the other hand he had the tenant meeting. This meeting considered the design of the interior of the building and thus consisted of interior designer, installations advisor and Heerema. These two different meetings were scheduled every other week.

"For Heerema the project felt like this: 'this is what I want; I just throw it to Peter (Delta Development Group) and he has to make sure everyone that works for him builds it the way I want it'" – Korpershoek, 2015.

These are all standard project structures in the building sector. Innovative in this project was the involvement of the client. HMC and Delta Development Group had weekly meetings to keep each other informed (Diepenhorst, 2015).

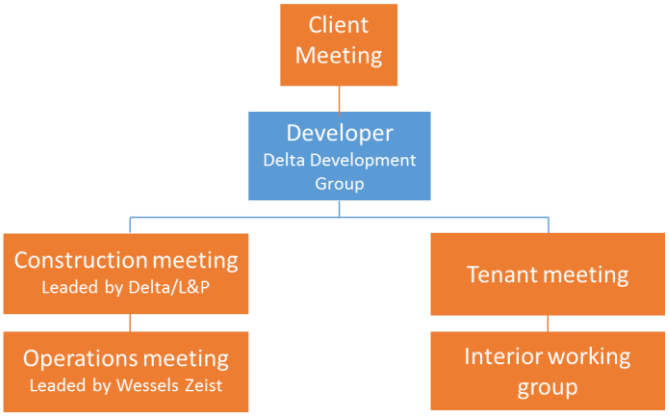


Figure 36 *– Project structure of Vondellaan47 in realisation phase (Diepenhorst, 2015; Korpershoek, 2015).*

5.3.3 Analysis: actor Network and collaboration

The actor network and collaboration aspects of the project at Vondellaan 47 is analysed according to its network composition, a description of resources and activities in the network and the actors and their relationships.

Network composition

The network established around the demolition and redevelopment of the HMC office, connects different actor groups. The different actor groups as indicated in the legend in Figure 37 are explained subsequently.

Figure 37 shows that relatively little knowledge actors are involved here. The main actor in this subcategory is the DGBC. When the project for HMC started, the DGBC worked on a tool for a BREEAM demolition certificate. They used the support of twenty professionals and twenty demolition companies (Diepenhorst, 2015). Delta Development Group and Beelen (the demolition company) collaborated with these parties. They reached an agreement to actually test in reality what was put to paper by the working group of the DGBC (Diepenhorst, 2015).

Governmental actors on different levels were involved in the HMC case. This involvement was required because the proposal for a new office building at the selected site needed a change in the zoning plan for the area. Royal Haskoning DHV was hired to coordinate the research for such a zoning plan change (BREEAM, 2013).

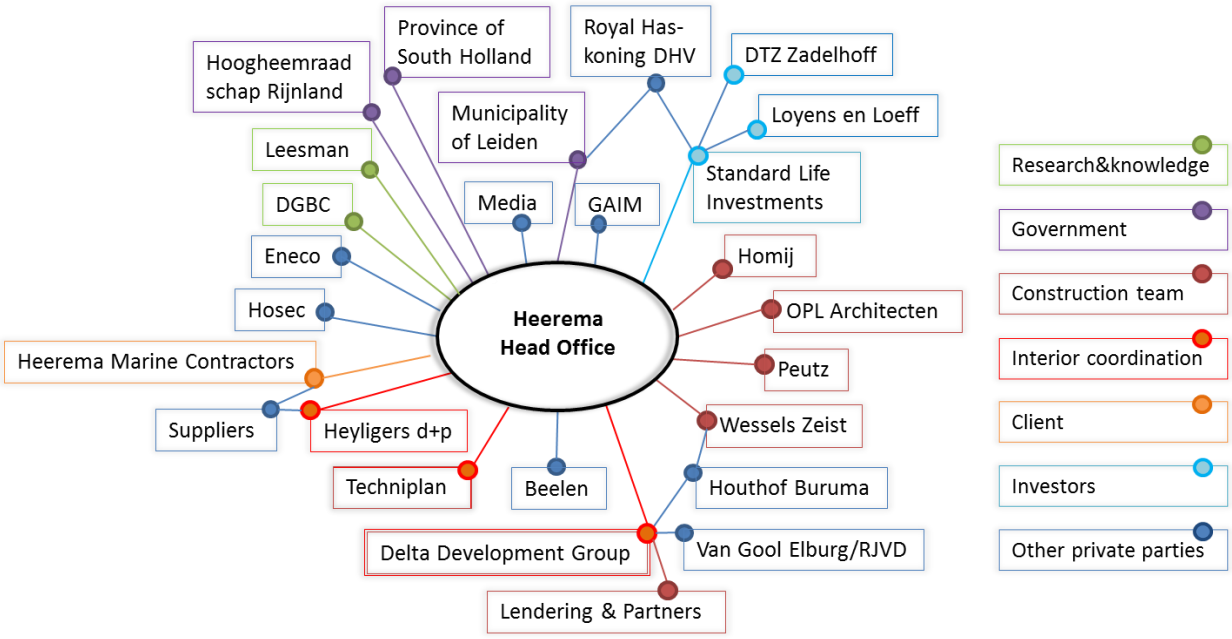


Figure 37 *– Overview of actor network around the project for HMC at Vondellaan 47.*

Actors involved in the design and construction of the new office building are united in the two teams as explained in Figure 36: the construction team and the interior team. The construction consisted of general contractor Wessels Zeist (a part of the VolkerWessels concern), the architect (OPL architecten), building installations expert (Homij), building physics expert (Peutz) and Delta as a developer. Delta Development Group hired Lendering & Partners to support them in the management of the whole project (Hoeben, 2015). The team that worked on the interior consisted of the interior designer Heyligers design+projects and the installations advisor Techniplan (who also participated in the construction team) and Delta Development Group was involved in this team again.

HMC rents the building so additional investors were needed to finance the project. Standard Life Investments financed the new office in the end. The transaction was supported by Loyens en Loeff for a legal opinion, by Royal Haskoning DHV on technical aspects and by DTZ Zadelhoff on commercial aspects (DTZ Zadelhof, 2014b).

Finally some additional private parties are involved for various purposes. Advisory expertise was delivered by Houthof Buruma on legal aspects and by Van Gool Elberg and RJVD Vastgoed on commercial aspects (DTZ Zadelhoff, 2014). The demolition of the former HMC building was realised by Beelen Sloopwerken and the thermal energy well was realised by Eneco. The interior designer together with HMC coordinated the purchasing process for the interior of the building and thus cooperated with diverse suppliers. Two final advisory parties are involved in advising on security (Hosec) and infrastructure (GAIM).

Next, actor groups are plotted along the real estate lifecycle again (see section 2.3.3) On the outside of this cycle the innovations in the process are visible: these actor groups have been added to the different phases. This overview shows that in this case process innovation happened only marginally (Figure 38).

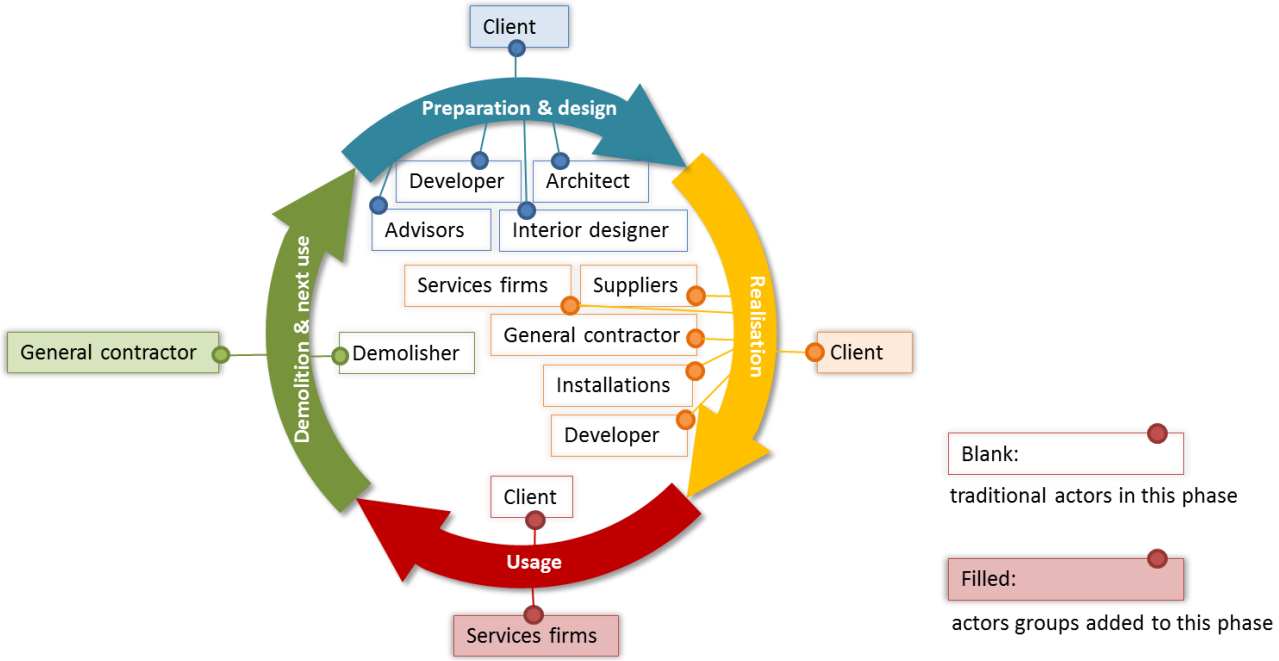


Figure 38 *– Actor groups at Vondellaan 47 plotted along real estate lifecycle.*

Resources and activities

Regarding essential activities in the network the **intermediating** role of the developer can be named. Delta Development Group connected all different aspects and parties of and around the development. The importance of this activity was confirmed by all interviewed actors in this case. Moreover the role of the developer was named for actually realising the vision and requirements of HMC for the new building.

Resources are analysed based on material inputs, financial capital, technology, knowledge and labour. Choices around material inputs were made based on the requirements of HMC. This led to the application of mainly traditional building materials for both the interior and façade materials (Diepenhorst, 2015; Leijnse, 2015). Some sustainable materials were applied (like the C2C certified Mosa tiles), but it could have been more progressive. Financial capital comes from two main actors: Standard Life Investement invested in the building and Heerema invested in all aspects related to the interior. Eneco moreover takes all responsibility for the energy supply and thus

invested in the construction of a thermal energy well. This thermal energy storage can also be regarded the main innovative technology applied. Technology used during the process in this case is the 'edscontrol' system of the general contractor: a BIM like software to align all design activities (Korpershoek, 2015). Most relevant knowledge produced during this project is the outcomes of the experiment with a sustainable demolition for a BREEAM certificate. This requires data transparency about all demolishing activities. Data handling in turn is linked to labour. Labour in this case furthermore included setting up the collaboration/contracts, designing the building, demolishing the former building and rebuilding the new Vondellaan 47 HMC office.

Actors and their relationships

Actors involved and their relationships are analysed along (1) strategic elements, (2) collaboration elements like process alignment or joint decision making and (3) cultural elements.

Strategic elements:

A first aspect of these strategic elements is process alignment among management and other parts of the organisation. Since this case was organised around the requirements of HMC, they needed to align their processes towards the vision of the project. It can be noted that this alignment was not there at first and it took a while before HMC tried to establish this internally – as stated by HMC's facilities manager:

> *"'We'll just make alternative workplace strategies work', is easier said than done. You need time to implement it. And this organisation [HMC] made us [facilities] responsible for implementing and that's difficult. Senior management needs to take charge and say: 'this is the way to go and we decide'.* – Siera, 2015.

So looking at HMC internally, corporate focus was not on a collaborative process. Collaboration was established though due to the approach of both the developer and the general contractor. The corporate focus of these two parties was explicitly on collaboration – grounded within a construction team approach (Korpershoek, 2015; Diepenhorst, 2015). The role of technology at the strategic level had some aspects of collaboration due to the application of BIM like software by the developer (Korpershoek, 2015). On a strategic level lastly the vision of the project did not contain a collaborative process. It focussed on a building where collaboration was to be facilitated, but no process requirements for collaboration were formulated. This can be seen from the process design that is completely centred around HMC's requirements which does not lead to a collaborative environment.

Collaboration elements:

Within the collaboration elements cross-functional activities were not present. As can be seen from the process design (Figure 36), a rather traditional functional separation was applied. Information exchange mainly happened via the developer, but the process did not involve the complete team from the start and did not easily allow for cross-functional activities. Another collaboration element deals with joint decision making. Since all actors agreed that HMC had decision making power, the case did not contain *joint* decision making. The decisions HMC had to take however were always due in time to optimally support the planning of the project (Siera, 2015; Diepenhorst, 2015). Collaboration elements also deal with performance standards for the supply chain as a whole. The main effort to improve the supply chain was put into the sustainable demolition. Van Es (2015) however explains that no serious innovation happened here since one has to deal with the (lobby) power of material suppliers. Their processes and BMs are not made to fit recycled content so they try to protect the current production methods. According to van Es (2015), suppliers influence updating of regulations to inhibit recycling of already applied materials:

> *"(The supplier industry) is not awaiting large scale application of (e.g.) existing insulation materials. And also here rules and regulations are updated so existing insulation materials don't comply anymore, so you have to buy new ones. That's how it works."* – van Es, 2015.

A final collaboration element is the contract. In these contracts best effort obligations were used for obtaining the BREEAM certificates. Apart from this no innovative contracting was applied during the project. It was however also mentioned here that you don't have to prescribe everything in a contract. Collaboration is about wanting to achieve something together and this does not always have to be reflected into contracts (Leijnse, 2015).

Cultural elements:

Trust was established as confirmed by all interviewed stakeholders. It was described as a way of working and the creation of a certain atmosphere where trust can grow (Korpershoek, 2015; Hoeben, 2015). More practical ways of establishing trusts that were applied are showing each other your 'world' as done by developer and client:

> *"They [HMC] know about offshore and about ships, but not so much about buildings. Se we [Delta Development Group] were taken to their ships and we showed them our buildings."* – Diepenhorst, 2015.

Moreover in both the construction team and the interior team several meetings were planned to discuss the process instead of the content. This is exceptional in the building sector and contributes to the development of trust by actually talking about the process and potential issues between parties. This was considered to be an essential element in this respect (Leijnse, 2015). Moreover on the cultural side of the collaboration, openness and a communication strategy were present. Delta Development Group secured this by support from Lendering & Partners who chaired meetings, provided structure and information and checked upon progress (Hoeben, 2015). A final cultural element is mutuality which was partly present. Mutual risks were identified upfront and agreements around responsibilities were made (van Es, 2015). Since none of the actors involved in design and construction was financially responsible, they did not share in risks which does not contribute to mutuality.

5.3.4 Analysis: vision aspects

Vision aspects are analysed according to (1) vision image, (2) vision guidance and (3) vision orientation via motivation, inspiration and direction (van der Helm, 2009).

Vision image

Vision image includes an analysis along (1) metaphors used and (2) explicitness. Contrary to the working of the vision in the previous cases, this case did not make use of any metaphors. The vision moreover was not made explicit in words: "we never saw or made a real vision on paper" (Siera, 2015). This (lacking) paper vision mainly considers the client requirements about central values of team working and connection. This however does not mean that the vision is not reflected in the final design for the building. The sustainability aims on the other hand were an explicit part of the vision. Altogether, the image of the vision did not stimulate to change current practices.

Vision guidance

This guidance or influence on behaviour can be analysed on (1) clear collective goals, (2) presence of alternative rule sets and (3) leadership (van der Helm, 2009; Quist, 2007).

Collective goals:

The aim of achieving the BREEAM certificates was a collective goal for all parties. This goal was also stated in the contracts, resulting in a collective search for a solution (Hoeben, 2015). In this search discussions then arose around where to gain BREEAM points. The choices made to achieve those points were mostly shared, although some different insights still exist among actors involved.

Alternative rule sets:

The vision for the new HMC office does not contain major new rule sets. The main rule set it proposed to change considered demolition practices by participating in the pilot of the DGBC. It turned out that during this demolition process no new practices were applied, but the process only needed to be documented extensively. The vision upon the process design can be described as fitting in the current rule set around (sustainable) building.

Leadership:

The sustainability part of the vision links mostly leadership. This part was established by the developer and in this way the vision showed some authoritative aspects. Diepenhorst (2015) also explains that they indeed managed to convince the client to invest in sustainable measures. This was mainly based on facts and financial impacts of sustainability measures that Delta Development Group collected during their previous experiences. The 'leading' qualities of the sustainability part of the vision are thus derived from historical records of the developer.

Vision orientation

Motivation, inspiration and direction are among this vision orientation. Some motivational influence can be described to the vision. This mainly relates to the BREEAM ambitions, both within the demolition and in the building itself. Since the demolition certificate would be the first to be assigned to a demolition project, this worked most motivational for the actors involved - as explained by the demolisher:

> *"By contract it could mean a financial cut down if we did not reach the targets, but since we agreed to go for those four [BREEAM] stars we just did it. So just go for it and keep your promise."* – van Es, 2015.

Inspiration refers to the central message of the vision, but since no central messages or metaphors were used in this case, the vision did not work in an inspirational way in taking actors with it in its belief to change material reality (van der Helm, 2009). A final aspect of the vision to be analysed is its provision of direction. The main direction the vision provided is in the steps to take in obtaining the BREEAM certificate. This guidance however is linked to rationalised goals instead of a tension between 'what is' and what could be' (van der Helm, 2009). The vision thus did not provide direction as indicated by van der Helm (2009).

5.3.5 Analysis: learning

The analysis of higher order learning will look into (1) a shift in defining or framing problems and a perceived coupling to technology or society; (2) a shift in problem solving approaches; (3) the level of dominant interpretive and cognitive frames; joint learning and shifting joint opinions among the actors involved. Next to these aspects of higher order learning, first order learning certainly occurred among the individual consortium actors and within Alliander. Examples of this first order learning are for instance understanding of the principles of BREEAM or sustainability or additional technical knowledge about new technologies (Hoeben, 2015; Korpershoek, 2015)

Higher order learning: framing the problem

A shift in framing the problem was not directly present in the construction team. The majority of the interviewed team members mentioned they did not change their interpretation of the project as initially presented to them. This can be clarified because they are either used to interpret the problem from out of different roles and perspectives or they stick to their original interpretation of the problem. One of the actors even stated that hopefully some parties learned to look beyond existing boundaries. The general contractor however did change its problem definition as stated below:

> *"I learned about the benefits and opportunities behind those buzz words [of CE and lean methods] (…) I got to know the principles and at the same time you see the threats to these developments."* – Korpershoek, 2015.

Higher order learning: problem solving solutions

This form of learning took place. Actors learned to change their problem solving approach. Together as a team they learned about the benefits of collaboration. The collaborative approach in this case was different from standard building processes due to its focus on creating trust and involving actors even in process meetings:

> *"I realised it helps to think about it (the BREEAM certificate): you need each other. So collaboration is certainly needed."* – Leijnse, 2015.

On the other hand it was also stressed that improvement is still possible in the problem solving approach. It was learned that it is important to involve all actors even more early on in the process (Korpershoek, 2015). The process also did not incorporate a multidisciplinary focus: everyone had their traditional role and the developer made sure everything fitted together (Diepenhorst, 2015).

Another aspect of the problem solving approach was decision making. HMC is a pragmatic company with a decisive approach. Delta Development Group learned from this approach. HMC on the other hand learned to delegate certain tasks. They are used to pursuing their own course, but during this project they learned they cannot do everything on their own and that additional expertise can be beneficial (Siera, 2015).

Higher order learning: joint learning and joint opinions

At the level of joint learning and joint opinions actors mentioned that learning did not take place. The only one that slightly changed its opinion based on joint learning is HMC. This learning mainly relates to their investments in sustainability measures while upfront these were not part of their requirements for the new building. They were convinced by Delta as a developer based upon facts that affirm financial benefits:

> *"It is examined that employees who overlook a green roof while they are having a coffee break are 30-40% more concentrated afterwards than employees looking over a standard roof. And we also showed at Park 20|20 that sustainable buildings lead to a 25% decrease of internal email traffic."* – Diepenhorst, 2015.

5.3.6 Analysis: Business Model

Based on the literature search in Chapter 3 the BM will be analysed according to (1) an introduction into the value creation, delivery and capture; (2) innovative circular aspects; (3) collaboration as part of the BM; (4) a reflection on the implementation of the initial ambition with regard to value creation as a future improvement of the BM.

Introduction: value creation, delivery and capture

The value created can be analysed along two main aspects: the demolition and the newly established building. The demolition created value in its contribution to the development of the certificate. The value of the certificate in turn can be described as offering a common language for sustainability in demolition activities, measuring impact of a sustainable demolition and stimulating reuse of materials derived from demolition (BREEM-NL, 2013). The central value that was created in the new development is a building that can host HMC for the next 20 years: it suits their needs and is flexible and adaptable on top of that (Diepenhorst, 2015). The building moreover has a sustainable value in its decreased cooling needs, economic energy use and waste separation for instance (Korpershoek, 2015). These values are delivered by means of design principles applied and BREEAM checklists used.

With regard to value capture, the demolition showed how material value is captured. Since the old building was not designed for disassembly, the demolition overall could still be regarded a loss instead of a profit. Within this loss however the value of the materials is already taken into account. The demolisher discounted this value in his contract price, so the client partly pays in natural capital via building materials (van Es, 2015). The biggest demolition streams in this case considered concrete rubble and steel reinforcements. Around 10.000 to 13.000 tonnes of these materials were 'captured' during the demolition (van Es, 2015). The value of the new building is captured in a very traditional way: an investor invests in the building and rents it to the client: HMC.

BM Innovation

The BM applied is compared to the strategies for CBMs as presented in Table 13 (Chapter 3). In the technological category some value is created from waste. This was mainly done via the demolition process where streams of demolition material were sorted and transported back to industry again to be reused, remanufactured or recycled. Moreover some C2C materials were used that could (in principle) create value from 'waste'. Another technological archetype applied is substitution with renewables. This mainly holds for the energy used for heating the building and its tap water. Electricity demand is reduced but is not provided on a completely renewable base.

On the social side the archetype of delivering functionality is applied for the thermal energy storage which is completely operated by Eneco while HMC uses the renewable heat and cold provided by this system. Moreover, by focusing on green roofs, walls and protecting existing greenery, a contribution is provided to biodiversity protection. This is an example of the archetype adopting a stewardship role. Organisationally the building is made for flexible working and alternative workplace strategies. This is an example of repurposing the building for society.

Collaboration as part of the business model

Although collaboration between different parts of the building supply chain and the client was a focus point in this case, collaboration however was not part of the BM. The construction team model grounds collaboration, but it does not link collaboration to financial incentives to stimulate this collaboration even more.

Reflection on used business model

When reflecting on BM innovation applied, it is noted that quite some improvements can still be made in getting to a circular building and supply chain. The categories of improvements are marked in Table 23.

Technological		Social			Organisational			
Optimise material & energy efficiency	Create value from waste	Substitute with rene-wables	Functiona-lity over ownership	Adopt a steward-ship role	Slow consump-tion	Co-creation	Repurpose for society/ environ-ment	Develop scale-up solutions

***Table 23** – Future improvement areas for the BM of the HMC Head Office in Leiden.*

Technologically, optimisation can be applied around lean manufacturing. As explained be the general contractor:

> *"It's best to remove all activities that do not add to value creation. Let's say I need a façade; then I will call my preferred supplier and he will automatically transfer money from our bank account without having to send an invoice, because that does not add value. The thing is: how do you assure he will do this honestly? It is not possible to have zero failure costs; these are inherent to building. Continuously optimising the process however is essential, so you have to keep talking."* – Korpershoek, 2015.

Another technological improvement is the creation of value from waste. Take back management of demolished materials can be improved here. This relates to either sorting the streams locally on site or centralised in sophisticated factories. BREEAM promotes local sorting of waste streams, but this requires a lot of human labour and space on the building site to place around twenty different containers. This space is often not present in city centres making it difficult to obtain BREEAM demolition certificates here (van Es, 2015). Moreover, additional separate transport of these sorted waste streams is needed, leading to additional costs and air pollution. The market can find an optimum:

> *"If you transport demolition waste over big distances, you make losses or burn profits. So when drafting sus-tainnability norms, you can rely on the entrepreneurial spirit of executing parties. That's also why you don't have to subsidise it: people will only drive additional miles and burn government money."* – van Es, 2015.

A final technological improvement has to with substitution of renewable sources. Since only the heating system relies on renewable energy, an improvement would be to also facilitate the usage of renewable electricity sources.

In the social archetypes a first improvement is the application of more functionality models like lease constructions. Diepenhorst (2015) explains that relatively little lease contracts have been applied here due to the image of lease. Lease is associated to be a solution for those who actually cannot afford to purchase and invest directly. Since HMC had the budgets, they wanted to invest instead of leasing assets. Very often this argument is supported by budget reservations of organisations. Since certain project budgets are already reserved for a renovation for instance, it will be difficult for accounting systems to change this (Cramer, 2015). A last social archetype to be improved deals with adopting a stewardship role. Resource stewardship via material passports for instance was not applied in this case and this can contribute to value capture of the material streams over time.

In the organisational category a focus on co-creation can yield additional results. Co-creation as seen in the Alliander case was not applied leading to a more traditional process and less technical innovations. Moreover collaboration can be coupled to financial incentives as also explained in section 5.2.6.

5.3.7 Conclusion and discussion

Comparing the analysis to the conceptual framework, the conclusion can be drawn that in this case the main contribution has been on the cultural elements among actors involved and the network established. The HMC case is based on the vision of a building that facilitates team work and communication. The sustainability influences are derived from BREEAM-NL guidelines around demolition and newly built projects.

The **network** established connects different private actors with some public ones. The most important activity in the network is the intermediating role of the developer. The project brings resources gained from the demolition back to industry again as is the current practice in the building industry. Some C2C and traditional material resources have been applied. For the cultural elements in the conceptual framework (see Figure 39 on the next page) it can be concluded that openness, a clear communication structure, trust and some mutuality were present. Trust was

developed by taking each other on a tour in each's "world" and by several meetings to actually discuss the process. This is exceptional in the building sector, but it is an effective strategy to create trust. The project however did not facilitate the collaboration elements due to the application of a rather traditional functional separation in the process design. The strategic elements of supply chain collaboration were also only marginally supported.

For **learning and visions** some correlations can be drawn. The vision did not contain metaphoric aspects to influence thinking. Actors in this way were not stimulated to broaden their framing of the problem, so no higher order learning took place here in framing the problem. The vision partly influenced behaviour due to some authoritative aspects and clear sustainability goals projected along BREEAM. The vision however did not provide alternative rule sets: it is based in current building practices. This relates to higher order learning about problem solving solutions were actors learned about the benefits of a collaborative approach, but also mentioned some improvements (involvement even more early on and a more multidisciplinary approach). The vision finally provided motivation to actors, but no inspiration and guidance were given. This is also why no joint learning took place: the vision did not challenge major cognitive frames of actors.

For the **business model** applied it can be concluded that two main values are created: a contribution to the demolition sector via the first BREEAM certificate for the demolition and a sustainable building that fits the needs of its users and is flexible so these needs can be fulfilled for at least the coming twenty years. Within the case aspects of all three main sustainable BM archetypes are applied, but the project also provides ample room for improvements here. Among these improvements is a focus on lean manufacturing where all activities that do not add to value creation will be diminished or removed. The image of leasing construction related to business operations of clients is another improvement together with developing a more efficient way to create value from waste than separating all demolished or disassembled materials on site.

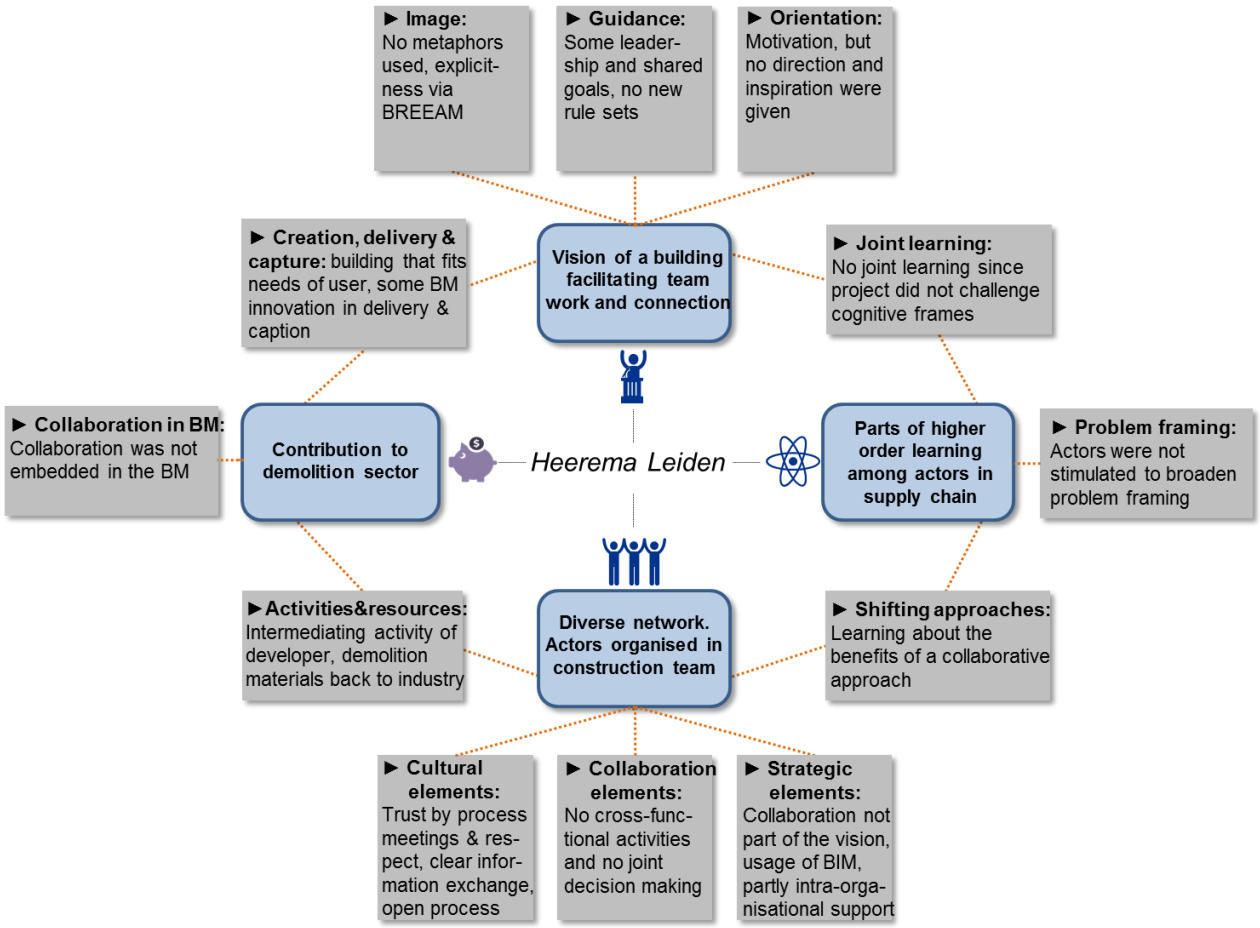


Figure 39 *– Conclusion for supply chain collaboration at HMC, Leiden.*

6. Cross Case Analysis and Lessons Learned for Circular Supply Chain Collaboration

In the previous chapter the concepts of visions, learning processes, actor networks and business models of circular supply chain collaboration were analysed in detail based on three case studies. These details support in understanding the key aspects of circular supply chain collaboration. In this chapter the findings of the previous chapter are used to describe circular supply chain collaboration. Therefore this chapter will firstly present a cross-case analysis in section 6.1. Section 6.2 will look into the broader implications of these findings for a circular building sector. These lessons learned, drivers and barriers and the transition towards CE in the built environment will serve as an input for the tool to be developed in the next chapter.

6.1 Understanding Circular Supply Chain Collaboration

Before analysing the elements that constitute circular supply chain collaboration, a definition of the supply chain in light of this research will be given. This supports in an understanding of the topic. Supply chains in this thesis are regarded as a network of businesses. These supply chains in the building sector are established per building project where they coordinate material and information flows with the aim of establishing a building. This leads to the following definition of a supply chain:

A supply chain is a special type of network involving material and information flows, established around a particular (building) project.

With this definition in mind, the cases studied in the previous chapter will be compared. These cases reveal both similarities and variation in their establishment of supply chain collaboration. The description will follow the four main concepts of actor networks, visions, learning processes and business models. Actors were moreover asked to prioritise these concepts. This prioritisation shows a basic process design of where to start when realising a circular building supply chain. The understanding of circular supply chain collaboration will thus be presented in this order. Vision development is prioritised by most actors (see Appendix C) followed by the network and collaboration established. Then the business model and learning processes follow, but some actors also mentioned the importance of an integrated whole: "*it is not one thing: it is the combined optimum*" (Niehof, 2015).

6.1.1 Vision development of a circular building (process)

The first step in circular supply chain collaboration is vision development. This was confirmed by thirteen out of eighteen interviewees (see Appendix C). This also relates to the amount of influence one has at the start of a building project (van Zantvoort, 2015). In the initiating phase the improvement potential (for collaboration) is highest (see Figure 6). There is a need for leadership among principals of projects from both public and private parties. This leadership exactly links to vision development, because principals can raise ambitions and ask for circular buildings and a collaborative process. This instead of the current practice of showing an over-specified list of requirements. The main similarities and differences per case will be explained in more detail subsequently.

Main similarities

Main similarities are analysed according to vision development sketched in the case introduction in chapter 5 combined with the three categories used in chapter 5: (1) vision image, (2) vision guidance, (3) vision orientation. When looking at the way the cases studied dealt with **vision development**, some main similarities can be found. The origins of the three visions all relate to the actual initiators of the building activities. In the Park 20|20 project, the developer initiated the building activities and thus the vision, while in the other two cases the actual users of the buildings initiated these aspects. Vision development consequently worked quite similar for Park 20|20 and Alliander: they both involved stakeholders with relevant knowledge to help them realise their vision. This was most explicit in the Alliander case where the tendering process even consisted out of a vision from participating parties on Alliander's initial ambition. In the HMC case stakeholders were not involved in vision development.

Some additional similarities can be identified between the functioning of the **visions image** where metaphors and explicitness have their role. Metaphors were used in both the project for Alliander and in Park 20|20. The metaphors are even related to each other: they both change our interpretation of the nature of a building: from immoveable property to a temporal storage of material value. The Alliander case even added the spin-off effects of the 'building as a catalyst for sustainable area development'. The second image aspect of explicitness was present in all 3 cases, but was established in different ways that will be explained in the next part of main differences per case.

Vision guidance entails the aspects of collective goals, leadership and the establishment of alternative rule sets (van der Helm, 2009). Collective goals were present in all three cases, guiding the collaborating actors. Implementing the vision into a real building however requires choices to be made and around these choices different opinions arose in all three cases. Another comparative element for vision guidance is the establishment of alternative rule sets as present in the Park 20|20 development and the project for Alliander. Since these rule sets are closely linked to higher order learning about joint opinions, the established rule sets follow in section 6.1.4.

Vision orientation is achieved via motivation, inspiration and direction. Motivation relates to the establishment of a team that wants to be part of the design of the future and this was present in all three analysed cases. Inspiration refers to the central message of the vision and the belief of actors involved to change the current situation to what is stated in this central message. Inspiration in this way was provided in the cases of Park 20|20 and Alliander. The inspiration needed some time to establish but actors internalised the ambitions during the process. Direction of where to go and what to do (not by means of exact aims such as BREEAM checklists) was provided in the Park 20|20 case and Alliander case as well.

Main differences

A first main difference in **Park20|20** is the origin and contents of the vision itself. The vision for Park 20|20 originated from an idea of the CEO of Delta Development Group, inspired by the William McDonough and his C2C philosophy. The vision therefore entails the development of the world's first full-service C2C business park. Compared to the other cases, Park 20|20 used its own method to make the vision explicit (this belongs to vision image). In this case actors made use of storytelling based on a vision booklet and a roadmap. Leadership moreover (as part of the vision guidance) was most clearly present in the Park 20|20 case where two essential people pursued in the realisation of the vision: Delta's CEO Coert Zachariasse and C2C founder and architect McDonough.

For **Alliander** the origin and contents of the vision are different compared to the other two cases. The vision is based on Alliander's mission of connecting to its environment and aiming to be the best service provider. The vision in this way focuses on this connection and on circularity. Moreover for the project in Alliander an integral approach should be applied. In the Alliander case another way to make the vision explicit (vision image) was used. Here measureable aims around circularity of materials and energy were used. Compared to the other two cases, in the Alliander case no direct authoritative aspects (part of vision guidance) were present since the vision was created in collaboration between Alliander and market parties. It however takes leadership to start such an innovative tendering process. For the vision orientation element, inspiration in this case performed well because actors internalised the vision and even increased the ambitions for the project.

In the **Heerema** case another origin for the vision and different contents of the vision can be found. The project is based on the requirements of HMC as a client. This means the building should accommodate team working and communication between HMC employees. Moreover sustainability criteria were added based on BREEAM. BREEAM certificates were to be collected for both the building itself and for the demolition process. In the vision development in the HMC case, stakeholders were not involved in vision development. With regard to the vision image, the HMC case did not provide metaphors in the way the other two cases did. The vision image was made explicit by means of BREEAM NL, which is also different from the strategies of the other two cases. In its vision guidance, the HMC case revealed some authoritative aspects around sustainability because originally this aspect was not among the clients' requirements. Moreover no alternative rule sets were established since the HMC case is much more based on current building practices, compared to the other two cases. A final difference around vision orientation is the fact that direction was not established in the HMC case. This relates to the usage of BREEAM with checklists instead of a more abstract notion of where the project wants to go that was present in the other cases.

The main differences and similarities for visioning in the three different cases are summarised in Table 24.

	Park 20|20	Alliander – Duiven	Heerema Head Office
Vision origin/contents	Vision based on C2C philosophy.	Vision based on Alliander's mission: connection & circularity. Integral approach.	Vision based on requirements HMC and BREEAM-NL demolition pilot.
Vision development	Involving stakeholders to support in realising vision.	Involving stakeholders to help both developing and realising vision & process	No stakeholders involved. HMC decided.
• Vision initiated by:	Developer.	User (Alliander).	User (HMC).
Vision image	Influence via metaphor of building as material bank.	Building as catalyst & building as moveable property.	No metaphors were used.
• Metaphors:			
• Explicitness:	Explicit vision via a vision booklet (storytelling) and roadmap.	Explicit via 80% circularity of materials, net positive energy building.	Sustainability part of the vision was made explicit via BREEAM.
Vision guidance			
• Collective goals:	Presence of shared goals.	Presence of shared goals.	Goals were mostly shared
• Leadership:	Leadership of Delta's CEO & C2Cfounder McDonough	Leadership to pursue in realising the vision.	Some leadership in sustainability part of vision.
• New rule sets:	Vision results in new rules.	Vision results in new rules.	No new rule sets.
Vision orientation	Influence via motivation of developer & architect	Influence via motivation: seen in availability of team.	Vision of first BREEAM demolition was motivating.
• Motivation:			
• Inspiration:	Actors gradually got inspired by the project.	Actors internalised vision and got inspired.	Actors were not inspired.
• Direction:	Presence of direction.	Presence of direction.	No direction was given.

***Table 24** – Comparison of functioning of the vision concept for three case studies.*

6.1.2 Actor networks and collaboration aspects

Whenever the vision is developed to support a circular building and building process, collaboration needs to be established as indicated by interviewees (see Appendix C). The importance of involving the right parties or people and connecting them was named multiple times. A need to facilitate these connections in the whole building supply chain is visible. Who to involve relates to the cultural aspects of supply chain collaboration. As van de Broek (2015) puts what is needed here: "commitment, energy, creativity, an open mind and knowledge".

Main similarities

Main similarities are analysed according to the elements in chapter 5: (1) network composition, (2) a description of resources and activities in the network and (3) the actors involved and their relationships. This final category involves three levels of elements: cultural, collaboration and strategic elements.

Considering **network composition**, all cases developed diverse networks although different accents in involving public parties are present. This relates to the private character of Delta as a developer, involved in the cases of Park 20|20 and HMC, whereas Alliander is a semi-private entity. With regard to the main collaboration type used, the two Delta cases applied the 'construction team model'. Spin-off effects in the network can be identified in the Park 20|20 case and in the project for Alliander. When plotting the network or supply chain involved along the real estate lifecycle, it became clear that in Park 20|20 and Alliander most innovation took place. Here additional expertise was integrated upfront via participation of clients, different building disciplines or suppliers.

With regard to **resources and activities**, an essential activity is to facilitate the connections in the supply chain - as fulfilled in all three cases. This connecting activity was performed by the initiating parties Delta Development Group (Park 20|20 and HMC) and Alliander. Next to these essential activities, resources need to be present in the

network. When looking into resources, all resource categories (material inputs, financial capital, technology, knowledge and labour) were present in all cases. The material inputs in the Alliander and HMC case were widely available because they dealt with mainly traditional building materials - whether or not reused/recycled.

Looking at **actors involved and their relationships**, supply chain collaboration needs to be facilitated along three elements: the cultural elements of the individual actors, collaboration elements and strategic elements. Within these elements, all cases performed well, although in each case the collaboration was set up differently. For the collaboration elements Park 20|20 and the project for Alliander showed a similar approach. They both facilitated joint decision making and process alignment. In all cases studied almost no innovation took place around contracts while many actors confirmed the relevance of 'circular' contracts (Roelofs, 2015; van Oppen, 2015; Kragtwijk & Warmerdam, 2015; Hoeben, 2015). What is needed in general in these contracts is a focus on the collective performance instead of the current focus on detailed specifications and externalising responsibilities. For the strategic elements the Park 20|20 and Alliander case embedded collaboration in their visions. In the strategic elements, the Park 20|20 project and the Alliander case also deal with technology to support the collaboration. BIM is such a collaborative technology as applied by the Alliander case and Park 20|20.

Main differences Park

For the resources used at **Park 20|20** high standards around C2C materials were set, leading to a small base of specialised suppliers. This as opposed to the widely available resource bases for the other two projects. Another difference is noted when looking at actors and their relationships along the cultural elements. Trust for instance was developed by providing certainty to participating parties that they would be involved during the complete park development. This was possible here due to the scale of the project with multiple buildings to be realised. Park 20|20 also used a distinct communication strategy with the general contractor as a central contact point. Trust in this project moreover has a historical reference in the collaboration at senior level between the three investing parties Delta Development Group, Reggeborgh and VolkerWessels.

A first main difference for the **Alliander** project is its collaboration type based on consortia, as opposed to the construction teams applied in the two other cases. Looking at this concept, it can be noted that the Alliander case had a clear focus on collaboration and showed most innovative solutions here. In the cultural elements this case mainly innovated around transparency, information exchange and trust. A clear information exchange policy was established since the tendering process involved an extensive amount of market parties, that all needed access to the same information. The process was very open and trust was established by Alliander showing its vulnerability: by admitting they do not know how to reach their ambition and asking the market for help, they initiated the establishment of trust. In the collaboration elements Alliander moreover facilitated cross-functional activities in its process design with different working groups combining both expertise from Alliander employees and the consortium. The contracts used here are DBMo contracts that make the consortium responsible for design, building, maintenance and part of the operation. Along the strategic elements, Alliander even made this vision of a collaborative process part of their tendering selection criteria. Alliander moreover put effort in establishing intra-organisational support by hiring a consultant to create this support within all parties involved in the project.

The project for **Heerema** showed a different approach in embedding cultural elements. Trust was established by showing each other ones "world". Moreover process meetings were held to discuss potential issues between collaborating parties. The HMC case however did not facilitate collaboration elements due to the application of a rather traditional functional separation in the process design (see Figure 36).

The main differences and similarities for actor networks in the three cases are summarised in Table 25:

	Park 20|20	Alliander - Duiven	Heerema Head Office
Network composition	Diverse network with little governmental actors.	Diverse network.	Diverse network: private actors & some public.
• Collaboration type:	Construction team model.	Co-creation between client and consortia.	Construction team model.
• Spin-off:	Spin-off in the network.	Spin-off in consortia.	No spin-off.

• Innovation in lifecycle	Involvement of clients, contractor(s) and suppliers upfront. Also involved re-research institutes and software developers.	Involvement of building & maintenance disciplines and client upfront. Also involving research, social workers and surroundings.	No direct innovation; client is somewhat more involved and general contractor assists in demolition.
Essential activities	Connecting role of developer: bringing supply chain together.	Facilitating role of client: design for an innovative collaborative tendering approach.	Intermediating role of developer.
Resources	C2C material resources with only limited suppliers present.	Over 80% circular material resources: reused and recycled resources.	Some C2C and traditional materials. Material from demolition feeded back to industry again.
Strategic elements			
• Collaborative vision:	Collaboration as part of the vision to realise aims.	Collaboration as part of vision in selection process.	Collaboration was not part of the vision.
• Intra-organis. support & process alignment:	Present at developer; developed in chain as well.	Hiring a consultant to create support&alignment.	Only gradually developed at client; present in team.
• Role of technology:	Support of BIM technology.	Support of BIM technology.	Support of BIM like soft-ware.
Collaboration elements			
• Cross-functional act.:	Present via project team & sounding board sessions	Clearly present via meetings &working groups	Not present: traditional functional separation.
• Joint decision making:	Present in team that was put together from start	Present in tendering, reali-sation needs improvement	No joint decision making because client decided.
• Contracts:	Standard building contracts.	DBMo contract.	Standard building contracts.
Cultural elements			
• Trust:	Established via provision of certainty and selection.	Initiated by client showing vulnerability & asking help.	Established by process meetings and respect.
• Mutuality:	Benefits&risks are shared.	Keeping same players in both design & realisation.	Some of the risks were shared and discussed.
• Information exchange:	Short and clear lines of communication.	Clear information exchange policy.	Hiring a management firm to assist in info exchange.
• Openness:	Open and transparent process.	Open and innovative (tendering) process.	Open process.

***Table 25** – Comparison of functioning of actor network and collaboration for three case studies.*

6.1.3 Business models for a circular supply chain

The third step in establishing supply chain collaboration is to use the right incentives in the business model. Especially in a rather traditional sector like the building sector, changing BMs is quite a challenge. There is a need for courage of actors to question current BMs (van Oppen, 2015). Business models are important enablers for the implementation of supply chain collaboration and CE in the building sector (Roeloefs, 2015; van Tuijl, 2015; Diepenhorst, 2015). In these BMs, values that contribute to circularity and sustainability have to be central – translated into a financial model that incentivises these values. These values thus transcend traditional corporate value creation that mainly focuses on financial value. A BM for a circular supply chain needs to take positive environmental and societal value into account as well as reflected in the TTL approach (see also section 3.6.2).

Main similarities

Main similarities are analysed according to the elements presented in chapter 5: (1) description of main value creation (2), circular BM strategies applied (3) collaboration as part of the BM and (4) future improvement of the BM.

When comparing the **value creation** activities of the three analysed cases, it is noted they all had a focus on positive impacts according to the TTL approach. When looking at **circular BM strategies**, the cases studied all showed progress around BM innovation and applied several of the strategies mentioned in Table 13. In a circular supply chain

the (technological) strategy of creating value from waste is essential and this strategy was indeed applied in all three cases. Due to the different starting points of the different cases (e.g. newly built, renovation or demolition) this value was created in different ways. In general it can be stated that when building a new project, the value of materials can be maintained by preventing they will become waste. This is to be done by using material passports and via design for disassembly. When renovating, value can be created by reusing or recycling materials from the building under renovation. In a demolition project value can be created by selling these materials to new users or back to industry again. Related to this strategy is the social BM archetype of delivering functionality over ownership as also applied in all three cases. Via orienting the BM on use, product or performance, the temporal character of a building can be facilitated and supply chains can be closed. Besides these two common strategies, the cases all had their own focus but incorporated strategies from the three main categories. In the Alliander case and the Park 20|20 most BM innovation took place.

Looking at the connection between supply chain **collaboration and the BM applied** it can be noted that none of the cases actually embedded collaboration in their BMs. The idea of using incentives to guard and ground collaboration in the BM was named several times however (Grosfeld, 2015; Korpershoek, 2015; van Oppen, 2015). In such a model the interests of all stakeholders should be taken into account and the collective goal (of a circular building) should be the incentive. This means financial rewards are coupled to the achievement of the collective goal. In this way actors involved need each other and this will secure supply chain collaboration – even over longer time frames. Grosfeld (2015) explains how to steer actors based upon the following idea:

> *"A kind of matrix of different values in bigger or smaller circles and whenever I place them on top of each other for the whole project, you can look through it: all elements have to be of the same size. If that works and we can steer people based on this we have achieved something."* – Grosfeld, 2015.

Coupling collaboration to the BM is one of **the improvements** for all cases. Moreover additional options for improvement came up that differ per case (see below).

Main differences

In its value creation **Park 20|20** shows most progress in creating positive impacts. The project has a clear focus on creating positive impacts in the quality of the buildings, established via cascades of circular value propositions around C2C materials. At Park 20|20 moreover an attempt was made to incorporate collaboration in the BM used via the innovation programme of suppliers. This however is not the incentive scheme mentioned as an ultimate solution here, but most progress can be ascribe to the attempt compared to the other two cases. At Park 20|20 finally additional research was named to improve the BM. This research deals with both the building as a material bank concept and the focus on people and productivity. There is a need to measure the impacts of C2C materials on people and productivity and to look for ways to monetise future material value today. Moreover software solutions were named to improve the material bank concept and to track all the material value. A final improvement is to expand the C2C certification and thus transparency around suppliers.

For the **Alliander** case, the positive impact at the value creation is slightly different compared to the other cases. Here the focus is on creating a building that is circular and on creating a positive impact via its iconic influence in the surrounding area. Some additional differences in this project lie in the improvements for the BM. More value from waste can be created in improving the 'Industrial Symbiosis' via more follow-up in the area. Moreover the energy efficiency of the building can be improved by conditioning only certain parts of the building when less people are present and getting everyone to work in these acclimatised parts. The functionality can finally be improved by adding incentives (like more responsibility for the consortium and suppliers) to guard the performance of materials and products or extending the responsibility to the maintenance phase as well.

The value creation in the **Heerema** case differs since the project aims to contribute to the demolition sector via a pilot in sustainable demolition. The HMC building itself is supposed to have a sustainable value in fitting the needs of its user. The HMC case also shows different possibilities to improve the BM. Here it is proposed to use material passports and to substitute also the electricity generation by renewable energy solutions. A final BM improvement is to increase the amount of circular value propositions by improving the clients' image of pay per use or performance options.

The main differences and similarities for BM strategies in the three different cases are summarised in Table 26:

	Park 20|20	Alliander - Duiven	Heerema Head Office
Value creation	BM focused on creating positive impacts: cascades of circular value propositions.	BM focused on (almost) circular building with an iconic value in surrounding area.	Contribution to demolition sector and building that fits needs of its user (for coming 20 years).
BM strategies applied	• Create value from waste: C2C materials • Deliver functionality: both result, product and use oriented • Increasing functionality • Dematerialisation • Repurpose for society • Alternative ownership	• Create value fr. waste: IS, recycle, reuse, take back • Delivering functionality: PSS lighting system & DBMo contracts • Adopting a stewardship role • Substitution with renewables • Encourage sufficiency: ESCo construction • Co-creation	• Create value fr. waste: some C2C materials&demolition • Deliver functionality: energy supply • Adopting a stewardship role • Repurpose for society
Collaboration as part of BM	Not directly: suppliers were provided guarantee for purchasing via sponsoring programme.	Collaboration was not embedded in BM.	Collaboration was not embedded in BM.
Value missed/ improvements	• Create value fr. waste: optimise material bank concept in monetising mat. value and software solutions • Adopting stewardship role: expand C2C certification and thus transparency. • Repurpose for society: additional research into effects on people and productivity. • Co-creation via incentive scheme.	• Create value fr waste: even more follow-up in surroundings. • Optimise energy efficiency: condition only part of building. • Functionality over ownership: add incen-tive to guard mat. performance/maintenance. • Co-creation via incentive scheme.	• Create value fr. waste: improve take back of demolition materials. • Adopt a stewardship role: use material passports • Substitute with renewables: also green electricity • Deliver functionality: improve image of lease/use options • Co-creation via incentive scheme.

***Table 26** – Comparison of BM strategies used and improvements to be made for three case studies.*

6.1.4 Learning processes

Collective learning (higher order learning) occurs throughout the whole process and in this way should not be seen as a final step. It is an important element however in the pioneering situation of CE in the built environment. There is a need to record the outcomes of learning processes to facilitate the diffusion of circular building practices (van Zantvoort, 2015). One interviewee also responded that learning is important since it contributes to how to actually collaborate (Korpershoek, 2015). Learning is moreover related to some aspects of functioning of the vision.

Main similarities

Main similarities are analysed according to the aspects presented in chapter 5: (1) framing the problem, (2) learning about problem solving solutions and (3) joint learning on joint opinions. Comparing the different cases, it can be noted in all cases learning at the level of **problem solving solutions** took place. In the three cases actors confirmed they learned about a new (collaborative) approach. The new rule sets that are established via **joint**

learning based on the visions of both Park 20|20 and Alliander Duiven reveal a similar image: they show a new perspective of ownership of materials that are only temporarily stored in a building.

Main differences

Ideally, learning should take place at all three levels of higher order learning. Comparing the different cases, it can be noted this only happened in **Park 20|20**. Actors here firstly learned to frame the problem differently – extending their problem scope to include end-of-life options. Actors also learned about a new approach of multidisciplinary work where all actors are involved from the start of the project. This new approach can be seen as the 'eco-effective trajectory': initially it takes additional investment in aligning all actors on the vision, but this approach has more impact than the traditional approach of diminishing negative impacts. Joint learning finally took place around new rule sets that were established (linking to vision aspects). This new rule set includes a new perspective of ownership of materials that are only temporarily stored in a building.

In the **Alliander** case learning developed differently. Learning about framing the problem happened only marginally since the problem was already framed in an abstract way. Actors learned to broaden their scope for a new approach based on (1) thinking in disciplines instead of companies and (2) a continuous dialogue and personal connection. Joint learning did not happen since actors were already selected on their open cognitive frames.

In the **Heerema** case actors also only learned about problem solving solutions and the benefits of a collaborative approach. Other forms of learning did not happen due to the process design and the way the vision was conceived.

The main differences and similarities for higher order learning in the 3 different cases are summarised in Table 27:

	Park 20|20	Alliander - Duiven	Heerema Head Office
Framing the problem	Actors learned to extend their scope of the problem to include end-of life and reusing materials.	Some actors learned to broaden scope: problem was however already framed in an abstract way	Actors were not stimulated to broaden their framing of the problem.
Problem solving solutions	It was learned that a multidisciplinary approach is needed that involved all actors right from the start: requires additional investment at start.	Actors learned to broaden scope for new approach: • Thinking in disciplines instead of companies • Based on dialogue and personal connection.	Actors learned about the benefits of a collaborative approach, but also mentioned improvement around involving actors even more early on.
Joint learning	New perspective of ownership of materials that are only temporarily stored in the building.	Did not take place since actors were selected on their opinion (in favour of collaboration/innovation).	Did not take place since project did not challenge major cognitive frames of actors.

***Table 27** – Comparison of learning processes for three case studies.*

6.2 Comparative conclusion

Based on the comparative analysis, the performance of the different cases on each of the four concepts can be determined. For this comparison the three cases are rated for the different elements in the four analysed concepts. This comparative conclusion per concept also allows for a comparison of the overall supply chain collaboration for the three cases. This conclusion only takes the three studied cases into account and draws conclusions for their comparative performance.

Comparing vision development

Looking at visions in the first place, the vision development and influencing nature worked quite similar for the cases of Park 20|20 and Alliander. The visioning process (from development to orientation) of the project for Alliander however was most based on collaboration while in the HMC case collaboration around vision development was least embedded. This can be derived from an analysis of the different vision elements as presented in Appendix D. Based on this analysis it can be concluded that the Alliander case performed best for vision development due to their

extended collaborative vision development process and the establishment of actual internalisation of the vision by the consortium (the inspiration element as part of vision's orientation). Park 20|20 scored well overall, while the vision process for HMC scored negatively for five out of nine analysed elements (see Appendix D).

Comparing actor networks and collaboration aspects

For the actor network, it can be concluded that all three cases performed quite well according to all elements of the network and collaboration. The Alliander case however slightly outperformed the other two cases as shown in an analysis of the different network elements in Appendix D. Alliander for instance not only embedded collaboration in their vision, they moreover made this collaboration a part of the selection criteria in the tendering process. They actively worked on this new collaborative process with working groups per vision theme, co-creating the building together with consortia of building parties. Another innovation they applied was creating trust by showing vulnerability. This is rare in the building sector, but proved essential in their approach. The Park 20|20 case scored well overall in their establishment of the supply chain and the collaboration. The Heerema case performed well on the cultural elements in the network, but other parts were less developed compared to the other two cases. The complete comparison for the different network elements can be found in Appendix D.

Comparing business models

Regarding BM strategies it can be noted that Park 20|20 focused mostly on positive impacts and incentives to make money with these impacts (see Appendix D). Appendix D shows that Alliander innovated around these positive impacts as well. These two cases both performed well, while the HMC case shows most options for improvement. Collaboration was not directly embedded in the BM in all three cases. Alliander and Park 20|20 both started with ambitions for this embedding and Park 20|20 came closest to this aim with their innovation platform of collaborating partners that is also linked to financial incentives. The comparative analysis in Appendix D shows the performance of the three cases on the BM elements, leading to the overall best performance on this topic for the Park 20|20 case.

Comparing learning processes

The learning processes for the three different cases are compared on the different analysis elements in Appendix D. Based on this comparison, it can be concluded that the Park 20|20 case performed best because learning happened here at all three levels. Some learning also took place in the Alliander case, but most actors were selected on their open mindset, eliminating joint learning and shifts in framing the problem. This is why this case scores neutral on learning overall (see Appendix D). In the Heerema case lastly, learning only took place at the level of problem solving solutions, leading to a negative performance compared to the other two cases (see Appendix D).

Table 28 provides a general indication of the performance of each case on the four concepts that are part of supply chain collaboration as derived from Appendix D. This leads to an overall performance on supply chain collaboration for the different cases. Table 28 shows that the Park 20|20 case and the Alliander case both performed best on circular supply chain collaboration.

	Park 20|20	Alliander - Duiven	Heerema Head Office
Vision	**+**	**++**	**-**
Actor network	**+**	**++**	**+/-**
BM strategies	**+**	**+/-**	**-**
Learning processes	**+**	**+/-**	**-**
Overall supply chain collaboration	**+**	**+**	**-**

Table 28 *– Comparison of circular supply chain collaboration for three case studies (based on Appendix D).*

6.3 Lessons learned

Next to supply chain collaboration, a transition towards a circular building sector needs additional aspects to be changed. Actors were asked for the broader implications and lessons learned outside of the collaboration itself. Therefore the drivers and barriers for CE in the built environment will be described followed by changes needed.

6.3.1 Drivers and barriers for CE in the built environment

The main driver named is of financial nature. As also explained by EMF (2012), CE could lead to costs savings, risk reduction and thus financial opportunities. Actors learned it is possible to make a difference with existing financial means (Roelofs, 2015). This can be done by smart integration of circularity into processes and BMs (van Zantvoort, 2015; van Tuijl, 2015). Another financial driver are benefits circular buildings offer to selling real estate (van Es, 2015).

A second driver mentioned covers societal aspects. A circular built environment clearly contributes to society by reducing building waste, pollution and emissions and establishing healthy buildings. Society moreover drives the development of CE by its interest in circular and sustainable solutions (Leijnse, 2015; Hoeben, 2015). In other sectors changes are visible as well, for instance in the banking sector, also influencing society (Piechocki, 2014).

Organisational drivers are present as well, relating to some lessons learned for supply chain collaboration. Two main drivers are willingness, ambition and shared passion among building parties (Dwars, 2015; van Oppen, 2015) and secondly the presence of clients that require circular projects and/or processes (Niehof, 2015; van Steijn, 2015).

Government provides drivers as well via the development of circularity roadmaps and visions. These will lead to strict circularity requirements for all different kinds of projects, providing incentives for circular practices (van Tuijl, 2015). An example of this is the vision for a circular Amsterdam city and region, where roadmap provides support and direction for steps and measures the municipality can take (Kruk et al., 2015). This is one of the ways government can lead by example. They can moreover actively lead by pursuing circularity goals for their own buildings and purchasing programmes for instance. The various green deals government is now developing (see also 5.2.3) are another means to embed circularity in both public and private parties per sector.

Technically the main driver is the start of small-scale project to prove the (technical) concept and inspire others (Diepenhorst, 2015; Korpershoek, 2015).

Among the barriers financial aspects were mostly pointed out by actors. This despite the fact that these financial aspects also form the biggest driver. Their restricting impact is firstly related to the indurated character of the market today. The market is not willing to invest upfront - as needed to set up new circular projects based on a collaborative approach (van Zantvoort, 2015; Hoeben, 2015). Payback times were also mentioned as a barrier (Siera, 2015) and this links to the current financial structure that focuses on short term goals. Actors moreover experienced a lack of money as a barrier (Kragtwijk & Warmerdam, 2015; van Steijn, 2015; van Es, 2015). Some other actors however mentioned money is not lacking but it is currently invested in traditional projects instead of in circular projects (Grosfeld, 2015). A final financial barrier is the current BM of many building material producers. Virgin resources are the core of their business case providing them highest profit margins (van Es, 2015). This is why they currently inhibit the take up of recycled resources in their products.

Societal barriers were mentioned as well. Limited awareness and a lack of embedding of circularity in organisations were named (van Oppen, 2015). Moreover a sense of urgency is missing as explained by the demolisher that is active in the supply chain of building materials:

> *"If we could not get any pebbles out of the earth from tomorrow onwards, we would have reached a 100% recycling already. So the necessity it lacking completely. And we are active in some of these platforms […] but we're not in the position to change it. If we have to argue against Heidelberg cement – one of the biggest companies in the world – we will never win this argument. We are not more than a mosquito with bright ideas against a mammoth with a 100 year old habit" – van Es, 2015.*

On the organisational side the opposite of the driver was named: a lack of passion and shared interests of building parties. Moreover parties lack transparency and are not willing to share information, inhibiting the development of circular supply chains (Diepenhorst, 2015). The collaborative process that is essential in a circular built environment takes more time which is a major barrier. The realisation of a project moreover is more difficult

than in a traditional building project. This has to do with coordinating recycled and reused material streams for which supporting infrastructure is not (yet) in place (Roelofs, 2015). A final organisational barrier is the current split incentive in the building industry. Due to sub-contracting, separated responsibilities and ownership constructions for the different phases of the real estate lifecycle, different interests arise. These inhibit the establishment of collective (circular) ambitions to reach circularity in the built environment.

In the domain of government some major barriers were mentioned as well. Firstly, coherence is lacking between policy measures (Korpershoek, 2015). Employment agreements are an example here. When connecting different disciplines and activities in a circular supply chain, employees in one project might be part of different employment agreements. This leads to different wages or working hours for employees in the same project (Cobouw, 2016). Certification schemes are perceived as a second barrier due to the administrative hassle connected to them (Leijnse, 2015). Policies moreover are not (yet) supporting circularity in the building sector; mediocre ambitious guidelines were released in 2015, while for the waste and packaging sector binding legislation is in place (Crisp, 2015). These obligations on the other hand could inhibit the development of CE as well. When government obliges industry to reach certain performance criteria, industry will look for gaps in this legislation (van Tuijl, 2015).

Finally some technical barriers are present. Current demolition processes inhibit the transition since reuse options can be considered downcycling. An example of this downcycling is the widely applied solution of using demolished concrete as road fill. A final barrier deals with separating demolition waste for which a solution still has to be found: either sorting waste on a building site requiring a lot of human labour or sorting waste mechanically in a centralised plant requiring additional transport and energy.

Altogether quite some opportunities were identified for a circular built environment together with some barriers as summarised in Figure 40. The next section deals with the changes needed to overcome the barriers.

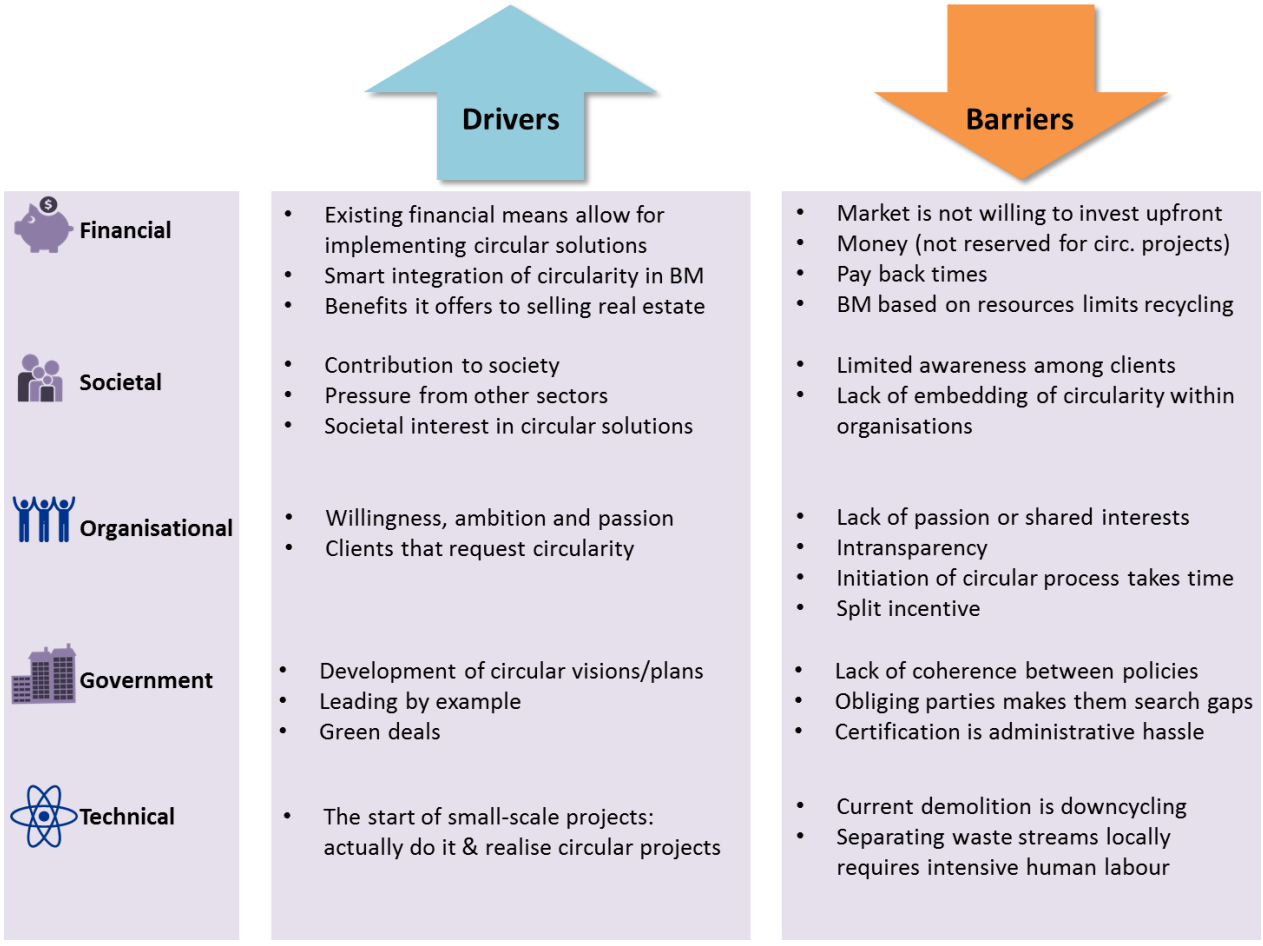


Figure 40 *– Drivers and barriers for a circular built environment.*

6.3.2 Transitioning towards a circular building sector

The cases studied provided some interesting lessons learned that can be used to sketch developments towards circularity in the Dutch building sector. These lessons learned combine the findings on supply chain collaboration (see Table 24 till Table 27) and the broader implications of a circular built environment as summarised in Figure 40 above. The developments will be explained along three different stages: short term (2015-2017), medium-term (2017-2020) and long-term (2020-2035). The developments will be coupled to actor groups responsible for these changes.

Short term: pilot projects, motivation, inspiration and connection

What is needed on the short term is to establish more circular projects. These projects will function as **icons** and inspire others to speed up developments. Actors in the building supply chain are essential in this development, but it was learned that a key role is played by clients that initiate building projects. Clients need to be clear why they want to build new projects and what they aim for in these projects. In this way it all starts with their vision and ambition. This means clients need to ask different questions to the market when assigning new projects. Instead of specifying requirements they need to ask the market to support them in realising their (circular) ambition and organisational needs. Traditionally clients think in terms of needs like: 'I need a desk for every employee' whereas a new way of formulating a need could be 'I want to support different working preferences of employees in an optimal way'. In creating these different demands and circular strategies from clients, the market will search for circular solutions. So **clients are key** in the first step of creating pilot projects (van Es, 2015).

Government can be a client of a building project as well and needs to set the right example in this. They moreover can support this development by motivating and inspiring potential clients. A final development for the government to assist in, is to take up the **role of 'connector'**. Actors in all three cases learned the importance of facilitating supply chain collaboration by getting different disciplines together. Certifying bodies like BREEAM are related to government and they have a role in keeping their certifications up to date. In this case this means they have to embed circularity in their certification guidelines. Examples are credits for indicators like usage of material passports, BIM, design for disassembly and flexibility or share of reused/recycled components.

Actors moreover learned what collaboration brings (see section 6.1) so within the supply chain collaboration needs to be established. On short term this means looking for the right parties to work with that are willing to contribute to circular pilot projects. Shared passion, trust, process alignment and a vision upon a collaborative implementation process are among some of the requirements for this collaboration. To facilitate in establishing circular buildings, integrated collaborative software like BIM is useful. Material passports consequently can keep track of the materials in the building. Developers can assist on the short term by measuring the impact of pilot projects. The impact translates the positive effects of a circular building on productivity of employees and materials, emission and pollution saved in financial terms. These financial benefits in turn help to persuade more potential clients for circular (re)development. External advisors on the short term can also assist in inspiring clients to do things differently and in the facilitation of the supply chain collaboration itself.

Medium-term: revaluation, business models, tendering and contracts

When the first clients are convinced to invest in circularity, on the medium term the circular supply chain collaboration should be supported by means of some 'tools' and documents. The first 'tool' is to revaluate the role of different disciplines in the building supply chain. It was learned that some disciplines add more value to the actual end product (a built circular object) than others. Within the supply chain thus some changes have to be established. These changes can be identified based on a **system scan** of parties in the supply chain and the value they add. Examples of this **revaluation** and changing roles are illustrated here for the developer, the contractor, the demolisher and the supplier. When looking at the current activities of a general contractor they can be described as coordinating (van Es, 2015). They purchase materials and resources from sub-contractors/suppliers and make most of their profits upon these purchased materials. They do not make products themselves; they assemble the whole built object. When moving to a circular supply chain where all actors work in a shard BIM model, it is known from the very beginning how much of each material is needed. This means the risks that general contractors currently bare will disappear. Since these risks are part of their current business model, they will have to change here.

> *"A contractor will become more of a project manager who makes sure everything is purchased in time. And he will be paid per hour and have some additional revenue and that's it. And does he still bare risks? […] The contractor will not be the general contractor anymore. An architectural firm will have a department with sub-contractors: you will make flooring, you do the ceiling and you will take care of lighting."* – Grosfeld, 2015.

Traditionally developers had a similar role with limited added value. They made as much money as possible on the short term: develop a project for an investor (not a real client!) and then directly sell it and move on to the next development (Grosfeld, 2015). This is now changing since developers are now delivering their products in a different way: as a product of service. So they are not anymore directly selling their property but they might even be the (temporal) owners of the building. They will focus more on the actual client and his needs: whenever he is happy he will return to the developer (Grosfeld, 2015). Suppliers traditionally add value via their products that can be used in the building. Their role will become more important in a circular building sector where their products are valuable assets stored in a built object. The main change for them relates to transparency about their products. The more is known about the exact composition, the more value can be regained when disassembling. At this moment they protect most of the information however (van Es, 2015). A final example is the role of the demolisher. In the current situation they are needed since material value depreciates over time to result in waste. When working with material passports value is tracked in the building and the potential for reuse can be shared (van Tuijl, 2015). Demolishers in this future situation are not needed in their sorting and labelling of waste streams again, because this information stays available for next use. So the whole building supply chain is involved with this revaluation of roles. External advisors can assist here in scanning for value of parties.

> *"We are moving towards an economy where people that actually don't have added value, won't earn anything."* – van Es, 2015.

Another development on the medium term is the introduction of the **incentive scheme** where supply chain collaboration is coupled to business models of firms. This could be done by coupling circularity ambitions to financial rewards as also explained in section 5.2.6 (van Oppen, 2015). This incentive scheme should be developed within the supply chain involved per project. This should also be reflected in the **contracts** used as learned from the case studies. Government can assist in stimulating this innovation in contracts and BMs. Government finally has a role in embedding circular supply chain **collaboration in tendering processes**. The process as used by Alliander is an example of a whole new approach and more experimentation could lead to new tendering processes government can use. This is especially important within public projects since these have to deal with strict tendering prescriptions that currently do not allow for circular principles (van Tuijl, 2015).

Long-term: building as material bank and material market place

As learned from supply chain collaboration in section 6.1, the vision of the **building as a material bank** is an important enabler for a circular building sector. This vision however needs to be translated into operable processes on the long term. This means per project (ranging from individual buildings to area development) a consortium will be formed that owns the materials in a building (van Tuijl, 2015; van Oppen, 2015). This consortium establishes a database – a materials pool – that shows what materials are in the project, what circular value they represent for which stakeholder in the consortium. Not all material value might be covered for by the consortium, so the database also shows value propositions open to the market. When sharing all this information, interested parties can be found. In this way a **material market place** is created.

A challenge for this material market place is the current information gap: it is unclear how to make money from the circularity in a building project (van Tuijl, 2015). This is why additional **software** is needed that builds on the information of the material passports (the database of the consortium) and the BIM as established during design and construction. In this way this software automatically integrates value streams of materials already at the start of a project. The material market place and software are to be established in cooperation within the whole supply chain. Whenever a client or end user owns the building instead of a consortium, they can use the materials as assets as well.

Stakeholders also learned about the role of government. On the long term government can facilitate the vision of the building as a material bank via several ways. Within guidelines for technical descriptions of building projects circular KPI's can be added. In this way design choices around materials and applications of these materials can be guided towards circular solutions. Environmental permits and zoning plans are other means for government. In environmental permits re-use can be obliged for instance (van Es, 2015). Zoning plans need to be more flexible in a circular built environment to allow for changes that occur when a building changes owner without demolition. On the long term all externalities moreover need to be included in pricing systems and tax systems can charge materials more to sustain their re-use and recycling options. Finally some ownership rules need to change in a circular built environment. When something is tightened to a building it legally becomes part of the building. This needs to change since it needs to be tightened for a certain period only (Emanuel & Rebel, 2015). In this situation third parties can thus own these materials as well, but this still needs to be reflected in regulations. These regulations will thus have to deal with the temporal character of buildings.

The lessons learned and developments for different actor groups on different terms are summarised Figure 41.

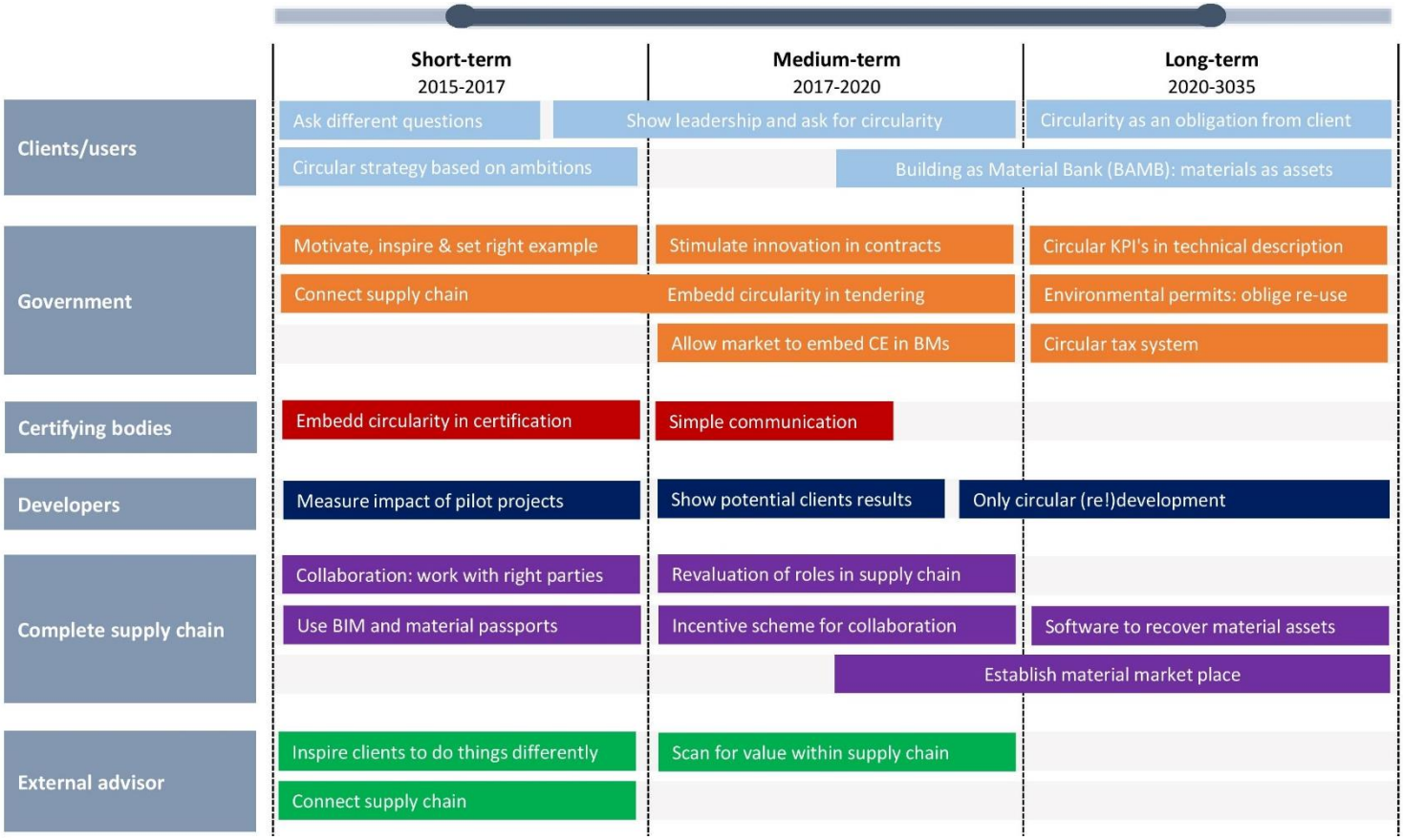


Figure 41 *– Developments for a circular built environment plotted in time.*

6.3.3 Conclusion

This chapter revealed the lessons learned for circular supply chain collaboration and the developments needed that support a transition towards a circular built environment. For supply chain collaboration it can be concluded that:

- It starts with vision development. The vision needs to be established in collaboration with client and supply chain. The functioning of the vision related to learning processes and can influence thinking processes, behaviour and finally material reality via motivation, direction and inspiration.
- The second step involves the design of the collaboration itself with the right parties based on co-creation. This should involve a diverse network. An essential activity in this network is connecting different disciplines in the supply chain. Moreover three kinds of elements should ideally be present in the supply chain: strategically a

collaborative process should be part of the vision/focus, collaboration wise the process should facilitate it and culturally openness, transparency and trust are important.

- Thirdly, the Business Model should facilitate a circular building and collaborative process. A circular building can be reached by combining value creation in technical, organisational and social fields. A collaborative process can be embedded by coupling collective circular ambitions to financial rewards.
- Finally, learning should facilitate the diffusion of circular building practices throughout the whole process. Actors need to learn to extend their scope of a project to include the end-of-life of the building. Circular building moreover requires a new approach based on multidisciplinarity (think in disciplines instead of companies) and based on a dialogue and personal connection. Collectively a new perspective on ownership of materials needs to be established. Materials are only temporarily stored in a building that functions a material bank.

For a transition towards a circular built environment it can be concluded the following developments are needed:

- Short term: developing more small scale circular projects. Clients have a key role in this in asking for circular project based on a new collaborative approach. These clients can be inspired to do so by showing the results of existing successes. Connecting the different parts of the building supply chain is another essential element of supply chain collaboration that needs to be done upfront. Circularity on short term can moreover be stimulated by building parties using BIM and establishing a data base of all the materials in the building (material passport).
- Medium term: facilitate supply chain collaboration via several tools or documents. A system scan for value reveals the value parties/disciplines add to the supply chain. By using this it will show who to involve in a circular project and/or who's role needs to change. Collaboration moreover needs to be embedded within the BM by coupling collective circular goals to financial incentives. Government can facilitate this by reflecting this into tendering processes and guidelines for contracts.
- Long term: buildings will function as material banks. This requires additional software that builds on BIM or material passports, showing the attractive options to make money from the material assets in a building. A material market place is moreover needed to allow for easy transactions around these building materials. This moreover needs legal support via for instance circular KPI's in technical descriptions of building designs or environmental permits, internalisation of externalities and taxing materials.

7. A Process Tool for Circular Supply Chain Collaboration

Tools have been identified as an important asset to assist businesses in practically implementing CE principles. In order to make the lessons learned as presented in the previous chapter practically applicable to business, this chapter firstly describes the tool development method in 7.1. This section also provides the outcomes for the tool development process. These outcomes deal amongst others with tool requirements, a tool format and tool definition. This section finally presents the supply chain collaboration tool itself in section 7.2.

7.1 Tool development method and outcomes

Based on the lessons learned, drivers and barriers and the transition towards CE as presented in Chapter 6, a process tool is developed in this chapter. While the contents for this tool are thus explored in the previous chapters, a methodology is needed to develop the tool. In this first section therefore a step by step tool development method is presented and applied, resulting in a final tool format. This format will be used and combined with the findings of Chapter 6 to present a tool that enhances circular supply chain collaboration.

Tool development method

Tool development deals with the third research question of this thesis:

What methods are useful for developing new circular projects in the building sector and how can these be applied in a tool to enhance circular supply chain collaboration?

The tool development method in Figure 42 is used to address this question and to develop the tool. The outcomes of the different steps as presented in Figure 42 are explained and described in detail in the next part of this section.

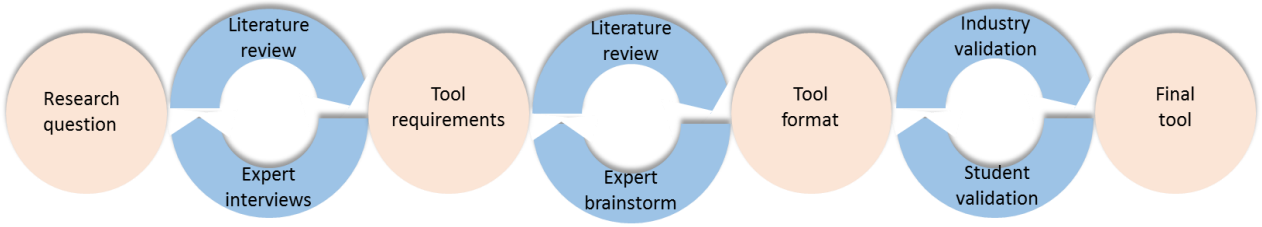


***Figure 42** – Overview of tool development method (based on Lehmann, Bocken, Steingrímsson, & Evans, 2015).*

7.1.1 Outcomes first iteration: literature review and expert interviews

Based on the research question above a first round of expert interviews and a literature review were conducted in the first iteration (first blue circle in Figure 42).

Literature review

Literature on environmental management was used where a wide range of tools has been developed. A classification is presented here based on tool categories used by Byggeth and Hochschorner (2006), Baumann et al. (2002) and Bocken et al. (2011). The different classes include two main types of tools: analytical tools and organising tools. The first category includes different sub categories of tools as explained below.

Analytical tools

Comparative tools make use of simple quantitative data. They involve a rating system that provides a scale for assessment, like relative impact. Often, multiple criteria can be assessed visualised in a spider web (Bocken et al., 2011). An example of this tool is the EcoDesign strategy wheel that uses data on reduction of materials usage, reduced impact during use or optimisation of initial lifetime. Other methods also go into broader dimensions including eco efficiency, sufficiency and social productivity (Baumann et al., 2002). These tools are often regarded as an alternative to the complex and time-consuming lifecycle assessment method (LCA).

Guideline/checklist tools have been described by Baumann et al. (2002) and by Byggeth and Hochshorner (2006) under the term prescribing tools. These tools provide sets of rules that assist in improving the environmental performance of a product or process (Bocken et al., 2011). Examples of these types of tools are the '10 golden rules' (Luttropp, 2006) for more efficient material use, simplicity or low impact materials and the 'Sustainable Product and Service Development (SPSD) checklist that provides recommendations on production, materials, distribution, end-of-life, functionality and consumption (Maxwell & van der Vorst, 2003).

Evaluative tools support in the improvement of environmental performance of the product development process. The Environmentally Responsible Product Assessment Matrix (ERPA) developed by Graedel (1997) is an example that aims at a quick evaluation of the environmental performance of a product in order to define the improvement potential. These strategies of improvement overlap with the framework tools as defined by (Baumann et al., 2002). They mention examples like Design for Recycling or Design for Disassembly as frameworks that come along with a toolkits, guidelines and strategies to make a product more sustainable.

Quantitative tools are in general quite comprehensive, quantitative tools for evaluating and measuring environmental performance. According to proponents of this tool, guidelines, checklists and evaluative tools are not sufficient for managers and technicians and that these analytical tools have the rigor that is needed (Baumann et al., 2002). The most important of these tools is LCA. Other quantitative tools include material flow analysis (MFA), total cost assessment or risk analysis. Within the category of analytical tools also some combination tools have been developed, integrating environmental, economic and technical aspects for instance. The latter aim to deal with trade-offs between environmental requirements and other requirements.

Software and expert systems can handle big amounts of environmental information, but be as quick as the simpler tools. This avoids the need for environmental expertise or elaborate data collection. Examples of these knowledge-based systems for ranking the performance of buildings are the US based LEED programme (USGBC, 2015) and the Dutch BREEAM score system (DGBC, 2015a).

Organising tools

Organising tools guide the organisation of collaboration (e.g. between business departments and stakeholders). Methods proposed for developing these tools range from interviews to workshops for raising awareness or discussing the tools and strategies (Baumann et al., 2002). An example of a tool that describes strategies for green supply chains has been proposed by Sarkis (2003). This Analytical Network Process, that visualises interdependent relationships based on a super matrix, requires large amount of decision-maker input.

Another organising tool is Value Network Analysis (VNA) as developed by Allee (2011). This is a role-based network analysis approach aiming to understand a firm's performance by looking into the dynamics of value creation in both financial and non-financial terms (Allee, 2011 in Bocken et al., 2015). The basic value network diagram consists of three elements: roles, transactions and deliverables. The deliverables can be tangible like confirmations or intangible like advice or recommendations (Allee, 2011). The tool shows links in business transaction in a way that eases cost/benefit analysis or asset management.

VNA is based on older tools around network analysis: Social Network Analysis (SNA) and Organisational Network Analysis (ONA). SNA is an approach focused on relationships among actors that can be members of a group, corporations, or nations (Freeman, 2004). It explores directional and bi-directional exchanges, including types of business relationships or sharing of information or collaboration (Cross, Borgatti, & Parker, 2002). ONA emerged between 2001 and 2003 when managers gained interest in understanding knowledge flows and identifying informal experts in their organisation (Allee, 2011). ONA applies SNA on organisational and business problems.

Weiseth et al. (2006) developed "The Wheel of Collaboration Tools" (WCT) that presents a typology of the capabilities of collaboration tools. Their typology makes use of three main layers, visualised metaphorically as the main parts of a wheel (see Appendix E1 for this visualisation). They distinguish between tools, functions and processes. These processes of collaboration are coordination, production and decision making (Weiseth, Munkvold, Tvedte, & Larsen, 2006). Although WCT does not give examples of actual collaboration tools to be used here (it evaluates online software tools), the typology provides useful elements for tool development and tool selection.

Expert interviews

Next to the literature review a first round of expert interviews was conducted. These 18 experts were all involved in the cases as described in Chapter 5 (see Appendix A for a list of interviewees). They were asked about their experiences with tools in general during the project. The outcome of this round of expert interviews revealed that the most used tool is BREEAM. It was used to make the project accountable for clients and to steer the project towards sustainability aims. Interviewed actors however mentioned the ambiguity of using such a tool: BREEAM stimulates to adopt sustainable building practices, but on the other hand also constrains innovation since it contains (only) certain options to obtain credits. In this way the certificate may force you to opt for a measure that does not provide the best option for the client or even for the building's sustainability performance (Leijnse, 2015).

> *"BREEAM is based on the current situation of usual technologies. And that's the main risk of those tools and software: what is the question posed by the tool, then I will answer that one only. And this is what you get by using BREEAM [at the project side of Alliander in Duiven]: you get credits when you have a bus stop within a certain distance. We are located at an industrial site that is not covered by bus lines at all, but we will make a bus stop to earn that BREEAM credit."* – Rebel, 2015.

The BREEAM certification moreover focuses mainly on the technological aspects and some management aspects. In this way it does not cover the full aspects of a circular building process (as developed by van Oppen, 2015): technological content, organisational process and financial models. BREEAM finally has become a marketing tool: you cannot sell a building without a BREEAM certificate. This is why BREEAM will not last long: within five years it is not distinctive to use a BREEAM certificate anymore (Kragtwijk & Warmerdam, 2015).

Related to BREEAM is the tool that was developed in the Park 20|20 process. Since the BREEAM certificate did not (at that time) cover C2C principles, different matrices were established to assist in choices for building methods (Grosfeld, 2015). In this project moreover an assessment methodology for the impact of materials was used and a measurement of the amount of recycled content and recyclability of materials (van Tuijl, 2015). Roadmapping was another method applied at Park 20|20 together with material passports (also used in the new Alliander office).

Besides these technological tools some interviewees also mentioned the process where they made use of a clear process structure (Hoeben, 2015), many dialogues (Roelofs, 2015; van Zantvoort, 2015) and 'experience' (van Steijn, 2015). Actors also stressed the importance of taking each interests into account and chairing dialogues.

Concluding about the outcomes of this first round of interviews, it was noted that tools to assist in technologies are widely available. Organisational tools are less developed and mainly contain some abstract lessons learned.

7.1.2 Tool requirements and tool comparison

Different tools for sustainability have been developed in literature and in practice, providing input for requirements for a tool (see also Figure 42). When comparing the reviewed tools, it becomes clear that they all make for instance choices about the intentions and purpose of the tool, quantitative or qualitative data to be used and general or concrete prescriptions as an outcome. The way these requirements are derived is attached in Appendix E2. Concluding about the requirements for the tool to be developed, it is noted that (see also Appendix E2):

- The tool should be based on a lifecycle perspective.
- The tool should be based on a qualitative approach.
- The tool should give concrete prescriptions.
- The tool should cover the technicalities of the development of a circular building as such.
- The tool should deal with the building development process in a company context, relating it to business strategy and management.
- The tool should deal with the building development process in the building chain perspective, including interaction with e.g. suppliers, clients, demolition companies.
- The tool should deal with the building development related to policy processes.
- The tool should be simple to use and not time demanding.
- The tool should trigger businesses to change current (linear) practices and stimulate innovation.
- The tool should be adaptable to different sectors, businesses or organisations and their needs.
- The tool should contain only a few main steps or phases.

The comparing traffic light analysis that can be found in Appendix E2 shows that **organising tools** are an interesting option to develop in this thesis. This category of tools scores best when compared to the previous tool requirements.

7.1.3 Outcomes second iteration: literature review and expert brainstorm

Based on the chosen category of organising tools, additional literature and an expert brainstorm were used here based on the second iteration step in the tool development method (the second blue circle in Figure 42).

Literature review

An additional literature search yielded three different organising tools that came close to the tool requirements for an specific type of organising tool as described in the previous section.

- *Flowchart:*
  In a flowchart a visual representation is given of the sequential steps and decisions required for a process. It is a tool that was originally developed by engineers to support structuring work processes (Smartdraw, 2015). Flowcharts these days are used for various purposes including project planning. Developing a flowchart helps users to gain understanding of their project and to communicate critical factors and the dynamics between them (Shane, Strong, & Gransberg, 2012). Appendix E3 provides an example of this tool.
- *Circular Economy tools:*
  Several CE tools and toolkits have been developed to support businesses in the transition to a CE (Bocken, Rana, et al., 2015; Evans & Bocken, 2015; Lehmann et al., 2015). These tools assist in creating value propositions that incorporate social, ecological and economic value and provide a network perspective instead of a firm centred view on value (Lehmann et al., 2015). They therefore look into options to decrease material usage and to design products with long lifespans, using cascades of circular value propositions (Evans & Bocken, 2015). In Appendix E3 the CE toolkit from Evans and Bocken (2015) is presented as example.
- *Process map:*
  Process mapping is identifying, analysing and developing an improved (business) process (Anjard, 1996). The process map as an outcome is a visualisation of linkages between inputs, outputs and tasks. Via the process mapping tool, a completely different thought pattern for a process can be conceived (Anjard, 1996). A process map in this way triggers ideas to improve business processes and it shows the areas where changing processes will have greatest impact (see Appendix E3 for an example).

Expert brainstorm

In this second iteration step moreover an expert brainstorm within KPMG Sustainability was organised at November 4, 2015. Four experts took part in this brainstorm about possibilities for tools, resulting in a preference for the process map. This process map also performs best when comparing the 3 organising with the tool requirements from section 7.1.2 (see for more information the comparison in Appendix E3). Based on this second iteration step as presented in the tool development method (Figure 42), it was then decided to focus on the **process map tool**. This tool can support in conceiving different thought patters - an essential element for circular supply chain collaboration.

7.1.4 Tool format

The format of the process tool gives direction on how to organise a sequence of tasks or collaboration between business functions and stakeholders. In this way this tool clearly focuses on inter-organisational relationships and a collaboration strategy. The sequences present in the tool allow for embedding both up- and downstream interaction and for a focus on the system of the complete lifecycle of a building, product or project. With its sequence of tasks this tool presents the right balance between complexity and accessibility. The tool is finally based on qualitative data.

The process tool however also presents some disadvantages. Although in general it is simple to use, the simplified guidelines (for the process or collaboration) can be misinterpreted by environmentally untrained firms or departments. The steps in the process should thus be backed up by examples to enlarge the usability of the tool for laymen in the field of sustainability/circular practices. Another disadvantage of this tool is that it does not naturally allow for a focus on the complete lifecycle. The process map is mostly visualised in a 'linear' way, so additional visualisation might be needed to incorporate this requirement as well.

Tool definition

This first two steps in the tool development process revealed that a wide range of tools is available. Tools can thus be interpreted in many different ways. To clarify the definition of a tool used in this thesis, a definition will be established based on definitions of tools and processes. The tool to be developed here is defined as:

A guide used to carry out a series of actions or steps to achieve a particular end.

Draft tool

Based on the outcomes of the second iteration, a draft tool was developed in the format of the process map. In this process map the lessons learned for circular supply chain collaboration as presented in Chapter 6 are used. This resulted in a draft tool based on five main phases of the process:

1. Preparation and vision development;
2. Involve market and supply chain;
3. Process design and collaboration;
4. Business model and implementation;
5. Usage and prepare for next use.

7.1.5 Outcomes third iteration: industry and student validation

The draft tool presenting the lessons learned for supply chain collaboration (Chapter 6) in the process map format was validated in a business setting and an academic setting. This validation focused on the following topics:

- Relevance of the tool: does the tool provide the right information to enhance business in circular supply chain collaboration?
- Intelligibility of the tool: does the tool provide clear indications for business to support circular supply chain collaboration – both for front running companies as for more traditional firms?
- Value of the tool: does the tool provide knowledge needed in the market? Is a need for this tool visible?

Industry validation

For the industry validation two stake holding businesses were approached. The first one is Copper8 who were also involved in the process for the Alliander office in creating the new tendering approach. They are moreover involved in multiple projects in the building sector and product fabrication sector (van Oppen, 2015). The validation took place on December 1, 2015. The relevance of the tool was proven: the most important aspects were extracted and presented. Regarding intelligibility, a change was proposed in the sequence of the steps of the draft tool. The process design and collaboration should be completed before drawing up BM strategies to prevent parties falling back into traditional firm centred BMs. The value of the tool was proven during this meeting as well.

A second firm that was approached for validation is Circle Economy. Circle Economy aims at accelerating the transition to a CE by acting as a platform for knowledge and best practices sharing (Kok et al., 2013). This second validation session took place on December 3, 2015. In this session the relevance of the tool was confirmed since the concepts presented in the tool were recognised. The intelligibility was to be increased according to Circle Economy and this considered mainly an explanation of some of the main tasks the tool proposes. The value of the tool finally was confirmed since Circle Economy makes use of several related tools for which they see a need in the market.

Student validation

For the student validation four IE graduate students were approached. These students all perform(ed) their thesis on the more organisational aspects of the Circular Economy. The validation took place on January 4, 2016. The relevance of the tool was proven since the students could relate to the process sketched and confirmed the results based on their own observations. The intelligibility could be increased by means of the following points:

- Accentuate the main different phases and let colours used for the different phases correspond.
- Add output per phase to the tool.
- The actual steps per phase partly overlap with the main theme of the phase; this requires restructuring.

Finally the value of the tool was confirmed as well: the students mentioned the tool would be useful to them.

7.2 Circular supply chain collaboration tool

Based on the outcomes of the third iteration step in the tool development method (Figure 42), the final process tool for circular supply chain collaboration is presented on the following pages. The tool consists of an overview of five main stages in the lifecycle of a product or building (see Figure 43). Here the main activities per stage (based on the outcomes of section 7.1.4) are briefly described together with a runtime of each stage. Most differences in this runtime are present in phase 5 where options for reuse will be developed. Preparation and vision development will follow this phase, but for different parts of a building or product different projects might follow. This means that different subsequent cycles can develop out of the fifth phase.

Next, these stages are elaborated in the process map with guidelines and steps to take when establishing circular supply chain collaboration. The tool mainly takes the perspective of the initiating party (in the building sector 'principals' that might also be end users). The tool should also apply to other sectors, so two version are presented. The first version (Figure 44) is specifically tailored towards the needs of the building sector. The second version (Figure 45) is to be applied to other sectors as well. For this translation to multiple sectors a sector comparison was performed by means of a quick scan. This quick scan can be found in Appendix E4.

The main steps for the different phases in the tool (versions) and their origins in the lessons learned from the case studies will be explained:

- Phase 1: The steps and guidelines presented here are based on the lessons learned for visions and vision development as discussed in section 6.1.1. This phase starts with the initiator of the process (principals or producers) and ends in a vision for a circular project or strategy.
- Phase 2: The guidelines in this phase are based on some of the lessons for vision development (6.1.1), learning a new approach (6.1.4) and the system scan that is part of the mid-term changes in section 6.3.2. This phase is basically the selection phase in the tendering procedure for building project.
- Phase 3: The steps for this phase are all based on the lessons learned for the collaboration and network that were described in section 6.1.2. Contracts and collaborative technology are concrete outputs of this stage.
- Phase 4: Guidelines shown here are derived from the lessons for business model strategies of section 6.1.3. The design principles and BM strategies coupled to the building as a material bank relate to vision aspects as explained in section 6.1.1. This phase results in a collaborative BM strategy and a circular building or product.
- Phase 5: Here guidelines are applied, derived from lessons learned for BM strategies (6.1.3) and the long term changes of section 6.3.2. This phases assures that material value is maintained via re-use, repair or recycling.

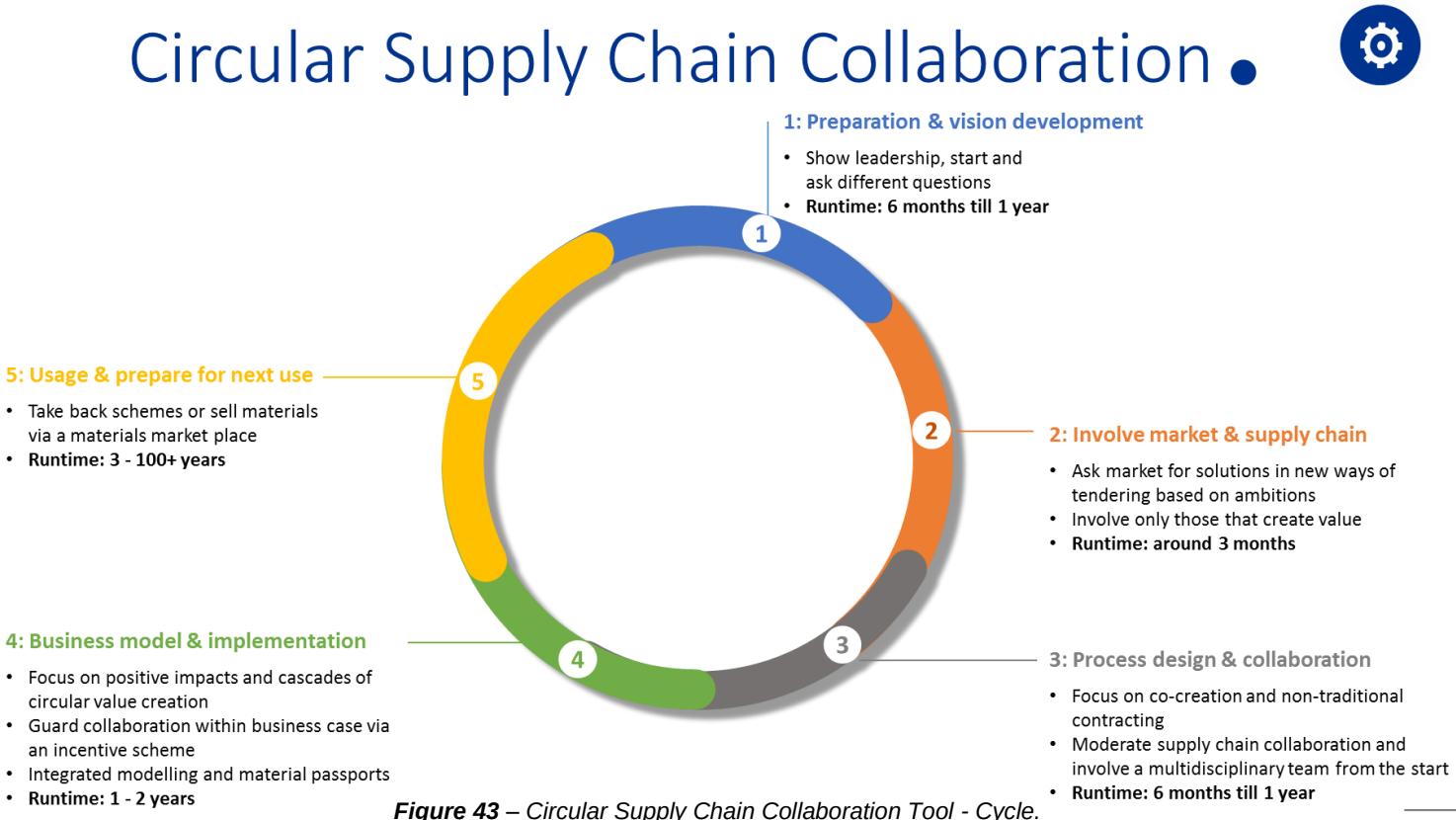


Figure 43 *– Circular Supply Chain Collaboration Tool - Cycle.*

Circular Supply Chain Collaboration

Building sector specific

	Phase 1: Preparation & vision development	Phase 2: Involve market & supply chain	Phase 3: Process design & collaboration	Phase 4: Business model & implementation	Phase 5: Usage & prepare for next use
Why?	• Leadership and additional examples are needed • Need to work from requirements • New circular strategies required	• Market can help finding solutions • Tendering based on ambitions • Involve only those that create value	• Need for a co-creative process • Emergence of new role of supply chain moderator • Multidisciplinary teams required	• Creating positive impacts and cascades of circular value propositions • Need to couple collaboration to business case	• Improve image of usage: lease and re-use • Secure next use of materials: re-use, refurbishment, components recycling, material recycling
Who?	• Principals/clients of building projects • External advisor can be added regarding the creation of internal support	• Principals/clients of building projects • Market • External advisor can be added in selection of parties	• Principals/clients • Suppliers • Consortium (realising parties)	• Principals/clients • Suppliers • Consortium	• Consortium (owners of materials) • Principals/clients • Suppliers (take back)
What?	• Involve organisation to create support • Think in terms of **ambitions instead of requirements** and translate this into ambitions for: 1. collaborative process, 2. business model 3. technicalities (materials)	• Scan for value of market parties: what value do parties add to the supply chain? Based on a **system scan** of value creation • Directly ask for multidisciplinary tendering teams (consortia) • Within parties to involve it's about personal connection: people will make the difference	• Non-traditional contracting: steering on ambitions in contracts • Make use of different disciplines and their added value • Show vulnerability to establish **trust** • **Building integrated modelling** that allows for tracking the material value in the building	• **Buildings as material banks** look for options to capture value of materials on the long term: owners of materials can get value back at disassembly • **Incentive scheme** for collaboration: couple collective circularity performance to profits of collaborating parties • **Material passports** guard tracking of the products, materials or components stored in the building	• Show financial benefits of re-use/lease over whole lifetime of product or component • **Material market place:** demolisher is not needed when material value is known. The owner of the materials (consortium) can sell the materials to new parties (even in other sectors!) • Take back schemes of suppliers for interior
Output	• Vision for circular building • Optional: circular business strategy	• Stakeholder involvement • Multidisciplinary tendering teams	• Collaboration secured in contracts • BIM model	• Collaborative BM strategy • Building with secured material value	• Reuse of building materials

***Figure 44** – Circular Supply Chain Collaboration Tool - building sector specific.*

Circular Supply Chain Collaboration

To be applied for multiple sectors

	Phase 1: Preparation & vision development	Phase 2: Involve market & supply chain	Phase 3: Process design & collaboration	Phase 4: Business model & implementation	Phase 5: Usage & prepare for next use
Why?	• Leadership and additional examples are needed • Need to work from requirements • New circular strategies required	• Market can help finding solutions • Tendering based on ambitions • Involve only those that create value	• Need for a co-creative process • Emergence of new role of supply chain moderator • Multidisciplinary teams required	• Creating positive impacts and cascades of circular value propositions • Need to couple collaboration to business case	• Secure next use of materials: re-use, refurbishment, components recycling, material recycling
Who?	• Producers (of products) or principals (of projects) • External advisor can be added regarding the creation of internal support	• Producers (of products) or principals (of projects • Market • External advisor can be added in selection of parties	• Producers and principals • Suppliers	• Producers and principals • Suppliers	• Suppliers (take back) • Producers and principals • Users • Other owners of materials (collectives/lease parties etc.)
What?	• Involve organisation to create support • Think in terms of **ambitions instead of requirements** and translate this into ambitions for: 1. collaborative process, 2. business model 3. technicalities (materials)	• **Scan for value of market parties:** what value do parties add to the supply chain? Based on a system scan of value creation • Directly ask for multidisciplinary (production) teams • Within parties to involve it's about personal connection: people will make the difference	• Non-traditional **contracting:** steering on ambitions in contracts • Make use of different disciplines and their added value • Establish **trust** • **Integrated modelling of product/project** that allows for tracking the material value in the building	• **Products as material banks** look for options to capture value of materials on the long term • **Incentive scheme** for collaboration: couple collective circularity performance to profits of collaborating parties • **Material passports** to track the products and resources stored in them	• **Take back schemes** of suppliers: especially B2B since this allows easy take back (central organisation) • Material market place: for whole products, components and resources
Output	• Vision for circular product/project • Optional: circular business strategy	• Stakeholder involvement • Multidisciplinary (production) teams	• Collaboration secured in contracts • Integrated model	• Collaborative BM strategy • Product with secured material value	• Reuse of building materials

***Figure 45** – Circular Supply Chain Collaboration Tool - for multiple sectors.*

8. Conclusions, reflections and recommendations

This chapter provides conclusions based on the literature search and case study presented in the previous chapters in section 8.1. It moreover provides reflections on the theory and conceptual framework used in 8.2 and a reflection on the methodology in 8.3. It finally provides recommendations for further research in 8.4.

8.1 Conclusions

After an investigation of theoretic concepts, three innovative cases in circular building were analysed and lessons learned were extracted. This investigation was guided by the following main research question:

How can new ways of supply chain collaboration in the built environment contribute to the transition towards a Circular Economy in the Netherlands?

This study showed that circular supply chain collaboration can contribute to a transition towards a CE by actually implementing solutions in real life projects. A **new process design is needed where a variety of disciplines in the supply chain is integrated upfront**. The responsibilities of these disciplines moreover need to be extended along larger parts of the supply chain in **new ownership models around materials** to actually close supply chains. Lessons learned in this thesis can lead to substantial spin-of and follow-up by their exemplary performance. This study also showed that collaboration depends on personal preferences. When clients or market parties have different personal preferences that do not reflect high circular ambitions, circular supply chain collaboration cannot be established

The main research question is divided into three specific questions for three separate parts of this study: the development of a conceptual framework, an analysis of selected circular cases and the development of a tool for circular supply chain collaboration. The following section will answer these three specific research questions. Central in the theoretical part of this thesis is the first research question that is formulated as:

1. *How can system innovation concepts be used to develop a framework to evaluate innovative circular cases in the building sector regarding their visions, network/actor dynamics, business models and learning?*

It can firstly be concluded that these **concepts relate to each other in different ways**. Business models are based on three main elements: network architecture, market offering and technology (Mason & Spring, 2011). Network architecture relates to the concept of network/actor dynamics, while the technology in circular building practices can rather be described as a combination of practices and processes that involve technology linked to this actor network. The business model and vision concept relate to each other in their strategic position in business practices. The vision concept in turn relates to the learning concept due to the functioning of visions as part of learning processes. The learning concept finally relates to actor networks since higher order learning takes place among actor groups.

The second conclusion to be drawn here is that these linkages and concepts can be turned into a conceptual framework when positioning them along the cases to be studied. System innovation concepts are thus developed into the following conceptual framework for circular supply chain collaboration (Figure 46):

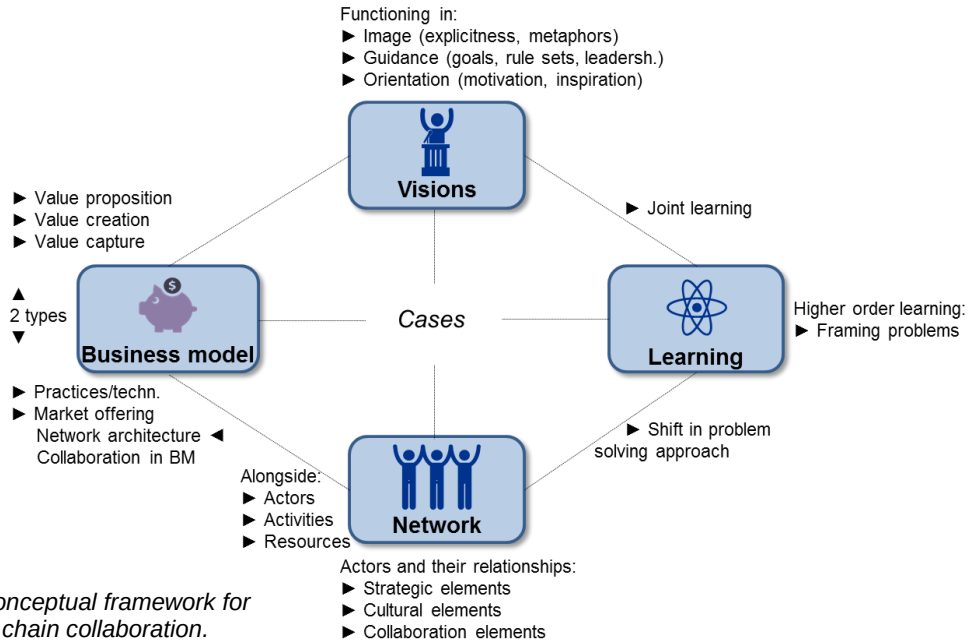


Figure 46 *– Conceptual framework for circular supply chain collaboration.*

The second research question deals with an analysis of innovative circular building cases:

2. *What is the contribution and relevance of visions, network/actor dynamics, business models and learning for supply chain collaboration in selected circular cases in the building sector?*

The first conclusion here is that all four concepts have relevance for circular supply chain collaboration and contribute to it. **Vision development is prioritised** however over the other concepts, indicating that this is a first step when working on circular supply chain collaboration. A second step is to establish the network/collaboration, followed by the business model and learning concepts.

Secondly, for the contribution of vision development it can be concluded that clients are needed that raise ambitions in their visions for a circular building and collaborative process. These **clients are key** in circular supply chain collaboration and when they do not ask different questions, circular buildings and supply chain collaboration can hardly be established. Vision development can moreover contribute to supply chain collaboration by **involving stakeholders with relevant knowledge to sharpen the client's vision and ambition *together***. Visions also contribute to supply chain collaboration. For the image of the vision, metaphors and explicitness have their influence: it was shown that metaphors stimulate to innovate and an explicit vision stimulates to actually realise what has collectively been agreed upon. At the next level of the network (collaboration elements), collective goals, leadership and alternative rule sets need to be present. Collective goals are crucial, but the case analysis also showed that despite these collective goals different opinions will always arise around choices in the implementation phase. At the strategic level finally visions contribute in providing motivation, inspiration and direction.

Thirdly it can be concluded that **collaboration with the right parties** is needed to establish the network. These 'right' parties can be found at the cultural level of the framework and should involve **actors with passion, commitment, energy, creativity, an open mind and knowledge**. The collaboration type of **consortia** shows most promising results to achieve circular supply chains. An essential activity that should be present in the network is **facilitating the supply chain collaboration by bringing all businesses together** – from suppliers to designers and demolishers or waste companies. In this way businesses increase their awareness of their impacts and circular solutions can be found together. The network concept also contributes to collaboration at the different levels of the framework just like the vision concept. At the actor level (of cultural elements) transparency, openness, information exchange and trust should be established. Different ways to create trust are showing vulnerability and asking others for help, providing certainty for upcoming assignments and openly discuss about the process instead of the content. These are all innovative aspects for the building sector. At the next level of the network (collaboration elements), joint decision making, process alignment and cross-functional activities should be present. This requires **new collaboration structures based on a continuous dialogue and multidisciplinary teams**. Whenever these aspects are absent it is difficult to innovate to circular building practices. At the strategic level finally, collaboration should be part of the vision for the project, facilitated by BIM technology and intra-organisational support.

The fourth conclusion is that business models strategies are important **enablers** for circular supply chain collaboration. They contribute to circular supply chains when the strategy incentivises **multiple value creation**. This means not only financial value is created, but environmental value and societal value are incentivised as well. This can be reached via several strategies that should combine social, organisational and technical innovations. In general it can be concluded that business models should focus on **maintaining material value** by preventing materials will be termed 'waste'. Most applied technological strategies to create 'value from waste' are to use **material passports/software** to keep track of the materials in the building and their value and to design for disassembly, allowing to easily remove the materials from the building. A pool of building materials or a **material market place** is needed to allow for easy exchanges of material value. For the connection between circular business models and supply chains it is concluded that this can be established via an **incentive scheme**. In such a scheme financial rewards are coupled to the achievement of collective goal(s) to guard supply chain collaboration even over longer time frames. This requires **innovation in contracts** as well. It is concluded that in contracts a focus on the collective performance should be present instead of the current focus on detailed specifications and externalising responsibilities.

The fifth conclusion is that there is a need to **record the outcomes of learning processes to facilitate the diffusion of circular building practices.** Collective learning (higher order learning) takes place at three levels that ideally should all take place in circular supply chain collaboration. This means problem boundaries should be extended

to **include the end-of-life options of a building** on the first level. On the second level new collaborative approached are required that **involve the same multidisciplinary team** from the very beginning of the project until the end. In this way actors can be held responsible by others for their tasks and deliverables by other team members. On the third level new perspectives and rule sets have to be established. For a circular building this entails **a new perspective on ownership of materials** that are only temporarily stored in a building.

For the final part of this research around tool development the question is formulated at:

3. *What methods are useful for developing new circular projects in the building sector and how can these be applied in a process tool to enhance circular supply chain collaboration?*

The first conclusion is that there is a need for process/organising tools over (technical) analytical tools. Flowcharts, circular tools and process maps are useful tools to visualise the lessons learned from supply chain collaboration. **Process maps** however can support in conceiving different thought patters - an essential element for circular supply chain collaboration, so this method was chosen for the tool development. **Expert knowledge** was used to validate the tool on relevance, intelligibility and value. This resulted in a process map with five main stages for circular supply chain collaboration: (1) preparation and vision development, (2) involve market and supply chain, (3) process design and collaboration, (4) business model and implementation and (5) usage and prepare for next use.

The second conclusion deals with broader implications with lessons learned for multiple sectors:

- A circular supply chain starts with clients asking for different/circular products and a collaborative process.
- A circular supply chain has to be supported by a circular process, business model and technological choices around materials and energy.
- Clients have to think in terms of ambitions instead of requirements or complete end products.
- Based on these ambitions, market parties have to be involved to sharpen the ambitions collectively in a co-creative process.
- Only ask for market parties that create value/conduct a system of value creation in the supply chain.
- Directly ask for multidisciplinary teams when involving market parties: think in disciplines instead of firms.
- Facilitate the supply chain collaboration by connecting these different disciplines (from design to waste companies!) with each other; make use of their different perspectives by searching integral solutions.
- Apply non-traditional contracting with a focus on collective ambitions instead of detailed specifications and externalising responsibilities.
- Use integrated modelling and material passports of the project/ product to allow tracking of material value.
- Capture material value on long term by creating positive impacts and cascades of circular value propositions.
- Use an incentive scheme to guard the collaboration in the business model as well: couple collective circularity performance to financial rewards of collaborating parties.
- Use take back schemes of suppliers, especially in business-to-business solutions.
- Establish a material market place where used products, components and resources can easily be exchanged.

8.2 Theoretical reflections

In this thesis I studied innovative circular cases in the building sector from the perspective of innovation theory and (circular) business model innovation. These two main perspectives are integrated in the conceptual framework (see Figure 46). In this conceptual framework circular supply chain collaboration is made up of four concepts: (1) actor networks, (2) visions, (3) actor learning and (4) business models.

The conceptual framework overall proved useful in structuring the research and obtaining the abovementioned conclusions. The conceptual framework in this way provided a relevant starting point, but some reflections need to be stated here. The main difficulty of the conceptual framework is in the overlapping parts of the four main concepts. An attempt has been made to integrate the four concepts, but some additional overlap is still present. This is mainly visible between the concepts of learning and visions. When analysing the three different cases this became explicitly clear. The three different elements of both concepts used in this thesis show overlap since the functioning of visions result basically in learning processes. Visions can establish new rule sets for instance, while

learning deals with new approaches and perspectives (and thus rule sets) that are established collectively. Parts of the actor network with its collaboration elements moreover overlap with these newly established approaches.

Moreover, with the knowledge gained from the case study research, the positioning of the four main concepts in the framework needs some additional reflections. The outcomes of the case studies clearly presented a sequence in the different concepts to be applied as presented in Chapter 6. This sequence of steps have been translated into the process tool. When translating the outcomes of the lessons learned to the conceptual framework, a revision can be made. This reflection is depicted in Figure 47. This reflection already leads to a recommendation: test this revision in additional research. Next to these reflections on the conceptual framework, reflections on the separate concepts are made in the next sub sections.

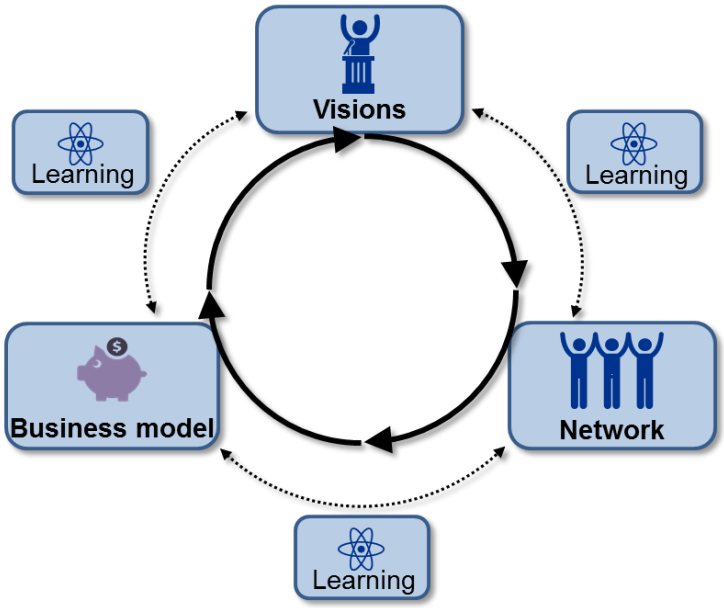


Figure 47 *– Reflection on the conceptual framework..*

Actor networks

The literature review revealed that knowing how actors interact in a network is essential and coordination of these interactions is required to move to circular supply chains. This study indeed showed the importance of this concept. The case studies however showed an interesting result: instead of establishing the network in the right way it is most important to establish the right network. Since collaboration is also in the cultural elements of individual actors it is most important to select the right parties that are willing to change their practices and learn. This is also why supply chain collaboration does not start with the network, but with the vision to select parties.

Regarding the applicability of the theories used in this concept, the industrial network theory provided most relevant outcomes for the activities in the network. Resources according to the different categories of the industrial network theory proved not relevant or distinct in supply chain collaboration in the building sector. All three cases dealt with (office) buildings where almost the same kinds of resources were used. The supply chain management literature on the other hand provided relevant explaining elements in the cases. The distinction between cultural, collaboration and strategic elements is based in this literature. Especially when analysing cases of building projects, this distinction was useful in looking at individual actors, the supply chain and firms that are part of the supply chain.

Visions

The conceptualisation for visions based on van der Helm (2009) was useful, but also revealed some difficulties when analysing the visions. While the analysis in this thesis considered visions of a project, the concept of van der Helm (2009) is derived from future studies with future visions on society as a whole. In a way the case studies do reveal a vision for a complete circular building sector, but difficulties arose in the description of the vision. The visions were analysed in their metaphoric meaning since this provided most ‘radical’ future visions as influencing factors. These visions with a clear metaphor however were not present in one of the cases, making it difficult to analyse this

case in this way. It turned out building project visions can be analysed according to future studies concepts when these projects have such high ambitions that they change our notion of the building and building process. This occurs in very innovative projects, but cannot be applied to a standard project based on current practices.

A final reflection on the vision concept deals with its applicability combined with learning processes. As stated before, these two concepts show quite some overlap in their elements and analysis. This overlap should have been noticed before and removed from the conceptual framework. Another solution would have been to integrate the two concepts into one concept.

Actor learning

The fact that learning occurred substantially may suggest that establishing circular supply chain collaboration is a good approach to achieve higher order learning. This relates for instance to the extended boundaries of the whole supply chain and closing loops of materials. The focus on the building sector allows for even more learning because of its traditional approach, long lifecycles and complexity of the 'product'. Analysing circular building projects thus led to selecting cases with substantial (higher order) learning. The other way around it also means that learning is necessary to achieve innovative case results. This was reflected in the cases studied where the least innovative case also revealed least higher order learning.

A next theoretic step might involve the role of learning processes in a transition towards a CE. Whereas learning was now analysed in the network around single projects, this type of learning involves achieving joint higher order learning among groups of actors that participate in an expanding amount of circular projects. Learning is essential in this transition and one of the cases already revealed the first steps towards this type of learning. Per project, several participating consortia learn about a new approach that they can apply outside of the initial project in new projects, involving new actor groups.

Business models

The concept for sustainable business model archetypes (Bocken et al., 2014) yielded additional insights in the functioning of BMs in the cases. It however did not reveal a major distinct strategy for creating circular supply chains, but it provided guidelines to create closed loops or to slow down resource loops. These elements are useful for businesses and have been used in the circular supply chain collaboration tool.

The concept of Mason and Spring (2011) has been used to establish the links between the other concepts in the conceptual framework. In this way this concept proved applicable in this research. Due to its interfirm perspective it moreover allowed to conclude on a 'collective' business model, a part of BM theory that is rather underdeveloped. This also links to multi-level applications of business models. Integrating BMs into transition theory is another field that needs additional conceptualisation since this was not the direct focus of this thesis.

8.3 Methodological reflections

The two main methods used are the case study method and the tool development method. The case study method firstly proved a valuable method for several reasons. It firstly allowed to integrate practice and theory. This is relevant for the emergent CE phenomenon that needs both theoretical and practical explanation. The case study method secondly provided the opportunity to study complex phenomena and turn them into original thought as has been proposed via the tool development part of this research. The method thirdly allows to investigate dynamic organisational processes that are the central theme in this thesis. The method was not only beneficial however and this is why the next sub sections deal with reflections per stage of the case study method as indicated in Figure 16.

1. *Define and design:*

   The first methodological reflection here is the selection of cases. The cases were selected based on their lifecycle stage: a newly built project, a renovation project and a (circular) demolition project. This was a relevant distinction, but different criteria could have been used in hindsight. Since this thesis revealed the importance of the client in a building project, different types of clients (private, public, semi-public, large or small organisations) could be used in selecting cases for instance.

Data collection protocols are a next methodological aspect. Interview questions were created for this data collection based on the literature review and conceptual framework. The framework provided some difficulties here: some translations had to be made and additional questions and examples had to be used to obtain the right information during the interviews.

2. *Prepare, collect and analyse:*

   In this stage the actual data was collected via interviews with stakeholders. A first reflection considers the selection of stakeholders for an interview. These stakeholders were selected and approached based on contact information gathered from the initial contact person per case. Most interviews yielded interesting results, but some interviews did not reveal any new information. The latter category could have been replaced with other stakeholders. This also relates to a second reflection around planning the interviews. It turned out to be rather demanding to plan all the interviews. Some interviews were cancelled, so new interviews had to planned, extending the timeframe needed to complete this stage of the research.

   After all the interviews were conducted, transcriptions were made as a first step of data translation. Transcribe software (online available) was used in this step, but despite using this software, this step still resulted in a high work load. On the other hand it also provided rich results to be used in the analysis step. In this this initial analysis step, results were linked to the conceptual framework. This resulted in a rather extensive analysis of the cases that has been condensed after a first review.

3. *Analyse and conclude:*

   The cross-case analysis revealed the similarities and differences between the cases. This was a useful step in understanding the conceptual framework and relations between the different concepts presented in there. It also revealed most of the valuable aspects and shortcoming of the framework. It moreover provided the main insights that were used in the general conclusions. A final reflection on this concluding step relates to the generalisation of the case study results. Generalisation is usually rather limited when using the case study method. This is a shortcoming of this method and this is also why the results in the tool should be adapted to each situation, especially outside of the building sector.

Reflection on the tool development method

The second main method that was applied is the tool development method (see Figure 42). This iterative process was only developed during the research process itself. In this tool development method I tried to overcome the shortcoming of generalisation in the case study method via validation sessions with stakeholders. More validation sessions with different stakeholders however would have resulted in a more robust tool.

8.4 Recommendations

Recommendations relate to both the theoretical and methodological parts and are based on the reflections above.

Theoretical recommendations:

Concerning the conceptual framework, some suggestions for improvement can be made. The main recommendation is to refine the framework via **integration** of all the concepts. As stated in the reflection, this mainly considers removing the overlap between visions and learning and between some aspects of network and learning processes. This will probably be an iterative process, where the framework can be improved theoretically while testing the adjusted framework in practice via case study work. This can be done based on the reflection in Figure 47 for instance.

The main value in the conceptual framework is its connection between more abstract organisational concepts and the practical level of businesses models. This framework provides a starting point for investigating this connection, but **additional conceptualisation into business models for integrated supply chains** is recommended.

A final theoretical recommendation is to **integrate a multi-level perspective** in the framework. This allows the development of transition pathways for circular practices in a broader part of society. This next theoretic step thus involves the role of supply chain collaboration in a transition of an entire sector towards circularity. This research touched upon this, but did not theorise this part completely. Additional research into this area is thus recommended.

Methodological recommendations:

Concerning the methodological part of the research, recommendations for data collection can be given. Due to restrictions in time, only three cases and a total of 18 actors were interviewed. When expanding the amount of actors and/or cases **more data** can be collected and instead of qualitative information, **quantitative information** can be extracted as well. When involving more actors, one can also think of new methodological approaches to apply, such as workshops, questionnaires or focus groups.

Another methodological recommendation is to investigate cases outside of the private part of the building sector. The cases studied in this research entail two private developments and one development in the semi-public sphere. A lot of developments in the building sector however are initiated by public parties and **public circular projects should be studied as well**. This is especially of importance when considering the role of clients in the tendering process. Public tendering processes follow strict European guidelines and these should allow for circular practices to expand the amount of circular building projects.

The tool development method also requires some recommendations. These recommendations mainly consider the final step of tool validation. The validation step in this research was limited due to actor availability and time restrictions. A first recommendation would be to **test the tool by means of an extensive stakeholder workshop**. The tool should firstly be tested on its value, intelligibility and relevance in the building sector itself. A next step would be to validate the tool also outside of the building sector. This will require additional workshops with front running companies in other sectors.

References

ABN Amro. (2014). Circular construction: new income models for construction industry. Retrieved June 22, 2015, from https://www.abnamro.com/en/newsroom/newsarticles/circular-construction-new-income-models-for-construction-industry.html

Agentschap NL. (2012). *We moeten op een andere manier gaan ontwikkelen, duurzamer en beter. Het gaat om kwaliteit.* Utrecht.

Albani, M., & Henderson, K. (2014). Creating partnerships for sustainability Creating partnerships for sustainability. *Turbulence. A Corporate Perspective on Resilience*, (July), 6. Retrieved from http://www.mckinsey.com /Insights/Sustainability/Creating_partnerships_for_sustainability?cid=other-eml-alt-mip-mck-oth-1407

Alker, J., Malanca, M., Pottage, C., & O'Brien, R. (2014). *Health, Wellbeing & Productivity in Offices - The next chapter for green building*.

Allee, V. (2011). Value Networks and the true nature of collaboration. Retrieved July 7, 2015, from http://www.valuenetworksandcollaboration.com/

Alliander N.V. (2011a). *Ambitiedocument Alliander Herhuisvestingsopgave Duiven*.

Alliander N.V. (2011b). Huisvestingsopgave Duiven Onderhandelingsprocedure Leidraad Dialoogfase.

Alliander N.V. (2011c). Selectieleidraad Huisvestingsopgave Duiven Onderhandelingsprocedure met voorafgaande bekendmaking, 1–44.

Alliander N.V. (2015). *Jaarverslag 2014 - Annual report 2014*. Arnhem.

Andersen, M. S. (2007). An introductory note on the environmental economics of the circular economy. *Sustainability Science*, *2*(1), 133–140.

Anjard, R. P. (1996). Process mapping: One of three, new, special quality tools for management, quality and all other professionals. *Microelectronics Reliability*, *36*(2), 223–225.

Ansett, S. (2006). Boundary Spanner: The Gatekeeper of Innovation in Partnerships. *Accountability Forum Issue 6*, (Special issue on Stakeholder Engagement), 36–44.

Argyris, C. (2003). A Life Full of Learning. *Organization Studies*, *24*(7), 1178–1192.

Arizona State University. (2015). Park 2020. Retrieved October 26, 2015, from https://sustainabilitysolutions.asu.edu/programs/solutionsservices/project-delta-development/park-2020/

Ayres, R. U., & Ayres, L. W. (1996). *Industrial Ecology: Towards Closing the Materials Cycle*. Edward Elgar Publishing.

Bakker, C., den Hollander, M., van Hinte, E., & Zijlstra, Y. (2014). *Products that last: Product design for circular business models*. Delft: TU Delft Library.

Barratt, M. (2004). Understanding the meaning of collaboration in the supply chain. *Supply Chain Management: An International Journal*, *9*(1), 30–42.

Baumann, H., Boons, F. A. A., & Bragd, A. (2002). Mapping the green product development field: engineering, policy and business perspectives. *Journal of Cleaner Production*, *10*, 409–425.

Bekkering, P. (2012). C2C-Ontwikkelaar van Nederland. *Real Estate Magazine*, *80*(2).

Benyus, J. (1997). *Biomimicry: Innovation Inspired by Nature*. New York: Quill.

BIS. (2013). *Supply Chain Analysis into the Construction Industry: A Report for the Construction Industrial Strategy*. *A Report for the Construction Industrial Strategy*.

Bocken, N. M. P., Allwood, J. M., Willey, a. R., & King, J. M. H. (2011). Development of an eco-ideation tool to identify stepwise greenhouse gas emissions reduction options for consumer goods. *Journal of Cleaner Production*, *19*(12), 1279–1287.

Bocken, N. M. P., Bakker, C., & de Pauw, I. (2015). Product design and business model strategies for a circular economy. Delft: Design Engineering department Industrial Design Engineering Delft University of Technology.

Bocken, N. M. P., Rana, P., & Short, S. W. (2015). Value mapping for sustainable business thinking. *Journal of Industrial and Production Engineering*, (January), 1–15.

Bocken, N. M. P., Short, S., Rana, P., & Evans, S. (2013). A value mapping tool for sustainable business modelling. *Corporate Governance*, *13*(5), 482–497.

Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, *65*, 42–56.

Boons, F. A. A., & Baas, L. W. (1997). Types of industrial ecology: The problem of coordination. *Journal of Cleaner Production*, *5*(1-2), 79–86.

Boons, F. A. A., & Lüdeke-Freund, F. (2012). Business models for sustainable innovation: State of the art and steps towards a research agenda. *Journal of Cleaner Production*, *45*, 9–19.

Boons, F. A. A., Montalvo, C., Quist, J., & Wagner, M. (2013). Sustainable innovation, business models and economic performance: An overview. *Journal of Cleaner Production*, *45*, 1–8.

Borup, M., Brown, N., Konrad, K., & van Lente, H. (2006). The Sociology of Expectations in Science and Technology. *Technology Analysis & Strategic Management*, *18*(3/4), 285–298.
Boulding, K. E. (1966). The Economics of the Coming Spaceship Earth. In H. Jarret (Ed.), *Environmental Quality in a Growing Economy, Resources for the Future* (pp. 3–14). Baltimore: John Hopkins University Press. Retrieved from http://www.geocities.com/combusem/BOULDING.HTM
BREAAM NL. (2015). Over BREEAM. Retrieved September 3, 2015, from https://www.breeam.nl/over-breeam
BREEAM. (2013). *Project : Vondellaan 47 Leiden BV Kantoor: Heerema Marine Contractors*. Retrieved from http://www.vondellaan47.com/upload/130927 BREEAM HMC_v4.pdf
BREEAM-NL. (2013). *BREEAM-NL Sloop en Demontage*. *Keurmerk voor duurzame sloop* (Vol. versie 1.0). Rotterdam.
Brown, H. S., Vergragt, P., Green, K., & Berchicci, L. (2003). Learning for Sustainability Transition through Bounded Socio-technical Experiments in Personal Mobility. *Technology Analysis & Strategic Management*, *15*(3), 291–315.
Brown, H. S., & Vergragt, P. J. (2008). Bounded socio-technical experiments as agents of systemic change: The case of a zero-energy residential building. *Technological Forecasting and Social Change*, *75*(1), 107–130.
Byggeth, S., & Hochschorner, E. (2006). Handling trade-offs in Ecodesign tools for sustainable product development and procurement. *Journal of Cleaner Production*, *14*(15-16), 1420–1430.
Callon, M. (1986). The sociology of an actor-network: The case of the electric vehicle. In M. Callon, J. Law, & A. Rip (Eds.), *Mapping the dynamics of science and technology: Sociology of science in the real world* (pp. 19–34). London: Macmillan Press Ltd.
Callon, M., Laredo, P., Rabeharisoa, V., Gonard, T., & Leray, T. (1992). The management and evaluation of technological programs and the dynamics of techno-economic networks: The case of the AFME. *Research Policy*, *21*(3), 215–236.
CBS. (2013). *Leegstand in Nederland anno 2013: Van krimpgebied tot dichtbevolkte Randstad*. Den Haag.
CBS. (2014). Very poor turnover results for Dutch construction sector in second quarter. Retrieved June 22, 2015, from http://www.cbs.nl/en-GB/menu/themas/bouwen-wonen/publicaties/artikelen/archief/2014/2014-4111-wm.htm
CBS. (2015). Voorraad woningen en niet-woningen; mutaties, gebruiksfunctie, regio. Retrieved June 30, 2015, from http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLnl&PA=81955NED&LA=nl
Ceron, I. (2006). *Shared Services, value creation in the Dutch construction and engineering industry*.
Chalmers, P. (2014). *Climate Change: Implications for Buildings*. Retrieved from http://www.cisl.cam.ac.uk/business-action/low-carbon-transformation/ipcc-briefings/pdfs/briefings/IPCC_AR5__Implications_for_Buildings__Briefing__WEB_EN.pdf
Chertow, M. R. (2000). Industrial Symbiosis : Literature and Taxonomy. *Annual Review of Energy Environment*, *25*(1), 313–337.
Circle Economy, van Odijk, S., & van Bovene, F. (2014). *Circulair bouwen*.
Cobouw. (2014). Award voor BIM-modellen Alliander en woningbouwproject. Retrieved January 6, 2016, from http://www.cobouw.nl/artikel/1069726-award-voor-bim-modellen-alliander-en-woningproject
Cobouw. (2016, February). Ketensamenwerking doodsteek voor CAO's of andersom?
Copper8, & Urgenda. (2015). *Duurzaam aanbesteden: van paradox naar potentie*. Nieuwkoop.
Crisp, J. (2015). New Circular Economy package still a work in progress for construction industry. Retrieved January 25, 2016, from http://www.euractiv.com/sections/sustainable-construction/new-circular-economy-package-still-work-progress-construction
Cross, R., Borgatti, S., & Parker, A. (2002). Making Invisible Work Visibe: Using Social Network Analysis to support strategic collaboration. *California Management Review*, 25–47.
Damen, M. A. (2012). *A resources passport for a circular economy: An assessment of the possible content and format of a resources passport in order to successfully contribute to the achievement of the circular economy*. Utrecht University. Retrieved from http://dspace.library.uu.nl/handle/1874/257741
Dangerman, T. C. J., & Schellnhuber, H. J. (2013). Energy systems transformation. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(7), 549–558. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3574957&tool=pmcentrez&rendertype=abstract
de Groot, F. (n.d.). Circulair en energieleverend herontwikkelingsproject. *Energiegids.nl*, 25–28.
de Kort, T. (2013). "Vastgoed is een lange termijnproject." *Weekblad Facilitair*, (280).
de Wit, R. (2013). "Ik wil me niet schulding voelen over het zoveelste gebouw." *Vastgoedmarkt*, 19–21.
Delta Development Group. (2014). Delta Development Group ontvangt eerste BREEAM-NL sloopcertificaat in Nederland voor project Leiden. Retrieved July 14, 2015, from http://deltadevelopment.eu/nieuws/delta-development-group-ontvangt-eerste-breeam-nl-sloopcertificaat-nederland-voor-project-lei
DGBC. (2015a). BREEAM NL. Retrieved July 14, 2015, from https://www.breeam.nl/

DGBC. (2015b). Huisvesting Alliander Duiven. Retrieved July 30, 2015, from https://www.breeam.nl/projecten/huisvesting-alliander-duiven
Diepenhorst, P. (2015). *Interview Case Heerema, Delta Development Group, Peter Diepenhorst*. *by E. Leising*. by Telephone, September 28, 2015.
Dobbs, R., Remes, J., Manyika, J., Roxburgh, C., Smit, S., & Schaer, F. (2012). *Urban World: Cities and the Rise of the Consuming Class*. *McKinsey & Company*. Retrieved from http://www.mckinsey.com/insights/mgi/research/urbanization/urban_world_cities_and_the_rise_of_the_consuming_class\npapers2://publication/uuid/C1BBC14A-B51F-43FC-AE92-CAC2DB6E346E
Doove, S. T., & Prince, Y. M. (2013). *De innovativiteit van het MKB in 2013*. Zoetermeer.
Dosi, G. (1993). Technological paradigms and technological trajectories. *Research Policy*, *22*(2), 102–103.
DTZ Zadelhof. (2014a). Park20|20 Haarlemmermeer even perfect als grensverleggend. Retrieved July 30, 2015, from http://www.duidelijkdtz.nl/groeien/grensverleggend-park2020-haarlemmermeer/
DTZ Zadelhof. (2014b). Standard Life Investments koopt nieuw hoofdkantoor van Heerema Marine Contractors Leiden. Retrieved November 30, 2015, from https://www.dtz.nl/
Duffy, F. (1994). Six S's. In S. Brand (Ed.), *How Buildings Learn: What Happens After They are Built*. New York: Viking Press.
Dukker, R. (2015). "Brancheorganisaties nekken de bouw." Retrieved from http://www.bouwformatie.nl/magazine/brancheorganisaties-nekken-de-bouw(1)
Dwars, O. (2015). Interview Case Alliander, Volker Wessels Vastgoed, Onno Dwars.
EC. (2012). Manifesto for a Resource-efficient Europe. Retrieved June 12, 2015, from http://europa.eu/rapid/press-release_MEMO-12-989_en.htm
EC Dg Env. (2011). *Service contract on management of construction and demolition waste - SR1. Final Report Task 2* (Vol. 33). Paris. Retrieved from http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf
Ecopro. (2015). Rico's Circular Economy, an interview with Mia Goetvinck. Retrieved December 15, 2015, from http://gef.eu/uploads/media/Mia_Goetvinck_Interview_on_Circular_Economy.pdf
EFBWW. (2015). Building & Construction. Retrieved June 22, 2015, from http://www.efbww.org/default.asp?Issue=CONSTR
Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century*. Oxford: Capstone Publishing.
Ellen MacArthur Foundation. (2012). *Towards the Circular Economy - Economic and business rationale for an accelerated transition (Vol. 2)*. Cowes, United Kingdom.
Ellen MacArthur Foundation. (2013). *Towards the Circular Economy - Opportunities for the Consumer Goods Sector (Vol. 2)*. Cowes, United Kingdom.
Ellen MacArthur Foundation. (2014). *Towards the Circular Economy - Accelerating the scale-up across global supply chains (Vol. 3)*. *World Economic Forum Reports*. Geneva, Switzerland.
Emanuel, M., & Rebel, H. (2015). *Interview Case Alliander, RAU Architecten, Marijn Emanuel & Henk Rebel*. *by E. Leising*. Amsterdam, October 20, 2015.
EnergieSprong. (2015). Alliander. Retrieved July 30, 2015, from http://www.kantoorvolenergie.nl/alliander/
Esco netwerk. (2015). Wat is een ESCo? Retrieved September 3, 2015, from http://www.esconetwerk.nl/Wat-is-een-ESCo
Evans, J. L., & Bocken, N. M. P. (2015). *Developing a Tool for Manufacturers to Find Opportunity in the Circular Economy - www.circulareconomytoolkit.org*. Cambridge.
Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. *International Journal of Production Economics*, *162*, 101–114.
Fernie, S., Leiringer, R., & Thorpe, T. (2006). Rethinking change in construction: a critical perspective. *Building Research and Information*, *34*(2006), 91–103.
Fernie, S., & Thorpe, A. (2007). Exploring change in construction: supply chain management. *Engineering, Construction and Architectural Management*, *14*(4), 319–333.
Ford, D., Håkansson, H., Snehota, I., & Gadde, L.-E. (2002). Managing networks. *18th IMP Conference*, 1–22.
Frankenberger, K., Weiblen, T., Csik, M., & Gassmann, O. (2013). The 4I-framework of business model innovation: a structured view on process phases and challenges. *International Journal of Product Development*, *18*(3-4), 249.
Freeman, L. C. (2004). *The Development of Social Network Analysis*. Vancouver, BC Canada: Empirical Press.
Garmendia, E., & Stagl, S. (2010). Public participation for sustainability and social learning: Concepts and lessons from three case studies in Europe. *Ecological Economics*, *69*(8), 1712–1722.
Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems. *Research Policy*, *33*(6-7), 897–920.
Geels, F. W., & Smit, W. a. (2000). Failed technology futures: Pitfalls and lessons from a historical survey. *Futures*,

32(9), 867–885.
Gimenez, C., & Tachizawa, E. M. (2012). Extending sustainability to suppliers: a systematic literature review. *Supply Chain Management: An International Journal*, *17*(5), 531–543.
Gordon, I. A., & McCann, P. (2000). Industrial Clusters: Complexes, Agglomeration and/or Social Networks? *Urban Studies*, *37*(3), 513–532.
Government of the Netherlands. (2015). Public-Private Partnerships. Retrieved September 3, 2015, from https://www.government.nl/topics/development-cooperation/contents/development-cooperation-partners-and-partnerships/public-private-partnerships
GPR. (2015). GPR Gebouw maakt duurzaam bouwen inzichtelijk. Retrieved September 3, 2015, from http://www.gprgebouw.nl/
Graedel, T. (1994). Industrial ecology: definition and implementation. In R. Socolow, C. Andrews, F. Berkhout, & V. Thomas (Eds.), *Industrial ecology and global change* (pp. 23–41). Cambridge: Cambridge University Press.
Graedel, T. (1997). Designing the Ideal Green Product: LCA/SCLA in Reverse. *The International Journal of Life Cycle Assessment*, *2*(1), 25–31.
Granovetter, M. (1985). Economic Action and Social Structure: The Problem of Embeddedness. *American Journal of Sociology*, *91*(3), 481.
Green, K., & Randles, S. (2006). *Industrial Ecology and Spaces of Innovation*. Edward Elgar Publishing.
GreenCalc. (2015). GreenCalc+. Retrieved September 3, 2015, from http://www.greencalc.com/Wat_is_GreenCalc.html
Greyson, J. (2007). An economic instrument for zero waste, economic growth and sustainability. *Journal of Cleaner Production*, *15*(13-14), 1382–1390.
Grin, J., & Grunwald, A. (2000). *Vision assessment: shaping technology in the 21st century towards a repertoire for Technnology Assessment*. Berlin Germany: Springer Verlag.
Grin, J., & van de Graaf, H. (1996). Technology Assessment as Learning. *Science, Technology and Human Values*, *20*(1), 72–99.
Groene Allianties. (2012). Participanten. Retrieved November 23, 2015, from https://www.groeneallianties.nl/samenwerkingspartners/
Grosfeld, J. (2015). *Interview Case Park20|20, N3O, Jeroen Grosfeld*. *by E. Leising*. Delft, September 25, 2015.
Håkansson, H. (1987). *Industrial technological development: a network approach*. Routledge London UK.
Hall, P. A. (1993). Policy Paradigms, Social Learning, and the State: The Case of Economic Policymaking in Britain. *Comparative Politics*, *25*(3), 275.
Hamari, J., & Ukkonen, A. (2013). The Sharing Economy: Why People Participate in Collaborative Consumption. *SSRN Electronic Journal*, 1–19. Retrieved from http://www.ssrn.com/abstract=2271971
Henket, M. (2014). Eerste energiepositieve bouwplaats van het land. Retrieved November 18, 2015, from http://www.cobouw.nl/artikel/1027106-eerste-energiepositieve-bouwplaats-het-land
Henket, M. (2015). Liander, Duiven - Een georganiseerd grondstoffendepot. *De Architect*, (May 2015), 82–88.
Henneberg, S. C., Mouzas, S., & Naudé, P. (2006). Network pictures: concepts and representations. *European Journal of Marketing*, *40*(3/4), 408–429.
HMC. (2015). HMC signs agreement for new headquarters. Retrieved October 26, 2015, from http://hmc.heerema.com/content/news-media/news-releases/news-detail/article/hmc-signs-agreement-for-new-headquarters/
Hoeben, P. (2015). *Interview Case Heerema, Lendering & Partners, Paul Hoeben*. *by E. Leising*. Soest, October 2, 2015.
Horvath, L. (2001). Collaboration: the key to value creation in supply chain management. *Supply Chain Management: An International Journal*, *6*(5), 205–207.
IPCC. (2014). *Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. Retrieved from http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf
Ireland, R., & Bruce, R. (2000). CPFR - Only the beginning of collaboration. *Supply Chain Management Review*, (September/October), 80–88.
Jackson, M., Lederwasch, A., & Giurco, D. (2014). Transitions in Theory and Practice: Managing Metals in the Circular Economy. *Resources*, *3*(3), 516–543.
Kamp, L. M. (2002). *Learning in wind turbine development: a comparison between the Netherlands and Denmark*. Utrecht University.
Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, *10*(2), 175–198.
Khasreen, M. M., Banfill, P. F. G., & Menzies, G. F. (2009). Life-cycle assessment and the environmental impact of buildings: A review. *Sustainability*, *1*(3), 674–701.

KIDV. (2014). *KPMG ondersteunt branches bij opstellen verduurzamingsplannen*.
Kleijn, R. (2012). *Materials and energy: a story of linkages*. Leiden University.
Kok, L., Wurpel, G., & Ten Wolde, A. (2013). *Unleashing the Power of the Circular Economy*. Amsterdam, the Netherlands: IMSA for Circle Economy.
Korpershoek, E. (2015). *Interview Case Heerema, Wessels Zeist, Erik Korpershoek*. *by E. Leising*. Leiden, September 29, 2015.
KPMG. (2012). *Expect the Unexpected: Building business value in a changing world: Executive Summmary*.
KPMG. (2015). Building & Construction. Retrieved June 22, 2015, from http://www.kpmg.com/global/en/industry/building-construction/pages/default.aspx
Kragtwijk, A., & Warmerdam, E. (2015). *Interview Case Park20|20, IBB Kondor, Alex Kragtwijk & Ed Warmerdam*. *by E. Leising*. Oegstgeest, September 25, 2015.
Kruk, K., de Wit, M., Ramkumar, S., de Winter, J., Güvendik, M., van 't Hof, K., … Frijters, E. (2015). *Amsterdam Circulair - een visie en routekaart voor de stad en regio*. Amsterdam.
Lai, K. H., Cheng, T. C. E., & Tang, A. K. Y. (2010). Green Retailing: Factors For Success. *California Management Review*, *52*(2), 6–31.
Lambert, D. M., & Pohlen, T. L. (2001). Supply Chain Metrics. *The International Journal of Logistics Management*, *12*(1), 1–19.
Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Technology Management*, *20*(3-4), 373–387.
Leek, S., & Mason, K. J. (2010). The utilisation of network pictures to examine a company 's employees' perceptions of a supplier relationship of a supplier relationship. *Industrial Marketing Management*, *39*, 400–412.
Lehmann, M., Bocken, N. M. P., Steingrímsson, J. G., & Evans, S. (2015). Incorporating Design Thinking into Sustainable Business Modelling. In *SDM 2015, Second International Conference on Sustainable Design and Manufacturing, Seville, Spain, 12-14 April 2015* (pp. 1–20). Seville.
Leijnse, L. (2015). *Interview Case Heerema, Heyligers design+projects, Lonneke Leijnse*. *by E. Leising*. Utrecht, October 9, 2015.
LenteAkkoord. (2015). Update 2015 Energiekosten Nieuwbouwwoningen - De Uniforme Bepalingsmethodiek. Retrieved June 30, 2015, from http://www.lente-akkoord.nl/update-energiekosten-nieuwbouwwoningen-uniforme-bepalingsmethodiek/
LME. (2015). LME Tin. Retrieved December 15, 2015, from http://www.lme.com/metals/non-ferrous/tin/
Lodder, M., Huffenreuter, R. L., Braungart, M., & den Held, D. (2014). *Regenerative Sustainable Development: Towards a Triple Top Line approach and Increasing Positive Externalities*. Conference Paper for the 5th International Sustainability Transitions Conference, Utrecht, August 27-29, 2014.
Lucon, O., & Urge-Vorsatz, D. (2014). Chapter 9: Buildings. In *Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 671–738). United Kingdom and New York, NY, USA: Camrbidge University Press.
Lüdeke-Freund, F. (2009). *Business Model Concepts in Corporate Sustainability Contexts: From Rhetoric to a Generic Template for "Business Models for Sustainability"* (Vol. 10). Lueneburg: Centre for Sustainability Management. Retrieved from www.leuphana.de/csm/
Luttropp, C. (2006). *10 Golden Rules in EcoDesign*. Stockholm. Retrieved from http://lpmc.lv/uploads/media/10_goldenrules_in_eco-design.pdf
Lyle, J. T. (1996). *Regenerative design for sustainable development*. John Wiley and Sons Inc.
Mak, A. (2013). Eerste C2C bedrijventerrein in Nederland. Retrieved November 4, 2015, from http://www.gebiedsontwikkeling.nu/artikel/5169-eerste-c2c-bedrijventerrein-in-nederland
Mason, K., & Spring, M. (2011). The sites and practices of business models. *Industrial Marketing Management*, *40*, 1032–1041.
Maxwell, D., & van der Vorst, R. (2003). Developing sustainable products and services. *Journal of Cleaner Production*, *11*, 883–895.
McDonough, W., & Braungart, M. (2002). *Cradle to cradle: remaking the way we make things*. New York: North Point Press.
McDonough, W., & Braungart, M. (2011). *Toward a Cradle to Cradle Park 20|20 - The work benefits, the world benefits*.
McManus, S., & Tennyson, R. (2008). *Talking the Walk: A Communication Manual for Partnership Practicioners*.
Meadows, D. H., & Club of Rome. (1972). *The Limits to growth: A report for the Club of Rome's project on the predicament of mankind*. New York: Universe Books.
Meadows, D. H., Randers, J., & Meadows, D. (2004). *Limits to Growth: The 30-Year Update*. Chelsea Green Publishing.

Meer Met Minder. (2015). Meer Met Minder Energie. Retrieved June 30, 2015, from http://www.meermetminder.nl/26/home.html
Menéndez, L. S., & Cabello, C. (2000). *Expectations and learning as principles of shaping the future*. Madrid.
Mentink, B. (2014). *Circular Business Model Innovation: a process framework and a tool for business model innovation in a circular economy*.
Milieu Centraal. (2015). Energielabel woningen. Retrieved September 3, 2015, from http://www.energielabel.nl/woningen/
Ministerie van VROM. (2010). Dossier Duurzaam Bouwen en Verbouwen, 1–4. Retrieved from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/brochures/2010/06/01/informatieblad-strategieen-duurzaam-bouwen/informatieblad-strategien-duurzaam-bouwen.pdf
Mont, O. K. (2002). Clarifying the concept of product-service system. *Journal of Cleaner Production*, *10*(3), 237–245.
MVO Nederland. (2015). LEED: de wereldwijde standaard in de bouw. Retrieved September 3, 2015, from http://mvodatabase.nl/nieuws/leed-de-wereldwijde-standaard-in-de-bouw/
Niehof, M. (2015). Interview Case Alliander, Kuiper Compagnons, Martijn Niehof.
Noordhuis, M., & Vrijhoef, R. (2011). *Ketensamenwerking in de bouw: Een aan de praktijk getoetst kader voor het toepassen van ketensamenwerking door bouwondernemers en hun ketenpartners*.
Noordhuis, M., & Vrijhoef, R. (2011). *Ketensamenwerking in de bouw: een aan de praktijk getoetst kader voor het toepassen van ketensamenwerking door bouwondernemers en hun ketenpartners* (RRBouwrapp). Zoetermeer: Stichting Research Rationalisatie Bouw.
Nürnberger, K. (2015). Tea? Coffee!! *Gaswinner*, pp. 38–40.
Oerlemans, L. A. G. (1996). *De ingebedde onderneming: Innoveren in industriele netwerken*. Tilburg Unversity Press.
Orgaworld. (2014). Niets meer weggooien. Retrieved December 16, 2015, from http://orgaworld.nl/nieuws/niets-meer-weggooien
Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation*. Hobroken, NJ: John Wiley & Sons Inc.
Osterwalder, A., Pigneur, Y., & Tucci, C. (2005). Clarifying business models: origins, present, and future of the concept. *Communications of the Association for Information Systems*, *15*(May), 1–43.
Park 20|20 C.V. (2010a). Newsletter Park 20|20, *1*.
Park 20|20 C.V. (2010b). Newsletter Park 20|20, *2*.
Park 20|20 C.V. (2010c). Newsletter Park 20|20, 4.
Park 20|20 C.V. (2010d). Newsletter Park 20|20, 5.
Park 20|20 C.V. (2011). *Overzicht BREEAM BSH*.
Park2020. (2015a). Background. Retrieved April 20, 2015, from http://www.park2020.com/background
Park2020. (2015b). FOX Vakanties achieves BREEAM-NL Excellent rating. Retrieved October 26, 2015, from http://www.park2020.com/news/fox+vakanties+achieves+breeamnl+excellent+rating_36
Parlikad, A., McFarlane, D., Fleisch, E., & Gross, S. (2003). *The Role of Product Identify in End-Of-Life Decision Making*. Retrieved from CAM-AUTOID-WH-017
Pauli, G. A. (2010). *The blue economy: 10 years, 100 innovations, 100 million jobs*. Taos, NM: Paradigm Publications.
Pearce, D. W., & Turner, R. K. (1990). *Economics of natural resources and the environment*. London: Harvester Wheatsheaf.
Philips. (2015). Circular Economy. Retrieved December 15, 2015, from http://www.philips.com/about/sustainability/ourenvironmentalapproach/greeninnovation/circulareconomy.page
Plan C. (2015). The Business Model Innovation Grid. Retrieved January 1, 2015, from http://www.plan-c.eu/bmix/
Porter, M. E., & Kramer, M. R. (2011). Creating Shared Value: The Idea in Brief. *Harvard Business Review*, (January), 1–17.
Poulus, C., van Leeuwen, G., Omtzigt, D., & Heida, H. (2014). *Ontwikkelingen op de woningmarkt*. Delft.
Preston, F. (2012). A Global Redesign? Shaping the Circular Economy. *Energy, Environment and Resource Governance*, (March).
Prijs-Inzicht. (2015). Wat is de prijs van beton? Retrieved December 15, 2015, from http://www.prijs-inzicht.nl/index.php/bouwmaterialen/prijs-van-beton
Quist, J. (2007). *Backcasting for a sustainable future: the impact after 10 years*. Delft University of Technology.
Quist, J., & Vergragt, P. (2006). Past and future of backcasting: The shift to stakeholder participation and a proposal for a methodological framework. *Futures*, *38*(9), 1027–1045.
Richardson, J. (2008). The business model: an integrative framework for strategy execution. *Strategic Change*, *17*(5-6), 133–144. Retrieved from http
Rietveld, E., Roelofs, E., Bastein, T., & Hoogendoorn, A. (2013). *Kansen voor de circulaire economie in Nederland*. Delft.

Robinson, J. (2003). Future subjunctive: Backcasting as social learning. *Futures*, *35*(8), 839–856.
Roelofs, S. (2015). Interview Case Alliander, Fokkema & Partners, Saskia Roelofs. *By E. Leising*. Delft, September 29, 2015.
Romero, D., & Molina, A. (2009). Value co-creation and co-innovation: Linking networked organisations and customer communities. *IFIP Advances in Information and Communication Technology*, *307*(June 2015), 401–412.
Rotmans, J., Kemp, R., van Asselt, M. (2001). More evolution than revolution. *Transition Management in Public Policy*, *03*(01).
RVO. (2015a). Energieprestatie (EPC). Retrieved September 3, 2015, from http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/energieprestatie
RVO. (2015b). Met Green Deals naar een duurzame samenleving. Retrieved November 23, 2015, from http://www.greendeals.nl/
Sabatier, P. A., & Jenkins-Smith, H. C. (1999). The advocacy coalition framework: An assessment. In *Theories of the policy coalition framework* (pp. 117–166). Boulder: Westview Press.
Saint-Gobain. (2015). Milieuprestatie. Retrieved June 26, 2015, from http://www.glassolutions.nl/sustainable-building/milieuprestatie
SAP. (2015). Business Process Map. Retrieved December 20, 2015, from http://wiki.scn.sap.com/wiki/display/ModHandbook/Business+Process+Map
Sarkis, J. (1995). Supply chain management and environmentally conscious design and manufacturing. *International Journal of Environmentally Consicous Design and Manufacturing*, *4*(2), 43–52.
Sarkis, J. (2003). A strategic decision framework for green supply chain management. *Journal of Cleaner Production*, *11*, 397–409.
Sarkis, J., Helms, M. M., & Hervani, A. a. (2010). Reverse logistics and social sustainability. *Corporate Social Responsibility and Environmental Management*, *17*(6), 337–354.
Sarkis, J., Zhu, Q., & Lai, K. H. (2011). An organizational theoretic review of green supply chain management literature. *International Journal of Production Economics*, *130*(1), 1–15.
Schäpke, N., Omann, I., Mock, M., & Wittmayer, J. (2013). Supporting sustainability transitions by enhancing the human dimension via empowerment, social learning and social capital. In J. Quist, J. Wittmayer, K. Umpfenbach, & T. Bauler (Eds.), *Pathways, Transitions and backcasting for Low-Carbon and Sustainable Lifestyles. Sustainable Consumption Transitions Series, Issue 3 Proceedings of SCORAI Europe & InContext Workshop*. Rotterdam, The Netherlands.
Senge, P. M. (1990). *The fifth discipline: the art and practice of the learning organization*. New York: Double Day.
Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16*(15), 1699–1710.
Shane, J., Strong, K., & Gransberg, D. (2012). *Guidebook: Project Management Strategies for Complex Projects*. *the Strategic Highway Research Program 2 Transportation Research Board of the National Academies*. Iowa.
Siera, B. (2015). *Interview Case Heerema, Heerema Marine Contractors, Bert Sierra*. *by E. Leising*. Leiden, October 16, 2015.
Sijbrandij, J., & Korbee, H. (2012). *ESCo voor wederzijds voordeel en gratis energiebesparing*. Utrecht.
Sisco, C., Chorn, B., & Pruzan-Jorgensen, P. M. (2010). *Supply Chain Sustainability: A Pracitical Guide for Continuous Improvement*. *Supply Chain Sustainability*. Retrieved from http://www.unep.fr/scp/business/dialogue/2011/pdf/UNEP_2011_BIGD_Agenda.pdf
Slimbouwen. (2015). Rendement en continuïteit van begin tot eind... Retrieved September 3, 2015, from http://www.slimbouwen.nl/
Smartdraw. (2015). Flowcharts. Retrieved December 20, 2015, from http://www.smartdraw.com/flowchart/
Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, *34*, 1491–1510.
Smith, N. C., Ansett, S., & Erez, L. (2011). How Gap Inc. Engaged With its Stakeholders. *MIT Sloan Management Review*, *52*(4), 69–76. Retrieved from http://elib.tcd.ie/login?url=http://search.proquest.com/docview/875531968?accountid=14404
Stahel, W. R. (1994). The utilization focused service economy. In B. R. Allenby & D. J. Richards (Eds.), *The Greening of Industrial Ecosystems* (pp. 178–190). Washington D.C.: National Academy Press.
Stahel, W. R., & Reday-Mulvey, G. (1981). *Jobs for tomorrow: the potential for substituting manpower for energy*. Vantage Press.
Stank, T. P., Keller, S. B., & Daugherty, P. J. (2001). Supply chain collaboration and logistical service performance. *Journal of Business Logistics*, *22*(1), 29–48.
Stiglitz, J. E., Sen, A., & Fitoussi, J.-P. (2009). *Report by the Commission on the Measurement of Economic*

Performance and Social Progress (Vol. 12). Retrieved from http://www.ssrn.com/abstract=1714428
Stubbs, W., & Cocklin, C. (2008). Conceptualizing a "Sustainability Business Model." *Organization & Environment*, *21*(2), 103–127.
Su, B., Heshmati, A., Geng, Y., & Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production*, *42*, 215–227.
Suurs, R., van Niekerk, E., van Barreveld, C., & Urlings, M. (2011). Duurzame innovatie in de bouwsector: Een analyse van kansen en belemmeringen. *TVVL Magazine*, (4), 36–40.
Svendsen, A. C., & Laberge, M. (2005). Convening Stakeholder Networks - A New Way of Thinking, Being and Engaging. *Journal of Corporate Citizenship*, (19), 91–104.
Swiercz, M. P. (n.d.). *SWIF Learning - A Guide to Student Written-Instructor Facilitated Case Writing*. Washington D.C.
Talberth, J., Cobb, C., & Slattery, N. (2007). *The Genuine Progress Indicator 2006: A Tool for Sustainable Development*. *Redefining Progress*. Oakland, Canada.
Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2-3), 172–194.
Tennyson, R. (2003). *The Partnering toolbook*. *IBLF and GAIN*. The International Business Leaders Forum (IBLF) and the Global Alliance for Improved Nutrition (GAIN). Retrieved from http://thepartneringinitiative.org/publications/toolbook-series/the-partnering-toolbook/
The Natural Step. (2015). Aanpak. Retrieved June 9, 2015, from http://thenaturalstep.nl/aanpak/
TU Delft. (2013). *Bouw Informatie Modellering (BIM) in het universitair onderwijs*. Delft.
Unilever. (2015). Recycling & moving to a circular economy. Retrieved December 15, 2015, from https://www.unilever.com/sustainable-living/what-matters-to-you/recycling-and-moving-to-a-circular-economy.html
Urgenda. (2015). Over Urgenda. Retrieved November 23, 2015, from http://www.urgenda.nl/
US EPA. (2008). *Sector Performance Report*.
USGBC. (2015). LEED. Retrieved July 14, 2015, from http://www.usgbc.org/leed
van Bergen, B., Mackinthosh, J., & McKenzie, M. (2014). *A New Vision of Value: Connecting corporate and societal value creation*.
van Bueren, E. (2012). Chapter 1 - Introduction. In E. van Bueren, H. van Bohemen, L. Itard, & H. Visscher (Eds.), *Sustainable Urban Environments* (pp. 1–14). Dordrecht: Springer Science+Business Media BV.
van de Kerkhof, M., & Wieczorek, A. (2005). Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations. *Technological Forecasting and Social Change*, *72*(6 SPEC. ISS.), 733–747.
van de Poel, I. (2003). The transformation of technological regimes. *Research Policy*, *32*, 49–68.
van den Broek, R. (2015). *Interview Case Park20|20, Delta Development Group, Rob van den Broek*. *by E. Leising*. by Telephone, September 23, 2015.
van der Gaag, F., de Graaf, M., & Vuik, I. (2014). *Trends en ontwikkelingen in de financiële functie*. Rotterdam.
van der Helm, R. (2009). The vision phenomenon: Towards a theoretical underpinning of visions of the future and the process of envisioning. *Futures*, *41*(2), 96–104.
van der Veen, B., & Laudy, S. (2005). *Marketing in de bouw op de particuliere markt*. Gouda: Stichting Research en Rationalisatie Bouw (RRBouw).
van Ee. (2015). Grote trappen/balustrades opdracht voor Hoofdkantoor Heerema Marine Contractors te Leiden. Retrieved July 23, 2015, from http://www.staalverleggend.nl/nieuws/grote-trappen-balustrades-opdracht-voor-hoofdkanto
van Es, K. (2015). *Interview Case Heerema, Beelen, Kees van Es*. *by E. Leising*. Amstelveen, October 12, 2015.
van Kasteren, J. (2013). Het gebouwen als grondstoffenbank. *Trouw*, pp. 8–9.
van Merkerk, R. O., & van Lente, H. (2005). Tracing emerging irreversibilities in emerging technologies: The case of nanotubes. *Technological Forecasting and Social Change*, *72*(9), 1094–1111.
van Mierlo, B. C. (2002). *Kiem van maatschappelijke verandering: verspreiding van zonnecelsystemen in de woningbouw met behulp van pilotprojecten*. University of Amsterdam.
van Oppen, C. (2015). Interview Case Alliander, Copper8, Cecile van Oppen.
van Steijn, P. (2015). *Interview Case Park20|20, Homij, Paul van Steijn*. *by E. Leising*. Amsterdam, October 12, 2015.
van Tuijl, H. (2015). *Interview Case Park20|20, EPEA, Hein van Tuijl*. *by E. Leising*. by Telephone, October 14, 2015.
van Zantvoort, H. (2015). Interview Case Alliander, Alliander, Hendrik van Zandvoort. *by E. Leising*. Arnhem, September 10, 2015.
van Zuilekom, L. (2013). Heerema keert terug naar zijn roots. *Installatie En Bouw Magazine*.
Vastgoedmarkt. (2012). "Waarde commercieel vastgoed daalt 10 procent." Retrieved June 25, 2015, from http://www.vastgoedmarkt.nl/nieuws/2012/07/11/Waarde-commercieel-vastgoed-daalt-procent
Vernay, A. (2013). *Circular Urban Systems - moving towards system integration*. Delft University of Technology.

Verwoerd, F., & Mulder, M. (2015). *Restschulden in Nederland - Omvang en effecten van restschulden*.
Vondellaan47. (2013). Spectaculaire start sloop. Retrieved July 30, 2015, from http://www.vondellaan47.com/
Vondellaan47. (2015). Vondellaan 47 take 2. Retrieved November 30, 2015, from http://www.vondellaan47.com/
Vrijhoef, R., & Koskela, L. (1999). Roles of Supply Chain Management in Construction. *Proceedings IGLC*, *31*(15), 133–146.
VW Vastgoed. (2015). Huisvesting Alliander Duiven. Retrieved July 23, 2015, from http://www.vwvastgoed.nl/nl/projecten/detail/huisvesting-alliander-duiven
Walrecht, A. (2015). *Expert consultation - sector comparison for best practices regarding collaboration and circular practices*. *by E. Leising*. Amstelveen, November 17, 2015.
WBCSD. (2011). *A vision for sustainable consumption: Innovation, collaboration, and the management of choice*.
WCED. (1987). *Report of the World Commission on Environment and Development: Our Common Future (The Brundtland Report)*. *United Nations* (Vol. 4).
Weiseth, P. E., Munkvold, B. E., Tvedte, B., & Larsen, S. (2006). The wheel of collaboration tools: a typology for analysis within a holistic framework. *CSCW 06 Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work*, 239–248.
Wessels, P. (2013). Delta vindt zichzelf opnieuw uit. *Property Magazine*, *2*, 36–37.
Wikipedia. (2015). Bouw. Retrieved June 24, 2015, from https://nl.wikipedia.org/wiki/Bouw#Bouwsector_in_Nederland
Wittmayer, J., Mock, M., Van Steenbergen, F., Baasch, S., Omann, I., Schapke, N., & Rauschmayer, F. (2013). *Taking stock – Three years of addressing societal challenges on community level through action research*. Pilot specific synthesis report.
Wrap. (2015). Developing resource efficient business models (REBus). Retrieved November 23, 2015, from http://www.wrap.org.uk/content/rebus
Wurpel, G., van den Akker, J., Pors, J., & Ten Wolde, A. (2011). *Plastics do not belong in the ocean. Towards a roadmap for a clean North Sea*.
Wynne, B. (1995). Technology assessment and reflexive learning: observations from the risk field. In A. Rip, T. Misa, & J. Schot (Eds.), *Managing technology in society: The approach of constructive technology assessment* (pp. 19–36). London: Harold Printer.
Yin, R. K. (1981). The Case Study Crisis: Some Answers. *Administrative Science Quarterly*, *26*(1), 58–65.
Yin, R. K. (2009). Identifying Your Case (s) and Establishing the Logic of Your Case Study. In R. K. Yin (Ed.), *Case Study Research: Design and Methods* (pp. 25–66). SAGE Inc.
Yuan, Z., Bi, J., & Moriguichi, Y. (2006). The Circular Economy: A New Development Strategy in China. *Journal of Industrial Ecology*, *10*(1-2), 4–8.
Zaaijer, L., Grouls, P., & van der Molen, K. (2009). *Levensduurzaamheid: van methodiek tot planvoorstel*. Den Haag. Retrieved from www.architectenvanmourik.nl/download.asp?id=3155
Zachariasse, O. (2015). Interview Case Park20|20, Delta Development Group, Owen Zachariasse. *by E. Leising*. Hoofddorp. September 9, 2015.
Zang, S., Hofer, A., & Adam, O. (2004). Cross-Enterprise Business Process Management Architecture - Methods and Tools for Flexible Collaboration. In *On the Move to Meaningful Internet Systems 2004: OTM 2004 Workshops* (pp. 483–494). Cyprus.
Zhu, Q., Geng, Y., & Lai, K. H. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. *Journal of Environmental Management*, *91*(6), 1324–1331.
Zhu, Q., Geng, Y., & Lai, K. H. (2011). Environmental supply chain cooperation and its effect on the circular economy practice-performance relationship among Chinese manufacturers. *Journal of Industrial Ecology*, *15*(3), 405–419.
Zilverprijs. (2015). Zilverprijs. Retrieved December 15, 2015, from http://www.actuelezilverprijs.nl/
Zott, C., & Amit, R. (2010). Business model design: An activity system perspective. *Long Range Planning*, *43*(2-3), 216–226.
Zucker, D. M. (2009). Teaching research methods in the humanities and social sciences: how to do case study research. *School of Nursing Faculty Publication Series*, (Paper 2), 1–17. Retrieved from http://scholarworks.umass.edu/nursing_faculty_pubs/2

Appendix A

List of interviewees

	Name	Company	Role in case	Interview date
Case: Alliander	Hendrik van Zantvoort	Alliander	Client/ End user	10-09-2015
	Onno Dwars	VolkerWessels Vastgoed	Developer	18-09-2015
	Cécile van Oppen	Copper8 (prev. Squarewise)	Consultant	21-09-2015
	Saskia Roelofs	Fokkema & Partners	Interior Architect	29-09-2015
	Martijn Niehof	Kuiper Compagnons	Urbanist	30-09-2015
	Marijn Emanuel & Henk Rebel	RAU Architecten	Architects	21-10-2015
Case: Park20|20	Owen Zachariasse	Delta Development Group	Consultant/developer	09-09-2015
	Rob van den Broek	Delta Development Group	Developer	23-09-2015
	Jeroen Grosfeld	N3O	Architect	25-09-2015
	Alex Kragtwijk & Ed Warmerdam	IBB Kondor	General Contractor	25-09-2015
	Paul van Steijn	Homij	Installation Advisor	12-10-2015
	Hein van Tuijl	EPEA	Materials certification	14-10-2015
Case: Heerema	Peter Diepenhorst	Delta Development Group	Developer	28-09-2015
	Erik Korpershoek	Wessels Zeist	Contractor	29-09-2015
	Paul Hoeben	Lendering & Partners	Developing Management	02-10-2015
	Lonneke Leijnse	Heyligers design+projects	Interior Architect	09-10-2015
	Kees van Es	Beelen	Demolition	12-10-2015
	Bert Siera	Heerema Marine Contractors	Client/ End user	16-10-2015

Appendix B

Interview Guide

Interview Doelen

Inzicht krijgen in hoe actoren omgaan met circulaire bouwprojecten, wat de ervaringen zijn, hoe de samenwerking en het business model is vormgegeven en wat voor mogelijkheden ze zien voor opschaling.

- Subdoelen:
  - Motivatie om aan het desbetreffende project deel te nemen is besproken
  - Algemene ervaringen tijdens het project zijn besproken
  - De rol en invloed van visies binnen het project zijn besproken
  - Leerprocessen, reflectie en hun invloed voor verdere diffusie van circulair bouwen zijn besproken
  - De samenstelling van het netwerk en de rollen van de verschillende partijen zijn behandeld
  - De vernieuwende aspecten van het (eventueel) toegepaste business model zijn besproken
  - De mogelijkheden en obstakels van een CE binnen de bouwsector zijn behandeld
  - Mogelijkheden van actor om deel te nemen aan een workshop voor validatie van de tool zijn verkend

Introductie – *5 min.*

1. *Korte introductie Eline:*
Eline Leising, 26, Bsc. BK, Msc. IE. Deze achtergronden samen binnen dit afstudeeronderzoek samen met KPMG Sustainability.

2. *Onderwerp:*
Circulaire Economie binnen de bouwsector met een focus op ketensamenwerking

3. *Hoofddoel:*
  - Inzicht krijgen in succesfactoren die het op organisatorisch gebied mogelijk maken circulaire bouwprojecten te ontwikkelen.

3. *Belangrijkste onderwerpen die zullen worden behandeld:*
  - Initiële betrokkenheid bij het project (motivatie) en algemene ervaringen
  - Visies
  - Lessons learned (leerprocessen)
  - Samenstelling van het netwerk/keten rondom het project incl. rollen
  - Samenwerking (vertrouwen, contracten, communicatie, vernieuwende elementen)
  - Waarde creatie, business model
  - Drivers voor CE in de bouwsector
  - Barriers voor CE in de bouwsector

4. *Tijdsduur*
Het interview zal ongeveer 1 uur in beslag nemen.

5. *Uitwerking resultaten interview:*
Dit interview zal worden gebruikt als input voor het creëren van een tool voor het stimuleren van ketensamenwerking binnen de bouwsector als onderdeel van mijn scriptie. Een draft hiervan zal in november verkrijgbaar zijn. Wilt u de resultaten van dit onderdeel van het onderzoek ontvangen?
Uitwerking van de notulen van dit interview zullen binnen (X) weken gereed zijn. Wilt u deze checken?

6. *Opname van het interview*
Kan ik dit interview opnemen? De opname zal gebruikt worden voor de wetenschappelijke waarde van dit onderzoek; er zal een transcript worden gemaakt.

Introductie van geïnterviewde – max. 3 min.

Kunt u zichzelf introduceren? Wie bent u, wat doet u, en wat doet uw bedrijf?

Interview Vragen

1. Onderwerp verkennen - 3 min.:
    a. Wat verstaat u onder Circulaire Economie? En wat verstaat u onder CE in de bouw?
    b. Hoe werkt uw bedrijf aan circulariteit in de bouw? Welke activiteiten/projecten doet u hierbij?

2. Case study verkennen - 5 min.:
    a. Hoe bent u (als bedrijf) bij dit project betrokken?
    b. Waarom bent u (als bedrijf) bij dit project betrokken?
    c. Wat waren uw belangrijkste ervaringen tijdens dit project?
    d. Wat was het meest vernieuwende aan dit project?

3. Visies - 7 min.:
    a. Is er een visie in dit project? Zo ja, wat houdt deze visie in/ wat is het doel van het project?
    b. Hoe is deze visie ontwikkeld/ tot stand gekomen?
    c. In hoeverre werd deze visie door iedereen gedeeld en/of waren er andere interpretaties?
    d. Hoe sluit de ontwikkelde visie aan bij de visie/opvattingen van uw bedrijf (op duurzaamheid/CE)?
    e. Hoe dragen deze visies bij aan het vormgeven/praktisch maken van de CE in de bouwsector?

4. Leerprocessen - 7 min.:
    a. Wat heeft u zelf en als bedrijf geleerd van deelname aan dit project?
    b. Wat hebben anderen volgens u geleerd van dit project en wat is er gezamenlijk (binnen het projectteam) geleerd?

    Eventueel a en/of b aanvullen met volgende aspecten van leren:
        i. Wat is er geleerd over (take back!) infrastructuur en nieuwe technologieën?
        ii. Wat is er geleerd over de gebruiker, zijn eisen en kenmerken?
        iii. Wat is er geleerd over (keten)samenwerking?
        iv. Wat is er geleerd over beleid, wetgeving en de rol van de overheid?

    c. Welk probleem wilde het project aanvankelijk oplossen (bijv.: een technisch of management probleem) en heeft u deze probleemdefinitie bijgesteld tijdens het project?
    d. Zijn er binnen het team algemene interpretaties bijgesteld? Bijvoorbeeld over het belang van duurzaamheid, waarde toevoegen, normen en waarden?
    e. Wat zou u een volgende keer anders doen en hoe zou u dat aanpakken?
    f. Welke methoden en tools zijn gebruikt in dit project? Welke methodes werkten goed en waarom? Welke methodes heeft u gemist (of zouden ook geschikt zijn)?
    g. Wat is/zijn belangrijke les(sen) voor anderen die zich met CE willen bezig houden?

5. Samenstelling netwerk en samenwerking – 15 min.:
    a. Wie waren de betrokken partners binnen het project en wat waren hun activiteiten en rollen (formeel en informeel)?
    b. Wat waren uw belangrijkste activiteiten - zowel individueel als op bedrijfsniveau - bij dit project en bij welke activiteiten had u andere partijen nodig?
    c. Wie waren er nog betrokken buiten het directe project (adviesgroep, onderwijsinstantie etc.)?
    d. Welke partijen/mensen waren essentieel in dit project en waarom?
    e. Hoe zat de samenwerking / projectorganisatie in elkaar?
    f. Was er vertrouwen? En zo ja, op welke manier is er voor dit vertrouwen gezorgd?
    Hoe verliep de communicatie? Hoe werd er omgegaan met (vertrouwelijke) informatie? Hoe werd er omgegaan met gezamenlijke risico's?
    g. Wat was er contractueel afgesproken (anders dan standaard)? Waren er bepaalde performance standards voor alle partijen om het gezamenlijke resultaat te verbeteren?

h. Wat was het meest vernieuwende element in de samenwerking tijdens dit project?

6. Business model - 5 min.:
   a. Kunt u het business model dat ten grondslag lag aan dit project omschrijven? Waar lag de belangrijkste waarde bezien vanuit CE? Is er bijv. extra waarde gecreëerd voor het milieu of de maatschappij Zo ja, op welke wijze? Hoe verhoudt zich dit tot uw business model?
   b. Wat was hier anders aan dan aan een standaard business model? Check eventueel op:
      i. Welke waarde wordt er gecreëerd voor wie)/wat is de waarde propositie?
      ii. Hoe wordt deze waarde gecreëerd/welke activiteiten, technologieën en partners nodig?
      iii. Hoe wordt waarde/winst gegenereerd voor u en betrokken partners en hoe wordt deze verdeeld?
   c. Is de samenwerking expliciet meegenomen in het business model? Zo ja, op welke wijze?
   d. Hoe zou de waarde creatie verbeterd kunnen worden? Op welke vlakken (sociaal, ecologisch of economisch) heeft dit project waarde creatie laten liggen?

7. Check framework - 2 min.:
   Kijkend naar de behandelde onderwerpen (visies, leren, netwerk, BM): welke aspecten hebben het meeste invloed? Kunt u ze in een volgorde zetten van meest naar minst invloedrijk?

8. Opschaling van CE in bouwsector - 3 min.:
   Kijkend naar uw ervaringen met CE binnen de bouw:
   a. Wat is er nodig om dit project succesvol op te schalen?
   b. Welke activiteiten zijn hiervoor nodig en wie kan/moet die uitvoeren?
   c. Wat zijn drivers/barriers voor de opschaling van dit project?
   d. Hoe draagt dit bij aan een transitie van de bouwsector naar een Circulaire Economie?

9. Afsluiting - 5 min:
   a. Korte samenvatting / reflectie op gesprek
   b. Heeft u nog contacten die ik voor mijn onderzoek zou kunnen interviewen (binnen 3 cases)?
   c. Heeft u interesse in deelname aan een workshop om de samenwerkingstool te testen?
   d. Heeft u nog verdere opmerkingen?
   e. Bedankt voor uw tijd!

Interview questions related to theoretic concepts

Interview Question	Research Question	Theoretic Concept
3. Visies	**2 a**	**Visions – section 3.3**
a. Wat is de visie?	"	Algemeen
b. Hoe tot stand gekomen?	"	Algemeen
c. Gedeelde visie?	"	Vision as a frame for target-setting (Smith et al., 2005)
d. Aansluiting persoonlijk?	"	Influence human thinking (van der Helm, 2009)
e. Aansluiting bij bedrijf?	"	Influence behaviour and material reality (van der Helm, 2009)
f. Hoe bijdragen aan CE?	"	Framework van der Helm (2009) en integratie in thesis
4. Leerprocessen	**2 a**	**Learning – section 3.4**
a. Wat heeft u geleerd?	"	First order learning (Brown & Vergragt, 2008; Quist, 2007)
b. Wat samen geleerd? Aangevuld met add. aspecten	"	Double loop/higher order learning (Argyris, 2003; Quist, 2007) Aspecten aangepast vanuit SNM leren framework (Raven, 2005)
c. Leren v. probleemdefinitie?	"	Level 2 uit het framework van Brown and Vergragt (2008)*
d. Leren interpretative frame?	"	Level 3 uit het framework van Brown and Vergragt (2008)*
e. Wat anders aanpakken?	2 a & 2d	Algemeen
f. Hoe is het leren aangepakt?	2 a & 2d	Aspects that stimulate learning (Brown & Vergragt, 2008)
g. Methoden en tools?	2 a & 3a	Organising tools
h. Belangrijkste lessen?	2 a & 2d	Algemeen
5. Netwerk en samenwerking	**2 b**	**Networks – section 3.5**
a. Rol&activiteiten partners?	"	Industrial network theory (Håkansson, 1987; Quist, 2007)
b. Eigen rol en activiteiten?	"	Industrial network theory (Håkansson, 1987; Quist, 2007)
c. Verdere betrokkenen?	"	Stakeholders in supply chain (section 2.3.3)
d. Positie bedrijf?	"	Industrial network theory (Håkansson, 1987; Quist, 2007)
e. Essentiele partijen?	"	Social network model (Granovetter, 1985)
f. Samenwerking algemeen?	"	Algemeen
g. Hoe vertrouwen?	"	Social network model (Granovetter, 1985), Supply chain management (Svendsen & Laberge, 2005; Barratt, 2004)
h. Contractuele afspraken?	"	Supply chain management (Barratt, 2004)
i. Vernieuwende samenwerking?	2 a & 2d	Algemeen
6. Business model	**2 c**	**Business models – section 3.6**
a. Business model + CE?	"	Circular/sustainable business models (Bocken et al., 2014;2015)
b. Anders dan standaard?	"	Algemeen
c. Samenwerking in BM?	"	Circular business models (Bocken, Short, Rana & Short, 2015)
d. Verbeteren value creation?	"	Value mapping tool (Bocken, Short, Rana & Evans, 2015)
7. Check framework	**1 a,b & 2 d**	**Set-up of framework in section 4.1**
8. Opschaling CE	**3 c**	**System innovation (Geels, 2004)**
a. Wat is er nodig?	"	Backcasting (Quist & Vergragt, 2006)
b. Activiteiten en wie uitvoeren?	"	Backcasting (Quist & Vergragt, 2006)
c. Drivers/barriers?	"	Backcasting (Quist & Vergragt, 2006)
d. Transitie naar CE in bouw?	"	Transition theory

* Brown en Vergragt (2008) concluderen dat leren in bouwprojecten voornamelijk op deze twee levels plaatsvindt.

		1. Definition Circular Economy			
		Q1a: What is CE?		Q1b: How is your company working on CE?	
		What is CE?	What is CE in built environment?	How are you working on CE?	What activities/projects?
Case Alliander					
Henrik van Zantvoort	Client	Philosophy: how to make sure that what we have, doesn't get lost? Based on 3 pillars (1) prevent wasting (2) reuse materials you have (3) reuse/ recycling. Chained by supply chain collaboration.	Collaboration: think in disciplines instead of companies.	Ambition of becoming the first circular grid operator/world example. Aim for purchasing is to have 40% circular goods in 2020.	Support purchasers to keep circularity on the agenda. Also within total chain: talk to suppliers, waste companies. And secure this in systems used like supply methods, reports
Onno Dwars	Developer	"Container concept". How to deal with resources, value chains and financials around that?	It's not only resources for building, but also about resources for generating energy.	Always based in projects.	For instance also a housing project based on biobased economy.
Cecile van Oppen	Consultant	Creating an ecnomic system where all partners have an incentive to work together to maximise value of resources.	Difficult to obtain circularity, since techni-cally it's possible, but combined with orga-nisational & financial side it's difficult.	Projects in building and producing industry that are visible, where long value chains exist and people have to work	We don't write any reports, we just do what we believe in.
Saskia Roelofs	Interior architect	The awareness of the extend you can use the existing.	How to go forward with the existing and what is the necessity to add something?	Depending on assignment: approach every assignment individually.	Alliander: focus on existing. The Edge (Deloitte): future proof new building
Martijn Niehof	Urbanist	Combining processes that are now diconnected to reach efficiency in both resources and finances.	Reusing waste streams in a smart way. For urbanists it's at the level of	We are always in the middle of all different interests that are at play in an area.	All our urbanisms assignments basically.
Marijn Emanuel & Henk Rebel	Architects	That all materials and the whole economic system, are based on continuous renewable	A closed system where all materials are available in a sustainable manner.	Via our understanding that everything temporal: only use materials for certain	By using materials that can be dissassembled and/or are used already:
Case Park2020					
Owen Zachariasse	Consultant (from developer)	It has emerged from C2C: that's the intel inside of how the CE works.	Reconceptualisation of the foundation and core.	Ambition of becoming Europe's leading CE and C2C inspired real estate developer.	Responsibility to show it's possible: good for business and responsibility.
Rob van den Broek	Developer	How to disassmble things, but also: with what parties that can contribute to the collaboration and this all based on a positive business model.	It's about materials: think about all materials in the building and the building as a whole.	Suppliers have to be responsible so we flipped the process where the contractor isn't buying from suppliers, but we do this collectively.	Park2020 and hot bed vor the Circle Economy.
Alex Kragtwijk & Ed Warmerdam	Contractors	C2C: how to build a building where all materials that have been applied can be taken back into either a technical cycle or in a biological cycle.	Cycles are important, together with energy usage, water balance, solar energy, CSR: but this needed a lot of explanation! + BREEAM	Via Park2020 it started.	ISO 14001 and sorting demolition waste.
Jeroen Grosfeld	Architect	Coupling ecological, social and financial values into one value: Euco. C2C is means to close material cycles, but takes a while to reach a	Eliminate using petrol based resources.	Designing (building) products in a different way.	Park2020 and more.
Paul van Steijn	Installation advisor	C2C: you have to give back what you take	Within building this is already implemented, but within installations it is just starting.	Apply steel instead of plastics or increase the lifespan of installations via maintenance. Less materials are needed for	Get all suppliers round the table and look for programs they have to make the demolition of installations more easy.
Hein van Tuijl	Materials certification	Quantify business benefits of circular systems. Based on C2C: CE and C2C strengthen each other.	Valuating material streams as high as possible. Buildings as Material Banks.	We are a research and consultancy firm and founder of the C2C concept.	Translate the C2C concept into practice.
Case Heerema					
Peter Diepenhorst	Developer	How to make better projects in a hectic world; it's a combination between traditional building and innovating developer; work together with client.	Focus on long term (contracts)&performance via for instance lease. Leasing image has disadvantages for	Getting different parties together to get to know each others business. In this case mainly contractor and demolisher.	BREEAM-NL demolition: don't only look at price, but make agreements about the aim of the certificate and stick to the planning.
Erik Korpershoek	Contractor	Integration, efficiency and collaboration.	Combining different disciplines that are currently separated (via schuttingen).	Bouwteam experience: already combining the strengths of disciplines here.	No specific project: general way of (bouwteam) working.
Paul Hoeben	(developing) Management	Focus on re-use (receives little attention now).	Use available resources and materials wisely.	Supporting projects where circularity is central.	We advise client to look at sustainable measures when it's not part of
Lonneke Leijnse	Interior Architect	Reusing materials and also upgrading them.	Looking at the existing and how to use this instead of new products in the market.	No clients yet that ask for circular solutions. Is also difficult to achieve	No projects yet.
Kees van Es	Demolition	Ideally you follow Lansinks Ladder.	Reusing and recycling building materials: already within metal and concrete industry.	Everything related to demolition: from emptying buildings to complete demolition.	Wide range: student housing, hospitals and projects for housing corporations.
Bert Siera	Client	I don't know: via this project we have been confronted with BREEAM.	X	Separating waste and off-shore there is an even bigger potential for us.	X

		2. Experience and innovation within case			
		Q2a: Involvement in project?	**Q2b: Why are you involved?**	**Q2c: Experiences in project?**	**Q2d: Most innovative part?**
Case Alliander					
Henrik van Zantvoort	Client	Steering group from out of Alliander (client); started off in 2010 with new real estate strategy.	Innovation: If you do what you always did, I get what you got.	More questions arose than answers were given. This was the assignment the building sector needed.	Don't tell the market what to do, but ask what they can do to fill in our ambition.
Onno Dwars	Developer	Tendermanager and later on contract manager in realisation.	Invited to take part and beause of initiator role within consortium.	The impossible will be possible when developing goals together with client& sticking to them in a continuous dialogue.	The willingness of parties to aim for targets "over the horizon". Willing is more important than being able to.
Cecile van Oppen	Consultant	Offering a different perspective, to call everything into question, projectleader of purchaser process.	Because of knowledge in a previous tendering process for a housing project.	Amazing. Would love to do it over with an better process. You can never create too much organisational support.	The impact of vulnerability: the consortia at a time proposed to just stick to the decision of Alliander.
Saskia Roelofs	Interior architect	To develop the concept of 'het Nieuwe Werken' in the complex.	Because of our expertise in the field of 'het Nieuwe Werken'	It was the first client that openly dared to 'dream'. Main ingredients for the building were developed in the very first phase.	The fact that you can make such an integral complex based on existing buildings that were quite useless.
Martijn Niehof	Urbanist	To help developing the connection with the surrounding area.	Asked by VolkerWessels to get the flywheel effect for the whole area.	Informal way of working, looking for connections. High ambitions of Alliander.	With one measurement all came together.
Marijn Emanuel & Henk Rebel	Architects	Function of architect.	Because of the way Alliander formulated the question: temporal building!	Lot of collaboration. Everyone was bold & took risks: client, contractor, developer.	The way the client dealt with its own assignment.
Case Park2020					
Owen Zachariasse	Consultant (from developer)	We visualize and conceptualize the whole park	Personal belief that we need to re-visualize what we're doing here and to use business as engine for change.	The more we learn the less we know. Driving it from the business is the way to go. Underlying values have to be there.	The process. You need leadership for that.
Rob van den Broek	Developer	Connecting, motivating and look for the right qualities. From a passion.	Becasue I personally think this is important so taking responsibility.	People are often uninformed, ignorant, prejudiced & aren't open to new perspectives that influence their core business.	C2C philosophy and putting the whole chain at the table: they jus don't know each others business models!
Alex Kragtwijk & Ed Warmerdam	Contractors	Projectleader for realisation: guarding feasibility and budgets.	Because we are a VW firm and VW is one of the initiators.	Innovation and puzzle to realise all sustainable measures within budgets.	Building from out of the C2C philosophy.
Jeroen Grosfeld	Architect	As architect: we translate between America (McDonough) and NL.	Finding sustainable solutions is something close to my heart.	That clients at the park were motivated to integrate sustainable solutions.	The fact that you can evaluate between the different buildings at the park.
Paul van Steijn	Installation advisor	Because of VVW: IBB is our sister and that's why we are involved.	Because we try to come up with sustainable installations: nothing there yet!	It always bears additional costs. We now try to check processes of suppliers.	6-wegklep': a new type of HVAC with a reduction in energy losses.
Hein van Tuijl	Materials certification	Christallising the vision; providing training for parties involved.	To support in realising the C2C ambition.	Complex: (1) to align all actors on vision, (2) to provide access to relevant data (3) to 'speak the same language'	Creation of positive impact and that Delta believes in this: leaded to additinoal costs, but they invested.
Case Heerema					
Peter Diepenhorst	Developer	Endresponsibility for procedural aspects, 'bouwteam' and for the final delivery of the project.	We as a developer saw the opportunity for the location and linked it to Heerema looking for more office space.	Partnership in developer: always go for ambitions & high quality and achieve this in trust and challenging each other.	The process of putting everyone together to value and respect interests and knowledge.
Erik Korpershoek	Contractor	As project leader of the realisation.	VolkerWessels looked for an operating subsidiary and contacted us/me.	Bouwteam optima forma: user was involved very early on and lot of trust.	That we realised what is in buzz words: overlap and communication.
Paul Hoeben	(developing) Management	Chairing meetings and support in the broadest sense.	Delta wanted support in the management of this project.	Success is dependent on people: a lot is possible with the right (responsible) people.	Realise BREEAM Excellent based on a Very Good ambition. Know-how of end user was also impressive
Lonneke Leijnse	Interior Architect	Translating the requests from the client into an interior design.	We won the competition for this assignment.	BREEAM was leading, defeating its purpose: solution from label isn't always best solution.	Demolition although I wasn't involved in this.
Kees van Es	Demolition	Via Delta: relation from Wim Beelen. And I know Peter (Diepenhorst).	For the pilot project BREEAM NL certification for demolition.	Just pursue your own course: collaboration with client in this way (based on trust) leads to the best results.	BREEAM: we don't change anything, but we just report everything to be able to demonstrate our impact.
Bert Siera	Client	As principal from out of HMC.	Function of facility management in HMC.	We went back to our roots.	The open design of the building to facilitate internal communication.

		3. Visions				
		Q3a: Vision of project?	**Q3b: Development of vision?**	**Q3c: Shared vision?**	**Q3d: Relation company vision?**	**Q3e: Contribution to development CE?**
Case Alliander						
Henrik van Zantvoort	Client	Be the best serive provider in the area that is connected to us translated into 5 ambitions: (1) connection (2) energy neutrality (3) future proof (4) circularity (5) process.	First internally developed. Then market was asked for a vision on ambition on: (1) circularity (2) collaboration (3) realisation process. Parties were organised in consortia. 1 consortium won - always in dialogue.	Interpretations will always be there, but shared understanding of vision. Basic solution of final 3 consortia was the same and wouldnt have been established with different assignment.	Derived from vision of company, so easy link.	Starts with vision and ambition since you have most influence at the start of a trajectory.
Onno Dwars	Developer	Realising the existing stock is the basis for the next generations. Also a transition from welfare to wellbeing and creating a internal and external connections.	In the supply chain where we worked on it as people with passion and not as companies. Moreover, we alternated chairs and roles.	End result was shared and during the process choices could be made without consulting everyone.	With this project we created a basis where we now continu to work on.	X
Cecile van Oppen	Consultant	Two main themes: circularity and connection. For me the addition of doing things differently was added.	Lot of conversations in Alliander to ground the ambition. After that: co-creation with consortium.	In the end it wasn't completely part of the DNA of all the consortium partners	Not relevant since vision had to be part of Alliander for it's their project.	Very important since clients have to be able to explain why they want it. Selection of partners based on vision is also important.
Saskia Roelofs	Interior architect	Making a difference: putting the ambitions of Alliander even further.	People with different expertise were adding ini-tiatives to stretch the ambition even more and realise it.	Yes, vision was shared. Keeping to vision in execution is difficult: this isn't based on ad hoc decisions.	Difficult since different stories can be told for interior: reuse, atemporal. So always challenge yourself.	it supports in keeping the focus and not falling back in traditional methods.
Martijn Niehof	Urbanist	Looking for a maximum by combining existing elements.	It came together in one Eureka moment and that basic idea is still present in the realisation.	Basic idea is shared, but in the rea-lisation differences appeared.	X	It's crucial since it makes it easier to tell your ambitions and make choices together.
Marijn Emanuel & Henk Rebel	Architects	5 core ambitions in an integral approach: it had to be balanced.	Vision as starting point: stick to it and aim for optimal solutions per ambition, mirrored to the balance.	Energy positivity is measurable. And because we got to know each other, other aspects got shared as well.	Links directly: we found ourselves in this ambition for a temporal building.	Everything: it starts with ambitions. When you are aware of this it will steer all your actions.
Case Park2020						
Owen Zachariasse	Consultant (from developer)	To build the worlds' first C2C in-spired business park. For the work benefits & the world benefits.	Out of head of CEO and influenced by William McDonough and then within a synergetic development.	Yes, basically Bill with his vision of C2C was central.	Directly alligns since we conceptualised the park.	We have to see the world of tomorrow and then try to build it.
Rob van den Broek	Developer	X	X	X	X	X
Alex Kragtwijk & Ed Warmerdam	Contractors	Materials within design for disassembly and lease contracts.	Coert laying in his back yard.	Yes, got together after some friction: aannemer: beton! Difference ecological sustainability & lifecycle of product.	Park2020 is now changing our vision.	Can make it really pracitcal. For every aspect like foundation of the building: save materias in form work.
Jeroen Grosfeld	Architect	Make buildings that function as material banks that can be disass- embled at EOL and be 100% C2C.	First meeting in 2007 with Delta and Bill and advisors. Range of measures in spreadsheets. 3 sreadsheets came out with 3 sets used for vision.	Started with big team and selected until people with same vision. Still when new ones came in, niet opgevoed.	X	Especially contractor has a role here in embedding the vision. Difficult since contrator doesn't want to be transparent.
Paul van Steijn	Installation advisor	To create a park that can be demo-lished when it reaches the EOL and materials can be reused efficiently.	Delta is geestelijk vader. Others were attracted by enthusiasm.	Yes, shared. But problem is to make choices between costs and benefits.	X	Awareness creation for all elements in the supply chain because of the promotion and attention.
Hein van Tuijl	Materials certification	Ambitions based on C2C and positive impacts.	In direct collaboration with McDonough & Braun- gart. Tools are necessary as well.	No, many parties actually work from a negative footprint inst. of pos. impacts.	Direclty: we work from C2C.	Active measuring the impact on the indoor climate: quantify.
Case Heerema						
Peter Diepenhorst	Developer	For Delta it's a sustainable office, but for HMC their working environment for the coming 20 years. Could have been more innovative, but we had to choose for the best alternative for everyone.	BREEAM: we are not the type of developer that runs over all BREEAM aspects to gain points. We looked at every item and discussed if we could apply it or not. Started with Very Good, but winning mentality of Heerema lead to changing it to Excellent.	Everyone has their traditional role and looks into their own budgets since they are leading. We as developer had to guard the overall development.	Direct link: project is based on Delta vision of focus on (sustainable) quality of building	It is a means to explain things to each other.
Erik Korpershoek	Contractor	To provide a building for the needs of the client.	Sustainable demolition is completely realised by Delta.	Budgets are leading, but in general people like doing new things and are motivated to contribute to this.	We are a serving company and won't walk in front of needs.	It makes is tangible and practicle since - in a broader perspective - links it to societal sustainability.
Paul Hoeben	(developing) Management	Delta's vision.	Via a well-structured collaboration process where one can talk about the issues at hand.	This was more or less part of the contract so everyone had to have the same goal.	Fits more or less since we communicate that we advise in such processes.	Vision of client is most important: it starts with vision: asking the question.
Lonneke Leijnse	Interior Architect	Realising BREEAM and for us: creating an office that shows Heerema. That's not sustainable since you need adaptations to fit another company.	I guess the developer has driven this development. It certainly wasn't the client.	We all shared the vision - except for the client. Discussions arose around where to gain BREEAM points. And I am not sure we always made the right choices.	Aim is related because we share the aim going for the (individual) maxi-mum. In practice it's based on a lot of rules and that's agains my principles.	It is the way forward; it facilitated the discussions where you learn colectively. It also is a process where you can learn collectively about the possibilities.
Kees van Es	Demolition	Collaborate based on trust to develop a splendid building.	Starts with relationship and keep your promises.	For our part it was shared: just stick to the responsibilities.	Links directly since we always apply sustainable demolition.	Lobby is a big obstacle: whenever we aim to re-apply resources, doors close; production facilities aren't made for this; it is not wanted by the industry of building materials.
Bert Siera	Client	Informal contact and communication are central elements for us.	Based on priorities of HMC.	We pay for the building so we decide (Delta supports this).	Link is fine since by now we also have to report on sustainability etc.	X

		4. Learning					
		Q4a: What did you learn?	**Q4b: What did others learn?**				**Q4c: Learning fr. problem definition?**
		Eventually complented by learning about:		new technologies?	the user?	suppl. chain collaboration?	Level 2 in Brown & Vergragt framework
Case Alliander							
Henrik van Zantvoort	Client	Challenge yourself: suppress traditional reflexes. Personal connection is key, but finances will dominate. Guard everyones interests to keep the connection.	You will only get different answers when asking different questions, so you have to reveal vulnerability.	X	X	X	No, becasue problem definition was already conceived in an abstract way which increased the solution space.
Onno Dwars	Developer	Standards can never be too high. Making changes in a started building process is difficult & shouldn't be pursued.	That it's demanding to create this high level ambition, but the end result gave a kick to team.	X	You get to know each other & way of working.	X	Not for me personally, but others did learn this. Changing roles however does not work in realising the building though.
Cecile van Oppen	Consultant	Incentive pattern would've yielded better results. Scan added value of parties & leave out ones that don't add.	Value of collaboration: different results & innovation. Dare to call things into question.	X	X	Learning about res ponsibilities. Ask different questions.	No because of the orchestration of the process: they had to work together in consortia.
Saskia Roelofs	Interior architect	A lot about the world of CE.	You need each other. The realising party also learned to take the client with him in the process.	X	X	X	Yes, because of the collaboration with different disicplines you learn what is going on there.
Martijn Niehof	Urbanist	Strengthened in view that this way of working is the right way to create additional value.	The possibilities that collaboration brings. Normally you work after each other, not together.	X	Young passionate people representing general interest but slithgtly bureaucratic.		Not directly since we had the right people in this process that are open for each others expertise
Marijn Emanuel & Henk Rebel	Architects	That it is possible with this approach of collaboration & taking others seriously.	To come up with sustainable suggestions themselves (process facilitated this).	48V network, BaOpt system.	X	X	No we already work in a holistic way.
Case Park2020							
Owen Zachariasse	Consultant (from developer)	That it would take a contractor 3 years to understand it. It's also important to get your team together early on.	C2C helps by asking simple questions. You only fail when doing things the way you've always done it.	X	X	X	Not really, because there was no real problem definition: we just didn't know what it was.
Rob van den Broek	Developer	X	X	X	X	X	X
Alex Kragtwijk & Ed Warmerdam	Contractors	Additional material knowledge. Broaden scope: think about end user & exploitation costs.	Together you can reach higher aims. Collaboration is key; keep same partners.	X	X	X	Yes: we changed it within others. Also asks for different way of collaboration: Bouwteam.
Jeroen Grosfeld	Architect	That it takes time: more meetings to keep the change going.	Thinking differently: installations and elevators.	X	Takes 3-6 monthes before user is with you.	X	Yes, but it takes time and effort: lostrekken! Show that all different expertises are also of influence at the start (just like facade).
Paul van Steijn	Installation advisor	Mainly awareness of the process: now look into value creation (reuse/ recycling).	For most of them within the awareness.	Start certifica-tion to take back installations	Capricuous; C2C is not important for client.	Getting to know each other helps.	Yes: steel instead of plastic, but its always a trade off.
Hein van Tuijl	Materials certification	Infleunce of executing party when requiring C2C. Circular value proposition aren't restricted to materials.	It is difficult to build a completely C2C building. This however also drives continuous innovation.	X	X	X	X
Case Heerema							
Peter Diepenhorst	Developer	Collaborating with everyone and everything. Collaboration is essential and it is based on trust in each other.	Team consisted of people that wanted to contribute. Learned to express our needs&wants.	X	X	X	Yes: everyone put in some extra effort. Learned to complement each other.
Erik Korpershoek	Contractor	I learned about the opportunities of those buzz words. I got to know the principles & at the same time I see the threats to these developments.	The team character. I think everyone learned about the results of collaboration. So keep talking.	X	X	X	At the start we spoke about the process design collectively & created a new picture of the various relationships & where we wanted to go.
Paul Hoeben	(developing) Management	A lot is possible when working in a good team. I moreover learned about some (for me) new technologies.	To make the right choices to obtain the BREEAM Excellent certificate.	X	X	Communication is essential: need clear minutes to task responsibilities.	No, we are used to this from out of our project management role.
Lonneke Leijnse	Interior Architect	You need collaboration. Negative side of label is that innovation decreases: up-dates are needed for rules/guidelines.	I don't know: I hope some parties learned to look beyond existing boundaries. Some (technical) parties aren't that flexible.	X	X	X	No in that respect we did not innovate. Or at least not that I noticed in my participation.
Kees van Es	Demolition	Make sure the rules of the game aren't changed during the process. Moreover confirmation (of way of collaborating).	Whenever you express your trust upfront&arrange commitment, you can realise it with the budget.	X	X	X	Of course, you want to realise added value for someone, but this isn't standard in building sector: they come to this insight only by now.
Bert Siera	Client	To see the benefits of 'het Nieuwe Werken': both environment/economic + communication.	Collaboration whenever everyone shares the same goal.	Thermal energy storage.	X	X	Others learned from us to make decisions. We learned you cannot do everything on your own.

		4. Learning (continutation)			
		Q4d: Learning about join opinions?	**Q4e: What would you do different?**	**Q4f: Methods&Tools used?**	**Q4g: Lessons for others?**
		Level 3 in Brown & Vergragt framework			
Case Alliander					
Henrik van Zantvoort	Client	Yes, with higher ambitions that were more internalised. Concrete example of this was the availability of people (agenda wise).	Add a project secretary to secure the lessons learned.	Alliander Purchasing Method and use chairmen in dialogue sessions.	(1) optimise current linear system: supply chain collaboration (2) look disruptive to current economy; not waste anything.
Onno Dwars	Developer	Not really since everyone already had this open interpretative frame. Many are now working on the next step (in sust. building).	Strict decision making mechanisms: don't postpone decision making and don't change while you're building.	Not from consortium. It's a love letter where we wrote Alliander in 2 A4's how we saw the assignment.	Just ask. Realise that so much more is possible, but you just have to ask it to supliers.
Cecile van Oppen	Consultant	Yes: how to realise sustainability in cooperation. Even the consortia that didn't win still work together!	Add an incentive pattern to guard collaboration even in difficult times.	Just keep thinking. And especially think about each other's interests.	Keep thinking. Do what you do best, but recognize your shortco-ings and dare to indicate these.
Saskia Roelofs	Interior architect	No, that was already part of the team. That is were the selection was based upon.	You have to establish rules with each other. More weight on interior decisions.	BREEAM. Apart from that: many dialogues to get each other's vision.	That it's possible to make such an existing complex future proof.
Martijn Niehof	Urbanist	No; importance of sustainability was clear. I learned that BREEAM isn't always helpful.	Steering towards an optimum instead of only circularity literally by reusing everything. Some new elements are ok.	Not that I know.	Look for an optimum and make it practical. Collaboration is key since we are too specialised.
Marijn Emanuel & Henk Rebel	Architects	Yes, to trust the capabilities of the team to realise vision.	Explain upfront that it's important to keep the same team & establishing ambitions together.	BREEAM to make the project accountable for the client.	You need collaboration.
Case Park2020					
Owen Zachariasse	Consultant (from developer)	Yeah, that changes pretty drastically.	Built in the innovation platform and reverse engineering sooner.	X	Innovation comes from grassroot areas. Know who you are talking to at the other side of the table.
Rob van den Broek	Developer	X	X	X	Stick to the same team to protect the learned skills and knowledge.
Alex Kragtwijk & Ed Warmerdam	Contractors	Yes especially that it had to be financially sound. Not only C2C materials as holy grail.	Registring priorities earlier on. Clear boundaries between fixed budgets & freedom.	BREEAM, but this will last only 5 years: it has become a marketing tool.	Set clear goals together and take time for this. Plan a realistic process.
Jeroen Grosfeld	Architect	Yes, people think traditionally, but slowly this starts to change.	Design a quality tool to measure everyones role.	Matrices to assist in choices about building methods. With regard to process: bouwteam (but traditional).	Fixed team: exchanging and sharing info and document it.
Paul van Steijn	Installation advisor	Yes: less focus on profits because it contributes to reuse.	More suppliers involved that are already more ahead.	Experience.	Others have to be aware of what they are doing. List of C2C has to be positioned more clearly.
Hein van Tuijl	Materials certification	X	Close gap between science & complexity and practical tools for these kinds of projects.	Assessment methodology; measuring recycled content/recyclability; roadmap; material passports.	Tinking in value propositions. Share the potential of reuse: materials market place!
Case Heerema					
Peter Diepenhorst	Developer	For HMC sustainability wasn't first priority, so we were able to convince them with financial impacts of sustainable measures.	Not much: better take 2 months extra preparation to be able to explain why you work integral and collaborative.	Together with DGBC BREEAM demolition tool was established.	Focus on client (one that pays) and make sure they enjoy the benefits of the development.
Erik Korpershoek	Contractor	Project might have influenced the interpretative from of the client (not direcly used to high sustainability goal).	Get everyone together even earlier in the process on.	edscontrol system; a kind of BIM system and BREEAM of course: that forces you to check everything.	Key to success is the possibility to personally connect within the team (which is different every project).
Paul Hoeben	(developing) Management	No, I don't know.	Not so much: I would like the BREEAM to be less of the huge amount of paper work.	A clear process structure.	Just do it to learn that it does not have to be more expensive. Just use common sense.
Lonneke Leijnse	Interior Architect	No, not that I know.	Not much. With a different client I want to take circularity further: really use the existing.	An inventory of BREEM points.	Keep using common sense and no just follow these label lists.
Kees van Es	Demolition	Not that I know: our ambition was the certificate and we did stick to that.	Nothing.	BREEAM NL tool. We demolished concrete at the site; no new technologies or methods for us.	Principals have to be clear what they want to reach: they have to prescribe it. Even better if policy prescribes it.
Bert Siera	Client	X	Would like to work fulltime on a project like this.	Injury Incident Free (IIF) programme (used off-shore).	Others (contractors) learned from the IIF programme.

		5. Network and Collaboration				
		Q5a: (informal) roles?	Q5b: Main activities + need oth	**Q5c: Others involved?**	**Q5d: Essential parties/people?**	**Q5e: Project organisation?**
Case Alliander						
Henrik van Zantvoort	Client	Disciplines in consortia: design, build,installation, energy, maintenance, landscape, management, finances.	Role of purchaser and support on client side becasue of facility management background.	TU Delft, Study from UU, REBUS (EU), Green Deal Circulair Inkopen & Circulaire Gebouwen	Apart from market parties and our own: Squarewise/Copper8 (Noor and Cecile).	Just a project team: co-creative process. Collaborational project structure.
Onno Dwars	Developer	X	Contact and contract management and guarding KPI's.	No, relatively traditional, but people with special knowledge.	Client is essential for ambitions. Apart from that it varies: different people took their roles at diff. Times.	Once every 2 weeks the consortium & Alliander met. When starting building an execution meeting was added. Sub meetings for the 4 themes.
Cecile van Oppen	Consultant	Difficult since I wasn't directly involved after the award of the assignment.	Always needed others.	Not directly. We and TU Delft was in another consortium.	The core team from out of Alliander, the architect from the 3 consortia and Onno (developer).	Project leaders meeting. Project teams for 4 themes repported to project leaders meeting and they to steering group.
Saskia Roelofs	Interior architect	RAU could arrange a lot because of its reputation. Contractor was both facilitating client & part of consortium.	Designing atrium and social areas; needed all others (installations, casco, user etc.).	Municipality, surrounding companies & attract people with a disadvantage to the labour market.	Alliander on the one hand and the consortium VolkerWessels/RAU on the other.	Steering group of RAU/VolkerWessels and Alliander. Under the VolkerWessels part all the other parties acted.
Martijn Niehof	Urbanist	When talking to government: lobby needed sine they aren't open for these innovations.	X	Municipality and surrounding area.	Alliander for the ambitions & willing ness. Moreover Onno (connector), Thomas Rau for concept, INNAX.	Before awarding the assignment: consortium met every Friday.
Marijn Emanuel & Henk Rebel	Architects	We had some activities to get to know each other outside the project. No clear separation between client and consortium.	X	Urgenda for the connection with the surroundings.	Not one person or party: it is the team effort that results in a success story.	Ambitions were turned into teams. Teams with specialists from both the consortium and Allianders. Moreover a steering group to report to.
Case Park2020						
Owen Zachariasse	Consultant (from developer)	Same team, different clients. informal role is managing the client expectations in workshops.	Try to find common language. identify key aspects to the client. It is like executive coaching.	We always bring in an advisor from the clients end. And R&D with universities.	William McDonough and our CEO are the top two.	In the very beginning it was very ad hoc because you don't want to be so rigid, that's how we always did it
Rob van den Broek	Developer	Connection is established informally, so informal contacts are more important.	Create a safe environment where everyone can speak without being judged.	Universities Arizona State University, TU Delft, Wageningen Eductional programmes.	William McDonough and EPEA. IBB for realising. Municipality for area. Investors that have to look differntly.	CV of share holder and maintaining BV. Opstallen ontwikkelen vanuit CV. Projectteam per opstal.
Alex Kragtwijk & Ed Warmerdam	Contractors	X	X	X	Coert	X
Jeroen Grosfeld	Architect	Together with contractor: develop BIM.	X	Municipality. Services like Liander, KPN, Eneco	Developer that developed vision together with McDonough	X
Paul van Steijn	Installation advisor	Informal role since officially we are a subcontractor; now we are part of the team.	Technical installations and needed all others.	Subcontractors: plukber, sprinkler installations, building regulations.	The final user is essential.	Traditional organisation: Delta as client and they assigned it to IBB. IBB was our employer.
Hein van Tuijl	Materials certification	X	X	X	Coert Zachariasse and McDonough.	X
Case Heerema						
Peter Diepenhorst	Developer	We had very regular meetings to prevent surprises.	Intermediair between everything and everyone: so needed everyone.	Investor, financer, municipality	The projectteam: Heerema, Delta and WesselsZeist	Developer as central point: on the one hand the bouwteam and on the other hand HMC for the tenant meeting.
Erik Korpershoek	Contractor	Informal role since VWalso provided financial means; trusting each other also results in an informal character.	Link between internal part and external part (bouwteam): need advisors and sub-contractors.	A lot. If you pay attention to it you will be surprised by the size of the complete supply chain.	Bouwteam: Delta, Heerema, OPL, Heyligers, Construction, Homij, Techniplain, Peutz	Division between the clients input and Peter (Delta) passed this input on to our bouwteam
Paul Hoeben	(developing) Management	Relates to responsibillities, since in a good team people feel responsible to do things that are not directly arranged.	X	Investor, building supervising institutes (fire brigade)	Bouwteam including Heerema as end user	A developing/realisation meeting every other two weeks and a tenant meeting in the other week.
Lonneke Leijnse	Interior Architect	Yes: formally it wasn't my responsibility to move the stairs towards the window side, but if that results in an improved design.	X	DEP: lighting advisory and all suppliers (for the interior)	Developer (for vision) and general contractor (for realisation).	In ideal circular system: developer inspires and justifies finances and contractor guards and knows rules.
Kees van Es	Demolition	No, only via our contacts at the DGBC (for the certificate).	Regular work except for all the BREEAM work: we had someone internally working on this.	DGBC, supervisory bodies (VCA, ISO, MVO etc.) and labour inspection.	Delta (Peter), Wessels Zeist (Erik), Beelen with around 4 employees involved in this project.	X
Bert Siera	Client	Delta wasn't only developer but also advisor.		Eneco for thermal energy storage.	Delta as developer and the general contractor for the realisation.	X

5. Network and Collaboration (continutation)

		Q5f: Trust?	Q5g: Communication?	Q5g: Communication?		Q5h: Different contracts?	Q5i: Innovation in collaboration?
		And if so: how was is established?		Confidential info?	Shared risks?		
Case Alliander							
Henrik van Zantvoort	Client	Yes, always keep the dialogue, be transparent and open and you will get it back!	X	X	Talk about them: where is the risk? Help each other with	Not that much: contracts are guide lines, because when you need them it's too late. Contracts were made, based on output and	The co-creative aspect. Collaboration based on actually only an intentional statement.
Onno Dwars	Developer	Yes of course. Just a way of working. Imprtant is that we kept the same players also during the execution phase! That is essential.	X	X	X	Speial KPI's & longer time frames (15 year waranty from contractor); steer on targets instead of specifications.	X
Cecile van Oppen	Consultant	Yes it starts with showing vulnera-bility. Someone has to initiate this & Alliander did: saying they don't know.	X	Guarded that everyone could receive same info	Alliander just invested. No model that guards this.	No, that didn't pass. You can guard it via contracts, because now the contractor always dominates.	X
Saskia Roelofs	Interior architect	Yes, because dare to take risks together. Moreover short lines of communication and "feeling" together.	In principle open: information was passed to the consortium when needed from steering group.	Mostly in steering group.	X	No there is a disability to develop innovative contracts. Contracts were developed during execution so trust was needed.	The openness and the open and collaborative search.
Martijn Niehof	Urbanist	Yes, by talking a lot. In realisation this was different since contractor takes over.	Strictly organised meetings and workshops.	We only worked for VW, while we also needed client	X	No, not for us.	The dialogue that we had on a lot of different fronts.
Marijn Emanuel & Henk Rebel	Architects	Yes, it is an attitude of wanting to develop together. And guard that everyone sticks to its responsibilities.	X	X	X	No, rather traditional. Asignment was broadly formulated; that is the only innovation.	The collaboration: the project organisation used. This requires investment from the client to put employees fulltime on the project.
Case Park2020							
Owen Zachariasse	Consultant (from developer)	Yes, we removed uncertainty by pr-omising to do all projects toegether & opened up room for stress free working	Via a centraal aanspreek punt with really short lines of communication	X	X	Both clients and contractor had to sign they were working towards the parks vision of C2C.	We all simultaneously invest in the R&D: we, VolkerWessels and Reggeborgh
Rob van den Broek	Developer	Yes, because of the transparant process. Also because of the clear concept of where we want to go. Trust for investor	Normal project teams and building teams and sounding board sessions.	X	Responsibilities are shared per "product"	Ambition translated into contracts. Product of service: leaseproduct with prestationcontracts.	That parties were willing to change their business model.
Alex Kragtwijk & Ed Warmerdam	Contractors	Yes, respect for each other. Also because of selection: everyone in the team now wants to solve the problem and not create problems	X	X	X	No, not even bouwteam contract. Better would be UAV-GC where we also get design responsibility.	X
Jeroen Grosfeld	Architect	Yes: since whenever you are part of the team you are also able to participate in the next project, then you are willing to invest.	X	X	Risks were shared.	Not that much, but isn't needed in the end since you don't have tht much risks with a BIM	Make buildings that can be dissassembled. Think of different principles for standards
Paul van Steijn	Installation advisor	Yes by talking to each other. But trust can easily be damaged when something goes wrong.	X	X	Talk about it. But wasn't an issue.	Traditional: BREEAM Very Good was a performance.	X
Hein van Tuijl	Materials certification	X	X	X	X	Lease is not always best option: negative image and strange situations.	X
Case Heerema							
Peter Diepenhorst	Developer	Yes: created by showing each other your world (HMC showed their vessels to Delta).	X	X	X	No. We involved HMC in the design and technical specifications and that is unique.	The intensity. And a client that also knows about project management.
Erik Korpershoek	Contractor	It's a certain click. Also because of circumstances where you need trust and if you don't damage thit trust it can grow.	X	X	X	No much; only thing is that we started with a contract for a casco building.	X
Paul Hoeben	(developing) Management	By working together it can grow. You can influence it by creating a certain atmosphere.	X	Confidentiality is an unwritten rule.	X	No nothing and I'm also surprised by the fact that so little changes within these contracts.	Nothing.
Lonneke Leijnse	Interior Architect	Yes: for me the first project with meetings focused on trust/the process. That is essential.	X	Worked out since this is part of the contract.	Collective search for a solution.	No, but you don't have to prescribe everything in a contract. To my mind you just have to want it alltogether.	That we focussed no the collaboration aspect and integral approach during the process.
Kees van Es	Demolition	You have to earn trust: best promotion is the quality you deliver to make sure clients come back to you.	X	X	Mark them upfront and make agreements around them.	No, except the fact that we had a best efforts obligation to obtain the BREEAM certificate.	Nothing.
Bert Siera	Client	Yes, by being open and honest and professional. Connection establishes.	X	X	X	Purchasing process was complete responsibility of gen. contractor.	Involvement of a building expert as an internal advisor in supporting decisions.

		6. Business model			
		Q6a: Describe BM?	**Q6b: Different from standard BM?**	**Q6c: Collaboration part of BM?**	**Q6d: Improvement of value proposition?**
		Extra value creation?			
Case Alliander					
Henrik van Zantvoort	Client	Reimbursement for energy prestation, product as service concepts, green guide book for ourselves.	Based on Total Costs of Ownership (TCO).	Yes, when consortium collaborates and works efficietnely costs are low and no repairs & additional costs will show up.	Optimise the building in its use: condition only a certain part of the building when less people are present on a Wednesday or Friday for instance.
Onno Dwars	Developer	5 themes: energy positivity, circularity, connection, integral design and relation with surroundings.	Not really: Alliander is investing and hopes to earn it back via lower energy bill &more productive employees.	Not that I know.	Can always be better and bigger.
Cecile van Oppen	Consultant	TCO of 15 years which was already a challenge (long period!) for Alliander.	No tendering fee, because parties had to go for it instead of just gambling.	No.	incorporating collaboration within Business Case. Incentivising that.
Saskia Roelofs	Interior architect	Value in building documented in a resour-ces passport. And an icon was created.	X	No, only in a traditional way. VW wanted to assure this, but it wasn't realised.	The bigger picture is comprehensive. Would only be small details.
Martijn Niehof	Urbanist	Value is the synergy and the icon in the area.	Curious how it will function.	No.	To realise follow-up in the surrounding industrial area.
Marijn Emanuel & Henk Rebel	Architects	When recycling, you create value in saving investments: capitalise materials.	Actually not really: only a few main re-cycled materials, so purchasing is doable.	This was in the original assignment. Technical parties all part of same holding.	Ownership of materials should be guarded and materials should not depreciate over time.
Case Park2020					
Owen Zachariasse	Consultant (from developer)	Client is the people in the building (not investor!), so create value for them.	(1) maximize quality p. square meter (2) use products of service (3) focus on people and productivity.	The targets were leading and they guided the team within their collaboration.	Research on people & productivity aspect and materials banking: monetize future value now.
Rob van den Broek	Developer	X	X	X	X
Alex Kragtwijk & Ed Warmerdam	Contractors	Lot of effort needed to get to vision as sketchted by Park 2020.	Ideally you have to arrange that everyone gets its materials back when building is dissassembled.	No not at this moment.	For us the vision would mean that we (1) either just be there for shitty projects (2) only coordinate the building project with shrinking risks on our side.
Jeroen Grosfeld	Architect	Making buildings that can be taken away over 50 years. Also think about the ground underneath it: do you have to buy the ground?	In a different BM that is needed the mechanisms of purchasing of general contractor will disappear since it kills innovation.	No. But idea for incentives: when we collectively make a cheaper building in a shorter developing time, we make more profits.	Get more people involved at the park. Policy measures are currently inhibiting this: it took us a year to get a license to bring people together in a greenhouse.
Paul van Steijn	Installation advisor	It delivers ecological value, but also requires additional investments from our side.	Fact that Park2020 has its own energy 'grid': Dubo supplies heat and cold via thermal storage.	No: very traditional. We used BIM however.	Improve BIM: make even more arrangements upfront.
Hein van Tuijl	Materials certification	Different models. (1) Conventional purchsing, (2) pay per use, (3) contract with buy back,	Cascades of circular value propositions; creating a materials market place to use value.	X	See before; vision of a material market place.
Case Heerema					
Peter Diepenhorst	Developer	A building that can host HMC for the next 20 years: it is flexible and adaptable	No not much lease applied since you then pay the maximum because momey needs to be financed.	No, the demolition is on our part: that is our own sustainability ambition.	Intellegence of the building: technology development is rapidly increasing.
Erik Korpershoek	Contractor	Contribution to the demolition sector and it is an integral and flexible building.	X	Yes as in the process based on a 'bouwteam'.	Optimise process even more: turn more of the activities into actual value (a complete conversion is not possible however).
Paul Hoeben	(developing) Management	Decreased cooling needs, economic energy use, waste separation, etc. Demolition is only theoretic value since it doesn't directly return in the project.	X	No.	Make the decision for BREEAM Excellent in a more early stage because it took more time in this way.
Lonneke Leijnse	Interior Architect	Within the building itself, installations and sustainable demolition.	X	Not that I was aware of.	It's always possible to innovate more; development grows rapidly.
Kees van Es	Demolition	Client pays partly in natural capital since we get materials out of the building we can sell again.	X	X	No separation of waste at the building site: we have factories for this meaning less man hours for separation and more space at the building site.
Bert Siera	Client	Focus on acoustics and productivity and informal meeting spaces and isolation.	You cannot directly measure the impact of these measurements.	X	Mobility plan: additional BREEAM points. And maybe more plants?

		7. Check Framework				
		When looking at the different topics (visions, learning, network, BM): what aspects are most influential?				
		Visions	Learning	Collaboration, network	Business model	Other
Case Alliander						
Henrik van Zantvoort	Client	Vision and ambition: most impact at beginning		Quickly get all different disciplines at table.		
Onno Dwars	Developer	Ambition & passion has to be within the people in the team		When sharing the passion collaboration will come.		
Cecile van Oppen	Consultant			Starts with collaboration: takes time, but effect is big	Dare to question BM	
Saskia Roelofs	Interior architect	Start with vision			Financial model makes vision possible	
Martijn Niehof	Urbanist	Assignment & enthusiasm of client got consortium together		Also active collaboration of client.		It's not 1 thing: it's the combined optimum.
Marijn Emanuel & Henk Rebel	Architects	Start with ambitions: need awareness and courage				
Case Park2020						
Owen Zachariasse	Consultant (from developer)	Start with values because they stay over time			Business case is important	They all need to be done right
Rob van den Broek	Developer					
Alex Kragtwijk & Ed Warmerdam	Contractors	If you don't know where to go, don't start your journey		Collaboration at the third place	Business model comes at a second place	
Jeroen Grosfeld	Architect			Collaboration at all levels is most important		
Paul van Steijn	Installation advisor	Awareness and C2C concept		Collaboration at technical level: BIM		
Hein van Tuijl	Materials certification	Vision and goals actually at same level as BM			BM needed for implementation	
Case Heerema						
Peter Diepenhorst	Developer			Collaboration is most important	Business case is crux of CE	
Erik Korpershoek	Contractor		It's about how to colla-borate, so learning			
Paul Hoeben	(developing) Management	Vision and the contracts related to this vision				
Lonneke Leijnse	Interior Architect	Vision in agreement with the user of the building				
Kees van Es	Demolition	Collective ambition is supporting		Start with: 'let's do this together'	Be clear about financial possibilities.	
Bert Siera	Client	Vision of contribution to society.				

		8. Scaling up and closing						
		Q8a: What is needed?	**Q8b: What activities and who?**		**Q8c: Drivers/barriers?**		**Q8b: Contribution to CE?**	**Q9d: Remarks/questions?**
			Activities	Who has to perform thos	What are the drivers?	What are the barriers?		
Case Alliander								
Henrik van Zantvoort	Client	Willingness to share experiences with eachother and reach a broader audience.	Inspire people to do things differently.	Clients have to be inspired by other examples to start asking different questions.	Finances: earning money by smart integration of circularity in your process.	Finances again: the indurated market isn't willing to invest upfront.	Market forces will change: when demand is sufficient, supply will come.	X
Onno Dwars	Developer	Stimulating passion.	Asking different questions.	Clients and contractors.	Shared interests, shared passion and personal	Absence of these drivers.	X	X
Cecile van Oppen	Consultant	True willingness of clients to do things differently.	Questioning everything; from the finances to the technicalities.	The client in the end.	Willingness/ambition.	A lack of an ambedding within an organisation.	X	X
Saskia Roelofs	Interior architect	Make potential initiators enthusiastic.	Current successes as ambassadors. This can expand.	Client has to show the possibilities.	That it's possible with financial means to make a	Getting caught up by the realisation.	That it's reachable for different clients, not only private ones.	Contractor has difficult role: knows market
Martijn Niehof	Urbanist	Make each other enthusiastic, show guts and passion.	Show people the results.	Make sure the right people are at the right place.	Clients that propose fantastic assignments.	Initiation takes time, meetings & pre	Governments with power asking different questions.	X
Marijn Emanuel & Henk Rebel	Architects	Materials shouldn't depcreciate and owership be	X	X	X	X	X	X
Case Park2020								
Owen Zachariasse	Consultant (developer)	Guts and leadership to do things differenty.	Realize more examples and people to do these projects.	Ministry has to promote and actively suport these	Financials etc. see McKinsey paper.	We ourselves; need to do things instead of talking.	We need to do this yesterday	X
Rob van den Broek	Developer	Commitment, energy, creativity, open mind and knowledge.	Work with the right parties and manage the process well.	X	X	X	X	X
Alex Kragtwijk & Ed Warmerdam	Contractors	Give us different margins, then we are prepared to open up.	Motivate and inspire instead of pulling back.	Government.	Different sentiment in other sectors (e.g. banking world)	Money and vision.	Inspiring people with guts to do things differently. Dare to invest with uncertain	X
Jeroen Grosfeld	Architect	Politics: make a process where you bring all different disciplines together.	Remove regulations to allow circular practices. Make environmental costs equal to economic values. Collabora-tion: learn from ecosystems.	Government/political system; developers and technical (building) firms.	X	Policy instruments we have. Money is an issue as well, but it is present, but in the wrong place.	Convincing big concerns of the possibilities of this approach: it survived the crisis and society is moving this way.	X
Paul van Steijn	Installation advisor	Awareness of the environment and sustianability and that we are still able to create value.	That people rise that know what is needed to improve it: inspiration. Prescribe certain values in technical	Starts with developers. Government also works on it.	Client or principal that requests.	Money.	When government obliges measures, mar-ket will follow and we'll reach a point when you can't sell anything without C2C.	Technical side of C2C is difficult. Relates to the usage of assembled components.
Hein van Tuijl	Materials certification	Embedd circularity in tendering processes; especially in public development!	Asking the right questions and right requirements to invite the market to embedd circularity in BMs.	Government.	Smart business models based on quality and circularity.	When government asks something industry looks for ways to avoid it.	X	Vision is important, but you also have to measure your impact.
Case Heerema								
Peter Diepenhorst	Developer	Connecting the right parties: who pays has to receive the benefits: crux of CE.	A lot of enthusiasm from everyone walkin into the HMC building.	Telling the story of the positive experiences: client (and developer).	Make projects and DO things; might make less profits, but measure impact.	Parties that are not transparent & keep infor-mation for themselves.	Look at the bigger picture. Challenge suppliers to achieve best results and contractors to broaden into energy	X
Erik Korpershoek	Contractor	It has to be economic attractive.		Government: increase the (circularity) aims and at the same time keep it	The start of small-scale projects.	Lack of coherence between policy measures.		X
Paul Hoeben	(developing) Management	Via obligations. And allow for more intensive use of buildings (empty for parts of the week).	Re-use can be made obligatory via environmental permits.	In consultation with supply chain: from government to principals to investors.	The societal interest.	High costs: if it results in negative balance for prin-cipals they won't do it.	It is a slow process which government can speed up by changing policies - starting within zoning plans.	X
Lonneke Leijnse	Interior architect	Principals that know about the opportunities of circularity (need a briefing).	Simple communication: it has to be clear how to achieve (circularity) goals.	Certifying bodies.	The necessetiy to think about sustainability and CE.	Paper work.	Costs aren't main issue. Different approaches in bouwteam are obstacle: creative designer vs. rules and	Would be interesting to compare your cases + BREEAM score vs. supply chain collaboration.
Kees van Es	Demolition	Sustainability needs to be an obligation from the side of the principal.	Stimulate passion for sustainable solutions and ask the market for input on your sustainable challenge.	Principals of building projects.	The benefits it offers to selling real estate.	Money + Big producers don't want recycled resources: resources are	Mindset change is needed: sustainability needs to be a logical way of working/not more difficult or more expensive.	Needs to be sexy: then you want to change things. Trans- parency is needed, mainly from suppliers.
Bert Siera	Client	Money.	Look for opportunities for redevelopment.	Developers.	Contribution to society.	Money and payback times.		It's all about interests: we want to contribute but not no matter what.

Appendix D

Comparing case performance for the four main concepts

This comparison looks into the four main concepts of this thesis of visions, actor networks, business models and learning processes as presented by the three analysed cases. The findings are derived from the description in section 6.1. In this way it is a translation of Table 24, Table 25, Table 26 and Table 27.

Vision development:

	Park 20|20	Alliander Duiven – Heerema Head Office
Collaborative vision development:	**+**	**++** **-**
Vision image:		
• Metaphors	**+**	**+** **-**
• Explicitness	**+**	**+** **+/-**
Vision guidance:		
• Collective goals	**+**	**+** **+/-**
• Leadership	**+**	**+** **+/-**
• New rule sets	**+**	**+** **-**
Vision orientation:		
• Motivation	**+**	**+** **+**
• Inspiration	**+**	**++** **-**
• Direction	**+**	**+** **-**
Overall vision development:	**+**	**++** **-**

Actor network and collaboration:

	Park 20|20	Alliander Duiven – Heerema Head Office
Network composition:		
• Spin-off	**+**	**+** **-**
• Innovation in lifecycle	**+**	**+** **-**
Strategic elements:		
• Collaborative vision	**+**	**++** **-**
• Intra-organisational support & process alignment	**+**	**+** **+/-**
• Role of technology	**+**	**+** **+**
Collaboration elements:		
• Cross-functional activities	**+**	**++** **-**
• Joint decision making	**+**	**+/-** **-**
• Contracts	**-**	**+/-** **-**
Cultural elements:		
• Trust	**+**	**++** **+**
• Mutuality	**+**	**++** **+/-**
• Information exchange	**+**	**+** **+**
• Openness	**+**	**+** **+**
Overall network:	**+**	**++** **+/-**

Business model:

	Park 20|20	Alliander Duiven	–	Heerema Head Office
Value creation:	+	+		+/-
BM Innovation strategies:	++	+		+/-
Collaboration as part of BM:	+/-	-		-
Reflection:	+	+/-		-
Overall business model:	+	+/-		-

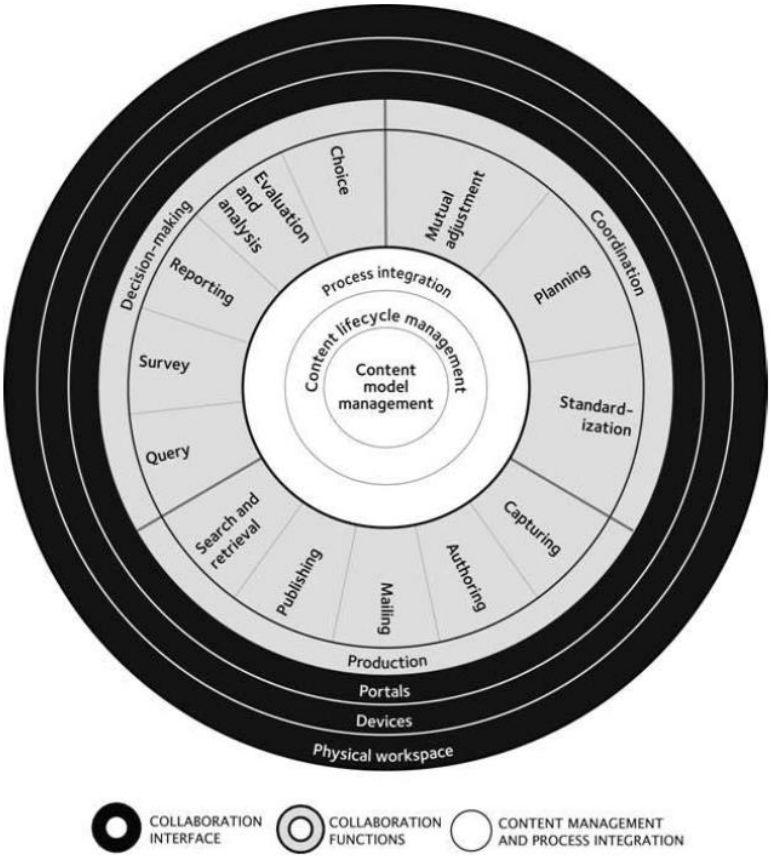
Learning processes:

	Park 20|20	Alliander Duiven	–	Heerema Head Office
Framing the problem:	+	+/-		-
Problem solving solutions:	+	+		+
Joint learning:	+	+/-		-
Overall learning:	+	+/-		-

Appendix E

E1: The Wheel of Collaboration Tools

"The Wheel of Collaboration Tools" (WCT; Weiseth et al., 2006) presents a typology of the capabilities of collaboration tools. It makes use of three main layers, visualised metaphorically as the main parts of a wheel. The core layer depicts the functions for content management and process integration (Weiseth et al., 2006). The middle layer represents the functions needed to support three sub-processes of collaboration that Weiseth et al. (2006) distinguish: coordination, production and decision-making. The outer layer shows the interface of collaboration functions, including devices, portals and the physical workspace. These layers together encompass the attributes of tools for collaboration. Metaphorically, the interface is the tire, the functions are depicted as the spokes, and content management, lifecycle management and process integration the centre (Weiseth et al., 2006).



The Wheel of Collaboration Tools (Weiseth et al. 2006).

E2: Comparison of tool categories

Based on a literature review of environmental management tools and a first round of expert interviews, several requirements can be derived for a comparison of different tool categories. These tool categories have been described in section 7.1.1 and are summarised in the following table:

Analytical tools	Examples	Organising tools	Examples
Comparative tools	EcoDesign strategy wheel		Analytical Network Process
Guideline/checklist tools	10 golden rules		Value Network Analysis
Evaluative tools	ERPA Matric		Social Network Analysis
Quantitative tools	LCA		Organis. Network Analysis
Software & expert systems	LEED, BREEAM		

Summary of tool categories found in literature (based on section 7.1.1).

The requirements for the tool are derived from literature and the first round of expert interviews. The following table reveals these requirements and their origins:

Tool requirement:	**Requirement based on:**
The tool should be based on a lifecycle perspective	Byggeth & Hochschorner (2006): p. 1425-1426
The tool should be based on a qualitative approach	Byggeth & Hochschorner (2006): p. 1425-1426*
The tool should give concrete descriptions	Byggeth & Hochschorner (2006): p. 1425-1426*
The tool should support the collaboration process	Weiseth et al. (2006): p.241
The tool should cover the technicalities of the development of a circular building as such	Baumann et al. (2002): p. 410 **
The tool should deal with the building development process in a company context, relating it to business strategy / management	Baumann et al. (2002): p. 410 **
The tool should deal with the building development process in the building supply chain (interaction with e.g. suppliers, clients)	Baumann et al. (2002): p. 410 **
The tool should deal with the building development related to policy processes	Baumann et al. (2002): p. 410 **
The tool should be simple to use and not time demanding	Expert interviews (see Appendix C)
The tool should trigger businesses to change current (linear) practices and stimulate innovation	Expert interviews (see Appendix C)
The tool should be adaptable to different sectors, businesses or organisations and their needs	Expert interviews (see Appendix C)
The tool should contain only a few main steps or phases	Expert interviews (see Appendix C)

Tool requirements and their origins.

* Byggeth & Hochschorner (2006) present a choice between a quantitative or qualitative approach and a choice between concrete or general prescriptions. Since in this thesis only qualitative data is used, this is adapted to a requirement for a qualitative approach. Moreover a choice for concrete descriptions was made since this is what is missing in developing CE.

** Baumann et al. (2002) developed these requirements for environmental product development. The requirements presented here are adapted to circular building development.

With these requirements the different tool categories can be compared. This comparison is presented in the traffic light analysis below. The rating on requirements 1-8 (based in literature) is directly derived from tool category ratings on these requirements in literature. For the requirements 9-12 (based on expert interviews), assumptions were used together with indications in literature (e.g. Byggeth & Hochschorner, 2006; Baumann et al., 2002).

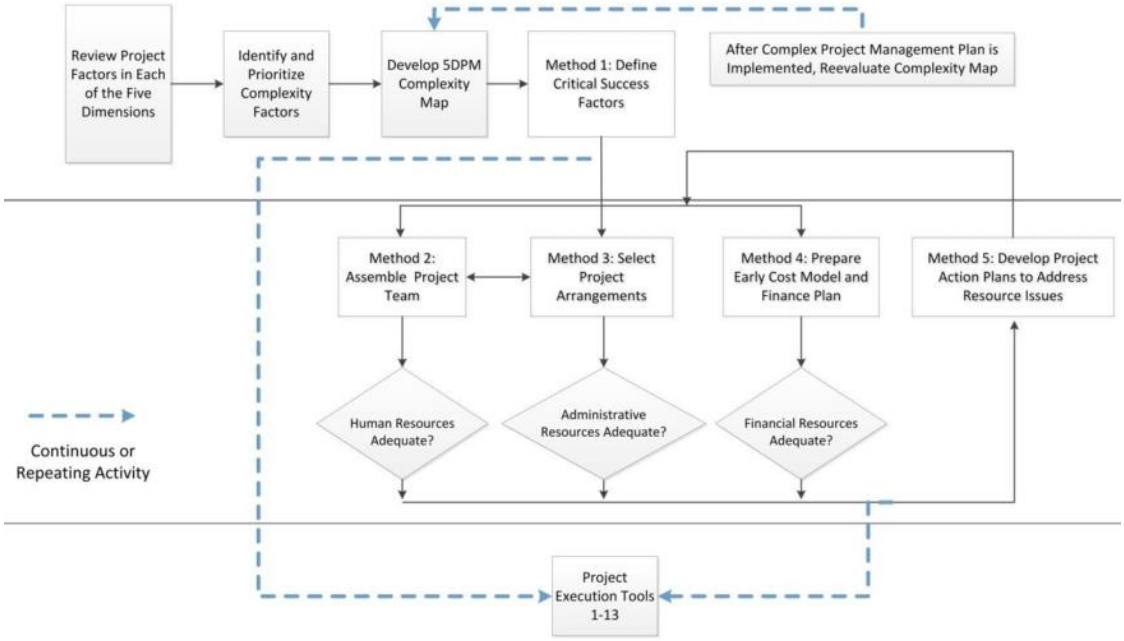
	Compara-tive tools	Guideline tools	Evaluative tools	Quantita-tive tools	Software tools	Organising tools
1. Lifecycle perspective						
2. Based on qualitative approach/data						
3. Concrete prescriptions						
4. Support collaboration process						
5. Circular building process (techn.)						
6. Building process in a company						
7. Building process in supply chain						
8. Building process related to policy						
9. Simple to use/not time demanding						
10. Trigger for change/innovation						
11. Adaptable to different sectors						
12. Presents only a few main steps						

Traffic light analysis for tool categories found in literature (based on Byggeth & Hochschorner, 2006; Weiseth et al., 2006; Baumann et al., 2002).

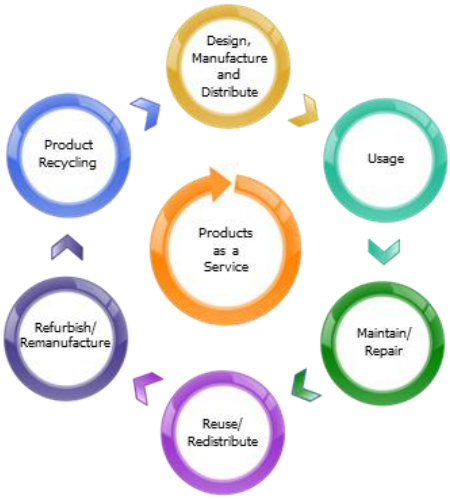
E3: Examples and comparison of organising tools

Visual examples for the three types of tools as described in section 7.1.3 are given below.

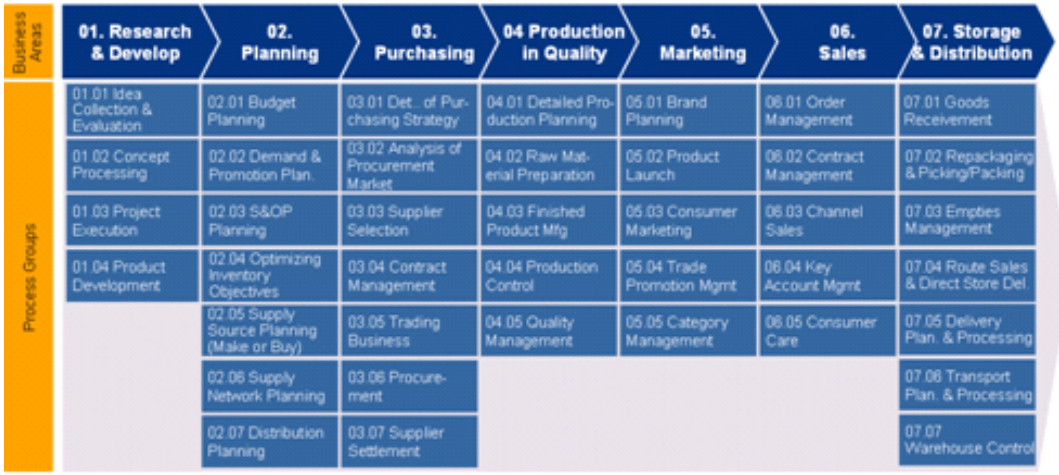
Flow chart: *Flowchart tool (Shane, Strong & Gransberg, 2012).*



Circular Economy tools: *Circular Economy toolkit (Evans & Bocken, 2015).*



Process map: *Process map (SAP, 2015).*



Comparing the three organising tools

The three different organising tools as visualised above are compared to the tool requirements in the following traffic light comparison. Since literature on the specific organising tools only described the functions of the tool and did not provide a rating, the comparison is based on assumptions and indications on the functions of the different tools.

	Flowchart	CE tools	Process map
1. Lifecycle perspective			
2. Based on qualitative approach/data			
3. Concrete prescriptions			
4. Support collaboration process			
5. Circular building process (techn.)			
6. Building process in a company			
7. Building process in supply chain			
8. Building process related to policy			
9. Simple to use/not time demanding			
10. Trigger for change/innovation			
11. Adaptable to different sectors			
12. Presents only a few main steps			

Traffic light analysis of three organising tools for initial tool format.

E4: Quick scan of best practices outside the building sector

This quick scan is based on an expert interview with Arnoud Walrecht, Senior Manager, KPMG Sustainability, that took place at November 17, 2015.

This quick scan is based on a sector comparison, because the tool to developed in this research should also be applicable to other sectors outside of the building sector. Several sectors can be scanned for best practices since they are ahead of the building sector in implementing circular solutions and practices. The fact that these other sectors have a lead over the building sector has multiple reasons as explained by Walrecht (2015):

- **Higher intrinsic value of materials:**
  Building materials have a rather low intrinsic value. This becomes clear when comparing commodities prices of commonly applied materials in construction to common materials in household appliances. Concrete for instance is valuated around 0,1 €/kg (calculated based on Prijs-Inzicht, 2015), steel at 0,2 €/kg (LME, 2015) and wood around 0,9 €/kg (strongly dependent on quality). Buildings also use metals that have a slightly higher intrinsic value, but these only come in small amounts and are non-ferrous with prices around 5 €/kg for copper for instance (LME, 2015). In household appliances also precious metals are applied with values of 13 €/kg for tin (LME, 2015) up to 700 €/kg for silver (Zilverprijs, 2015). These higher intrinsic values incentivise firms in other sectors to look for options to recover the materials used in products since this will save on purchasing virgin materials. In the building sector this need is not visible as also explained in section 6.2.1.
- **Higher price volatility of most used resources:**
  Resources that are widely applied in other sectors experience higher price volatility than resources in the building sector. Examples of these resources are tin, gold and silver (Walrecht, 2015). This situation stimulates circular practices since it makes businesses less reliable on these volatile prices of virgin recourses.

- **Security of supply:**
  The building sector does not rely on scarce resources with issues around security of supply. Security of supply is another driver to implement circularity.
- **Social issues in supply chains:**
  Supply chains in other sectors deal with more social issues around for example mining conditions of conflict minerals (Walrecht, 2015). Another example is formed by working conditions in the textile sector. With a focus on re-use/recycling business can respond to increasing societal pressures in preventing these social issues.
- **Fast moving goods:**
  The building sector produces 'products' with a long lifecycle. This makes the issue of waste less visible. Furthermore it is more difficult to close the loop around wasted/demolished building materials. In sectors where goods move faster, waste streams can be reconnected on shorter term.
- **Big corporates taking the lead:**
  In other sectors some big corporate parties set the example by actively working on circularity. In the fast moving consumer goods sector Unilever is a bright example of a corporate taking the lead.
- **Packaging of products:**
  In other sectors outside of the built environment, increased awareness of the impacts of packaging is a trend. Circularity is a focus point here as well. Environmental impacts of packaging along the complete lifecycle will be reduced. This considers design for recycling, using packaging sustainably, sorting, recycling and reuse of resources (KIDV, 2014).

Next to these sectoral drivers for circularity, the following best practices can be identified per sector (based on Walrecht, 2015):

- **Technology:**

In the tech industry recycling is obliged traditionally. Businesses have to pay for waste treatment upfront. This waste treatment can be termed traditional recycling, but new initiatives are visible as well. In healthcare technologies parties like Philips and Siemens recently started to refurbish imaging equipment like MRI scanners (Philips, 2015). Aim is to offer this equipment at lower costs without cutting on quality. The refurbishing process begins with selecting used systems and buying them back (Philips, 2015). These systems are then dismantled, disinfected and refurbished into new products with full warranty. Philips moreover actively works on recycling schemes, engaging in partnerships and applying these recycled resources back in their products. Examples are coffee machines, vacuum cleaners and flat-irons with recycled content ranging from 5% up to 53% (Philips, 2015). Another practice from the tech industry is Ricoh with its cameras and office equipment like printers. Rico does not sell products, but only leases them. During this lease period, Ricoh applies circular value propositions. This means products that do not function anymore, will firstly be repaired, then recycled with re-used parts and finally appliances can be donated (Ecopro, 2015).

- **Fast moving consumer goods:**

In the fast moving consumer goods (FMCG) sector a first best practice is the Dutch dairy producer Friesland Campina. This is a cooperative with communities of farmers. Their circular solution is at play at the level of farmers. Friesland Campina collects manure and agricultural waste of farmers and converts it into resources such as biogas. Another big player in the FMCG sector is Unilever. Their best practice relates to educating both their own staff and consumers. They train their engineers and prepare them for circular solutions by taking them to recycling facilities (Unilever, 2015). In this way employees are directly confronted with the challenges of recycling. Unilever moreover focuses on their packaging via new packaging materials, modular designs or refilling (Unilever, 2015).

- **Energy:**

The cascading principles of CE can be found in best practices in the energy sector. Orgaworld is player in this sector that extracts heat and biogas from organic waste. In their plant in the Amsterdam harbour area bacteria are used for fermentation, resulting in biogas. This gas is turned into electricity and CO_2 neutral waste heat. The remaining digested waste is separated into water and sludge. This sludge in turn can be dried into fertilizer grains. Orgaworld

can make 5.000 tonnes fertilizer out of 100.000 tonnes waste (Orgaworld, 2014). These fertilizers can be used to grow fruits and vegetables that could become an input (organic waste) for Orgaworld's process again. Parties like Heineken sell their organic waste streams to Orgaworld as well. Another best practice in the energy sector is the UK based start-up Bio-bean. Bio-bean turns spent coffee grounds into biodiesel and biomass pellets. These products are sold to companies to heat up buildings and fuel vehicles (Nürnberger, 2015). A final best practice of cascading energy in the Netherlands: waste heat from greenhouses is used to heat houses. This will be optimised by heating those greenhouses in turn with industrial waste heat from the Rotterdam harbour area.

- **Chemical:**

A best practice in the chemical world is a new technology by Avantium. Avantium is able to produce 100% bio based bottles with plant sugars. They collaborate with CocaCola amongst others to replace PET bottles with their next-generation bio based bottles.

- **Textile and clothing**:

In this industry, H&M takes steps towards circularity. They committed themselves to collecting used textiles and clothing in their stores worldwide. Fibers in these collected textiles are reclaimed and converted into new yarns for special clothing lines. H&M even collaborates with pioneering initiatives that are able to separate polyester and cotton from used clothing to recapture even more value from discarded textiles.

- **Installations:**

This sector is related to the building sector and although some major barriers regarding circular practices are still present (van Steijn, 2015), some opportunities arise as well. A best practice here is applied at Schiphol airport around its elevators. These are completely operated by the supplier while Schiphol Group only pays for the function they deliver: vertical transport.