Circular economy in the construction industry

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June 2018

Master of Science (MSc)
in Engineering/Sustainable
Design

Title page

Education:	MSc in Sustainable Design
Institution:	Aalborg University - Copenhagen
	School of Architecture, Design and Planning (SADP)
Project period:	February 2018 - June 2018
ECTS:	30
Supervisor:	Søsser Brodersen
External collaboration:	Rambøll
Type of thesis:	Master's Thesis
Title:	XXXX

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Pages:	116
Appendix:	83

Each member of the group confirms participation on equal terms in the process of writing the project. Thus, each member of the group is responsible for all the contents in the project.

Abstract

This master thesis investigates the concept of circular economy within the construction industry and which barriers that needs to be confronted in order to challenge the current linear economy model. Actor-Network Theory supported by Participatory design approach have been used in the project in order to define the configuration of the network for implementing circular economy, involving actors and matters of concern to provide insight on how a translation process might be achieved. This project aims at developing a design solution for Rambøll, the collaborative partner for this thesis, to implementing circular economy. Interviews and design games have formed the empirical work, from which an analysis of the actors of the construction industry, matters of concern, as well as barriers was undertaken. The result of the empirical work, is four key barriers that has the most potential to be changed within Rambøll, namely knowledge, collaboration, planning, and circular economy concept. Through a design process several concepts were created and evaluated in a workshop which helped define the final design solution. The solution is a combination of subsolutions; Platform, Specialist team, Screens in canteen and coffee stations, Info meetings, Innovation Time, Joint design, Digital catalogue with sustainable materials, Courses on circular economy, and a Common definition of circular economy. The final solution focus on changing two key barriers in order to incorporate a stronger focus on knowledge sharing and collaboration.

Acknowledgements

We would first like to thank our supervisor, associate professor Søsser Brodersen from Aalborg University in Copenhagen and the other professors at the University for guiding our project in the right direction. We could always contact her whenever we needed help.

We would also like to thank all interviewees from Rambøll, Lendager Group, RIB, Kingo Karlsen, Aarhus Arkitekter, Pension Danmark, Statens Byggeforskningsinstitut, and NCC who have dedicated their time for interviews, design games, or workshops. With their insights and participation, we were able to get an understanding of the different actors and phases, in the construction industry.

A special thanks to our contact person, Gitte Gylling Hammershøj Olesen for enabling a collaboration with Rambøll and for seeing the potential in this project. We hope Rambøll will be able to use the knowledge we have gathered through this project.

Finally, we must extend our gratitude towards both of our families who have supported us, through the process of writing this thesis. It has helped us make a project which we are proud of.

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Reading guide

Overview of the report

The structure of this report follows a chronological review of our process in the project (figure 1). Each chapter starts with an elaboration of the process, so the reader can follow along our journey from searching for a collaborative partner and start framing the project, to how we develop our solution.
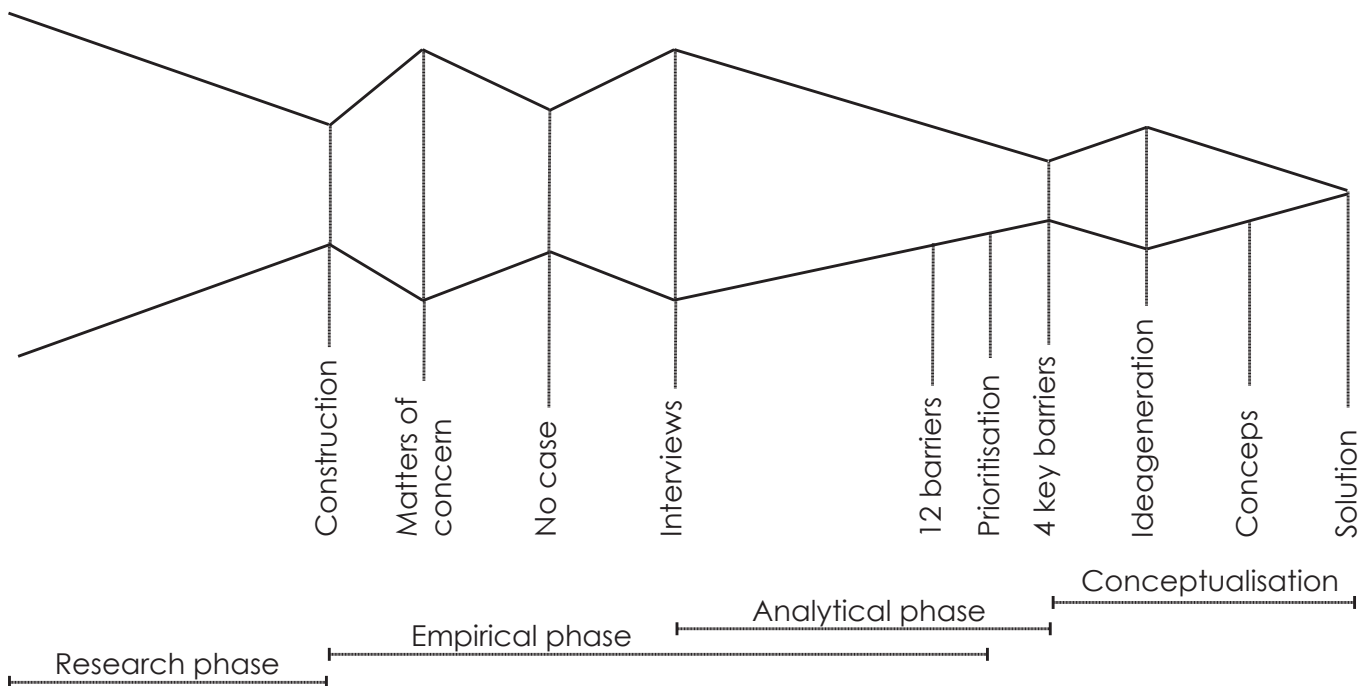
Figure 1 - The process of the report (Own illustration)

In the beginning of this project we identified the problem field and got an understanding of the concept of circular economy in the construction industry from relevant literature. We then investigated the phases of the construction industry and the common actors involved in the various phases, to understand the problem of implementing circular economy from various perspectives. Several design games have been made to support the interviews with different actors by opening a conversation of the problem. General barriers of implementing circular economy were identified through coding of the interviews. A prioritisation game was used to narrow down the barriers in relation to the context of Rambøll. Finally, we held a workshop at Rambøll to develop a solution together with the employees.

Elements to be considered
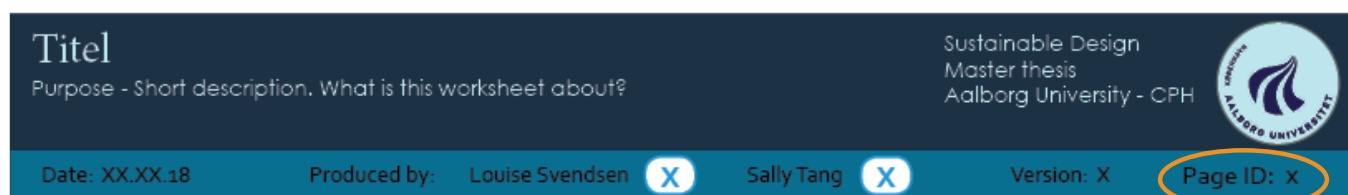
Picture 1 - Worksheet header (Own picture)

In our study we commonly use worksheets as a knowledge sharing tool. Since both of us are Danish, the reader will find some of the referred worksheets written in Danish. The worksheets are attached in the end of this report and will be referred to, by their ID, as (worksheet X), (picture 1). Throughout the report we have chosen to change the name of some interviewees from Rambøll, as some wished for anonymity whereas others wanted their name in the report (worksheet 1).

Some visualizations may have circular economy abbreviated as C.E. for the sake of clarity for the reader.

We distinguish actors in the construction industry by their discipline.

Chapter 1
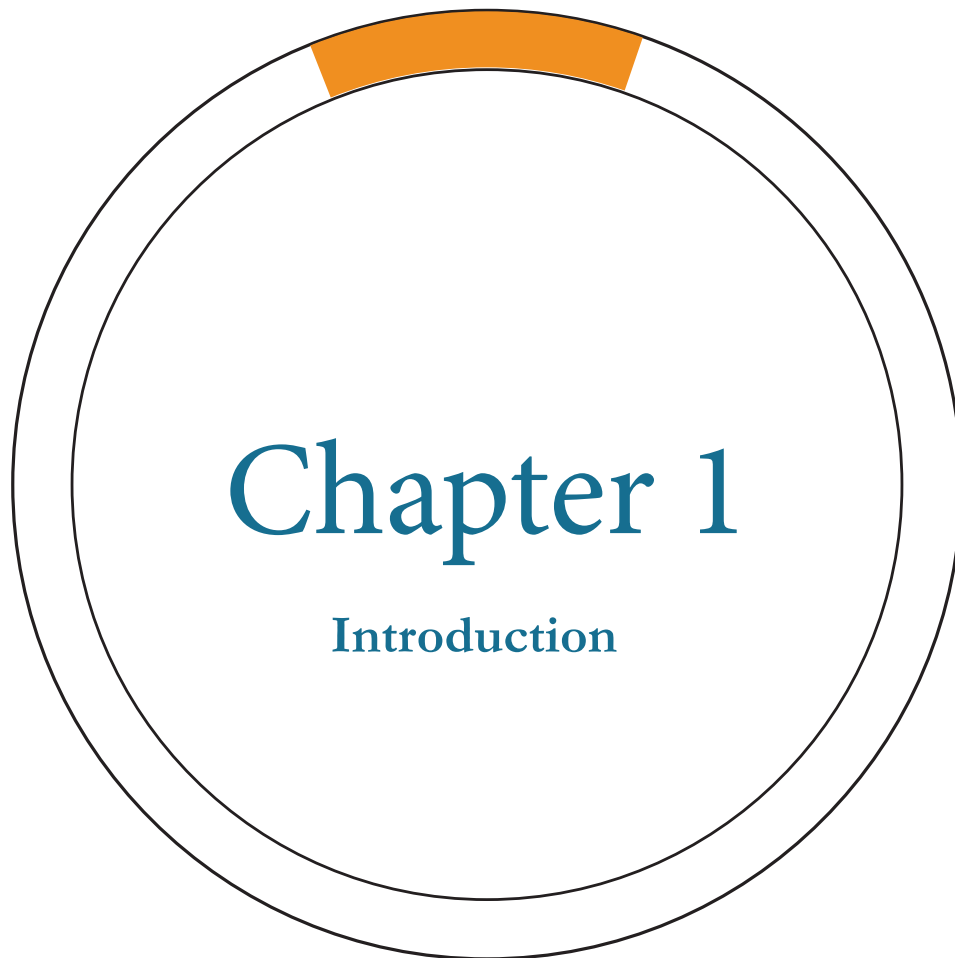
Introduction

This chapter gives a brief introduction to the project, and the problem area; circular economy in the Danish construction industry, and our problem statement. Moreover, we will introduce the company Rambøll, we are doing the project in collaboration with. Our academic background as sustainable designers will be presented, as well as our perspective when approaching the problem of implementing circular economy in the construction industry.

Process

Our project started when we approached several Rambøll employees for a collaboration. We were interested in working with circular economy and wanted to collaborate with Rambøll to experience the working environment in a large company. After several emails and phone calls, to several Rambøll employees, Gitte Gylling Hammershøj Olesen replied she was interested to hear more about the project. We then arranged an initial meeting with Gitte where she suggested three ways our project could proceed, all of which related to circular economy and construction. The scope of the project happened along our research and the empirical process of the project as we increasingly gained knowledge and found our focus.

1.1 Introduction to the project

The linear way of constructing buildings has led to global challenges and an increase in global warming. The construction industry accounts for approximately a quarter of the global greenhouse gas emissions (Bienkowski, 2017). It is an emerging sector, and a very active industry in both developed and developing countries (Ortiz, Castells and Sonnemann, 2009).

In Denmark, one third of the total amount of waste derives from the construction sector (Advisory Board, 2017). Population growth, urbanization, and a bigger demand for buildings are factors, that pushes the construction industry into a non-sustainable path. From World War II until today, construction highly relies on cheap building materials, cheap labour, and faster construction techniques. Soon this industry is facing resource depletion and is in desperate need of finding other ways to construct.

Some are beginning to realise that we cannot continue building the same way, in which extraction of scarce resources are treated as waste after it has been used. Instead there should be a change from the linear way of constructing buildings, to a circular where the waste can be included in a loop (picture 2).
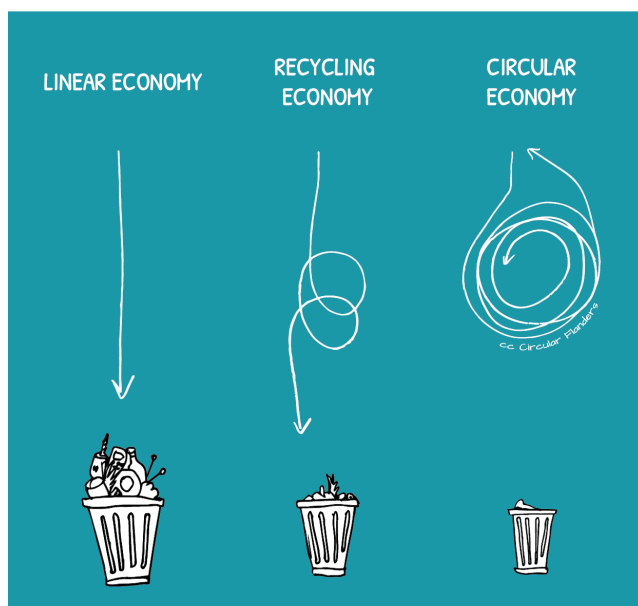
Picture 2 - From linear economy to circular economy (vlaanderen-circulair.be)

1.1.1 Our perspective as sustainable design engineers

This section is intended to provide the reader with an understanding of our academic background and how we approach problems.

We both have different educational backgrounds hence we have different knowledge and ways to tackle problems. However, studying *Sustainable Design* at Aalborg University, we will become design engineers. As design engineers, we are trained to have a holistic perspective when approaching problems and a transdisciplinary way of studying sustainability. This means that we can embrace aspects such as; ethnology, sociology, and technical knowledge of systems and processes, as well as design and concept development, which makes us creative engineers with social responsibility (aau.dk, 2018). Our holistic approach towards sustainability and the problems we are facing, allows us to understand a given problem from different angles of different actors and organizations, to solve complex problems.

Our vision on sustainability is; something which everyone should strive to achieve, since there will always exist more sustainable alternatives, so we can never and should never stop thinking in terms of sustainability when designing. There is always room for sustainable improvements, whether it is on a product level or a systemic level. We think it is important to constantly question and challenge what sustainability is as well as other concepts that derive from sustainability, such as circular economy.

1.1.2 External partner, Rambøll

This project is made in collaboration with Rambøll, a global engineering consultancy established in Denmark (worksheet 2). At first, we were certain that this project should explore the concept of circular economy, and we became even more excited when we discovered that Rambøll is developing and wants to use circular economy in projects. Thus, our project was highly relevant

for both parties. Collaboration with Rambøll meant that we had the chance to make our project not just in the university's theoretical framings but in a real business context. Moreover, our view on the values of sustainability matched both Rambøll's vision and their sustainability mission, as seen below. They have an ethical and environmental perspective in which long term sustainable solutions are a key focus of the company's policy.

Rambøll's vision:
"A **globally leading consultancy** delivering **integrated** and **sustainable solutions**, **shaping** today and tomorrow" - (Olesen, 2018)

Rambøll's mission:
"Create **sustainable** societies where **people** and **nature** flourish" - (Olesen, 2018)

Initial meetings with our company supervisor from Rambøll were held to discuss the focus of the project and to match our expectation with theirs, for both parties to achieve the most beneficial collaboration. We agreed that our contact person would support us with reading materials, experience, knowledge, and insight in Rambøll's workings, as well as helping us find relevant employees for indepth interviews. Moreover, we discussed various ways for how our project should proceed. The proposed ways for the project were:

- Investigate the concept of circular economy and develop a definition which Rambøll can use.
- Investigate projects that have been using circular economy in different construction cases.
- Design a tool box that helps them implement circular economy in their future construction strategies.

We wanted to proceed by going all three ways simultaneously, even though the time frame for writing a master thesis is short. However, we found it very challenging to pursue cases, as circular economy is a fairly new concept, and few have experience in using it in construction projects. Finding cases within Rambøll were even more challenging, as they have only been working with the concept in two projects. The projects,

'Støvring Ådale' which is not built yet, and a hotel in Bornholm 'Green Solution House', focus on circular economy (worksheet 3 and worksheet 4). In Rambøll's report 'Natural Resources' (Rambøll, 2018), they emphasise how they try to incorporate circular economy into projects, where subjects such as waste management, recycling, clean energy, innovation, and rethinking products and processes, are some of the values considered in the process of the projects (Ramboll Group, 2018). Still, there are not enough projects with circular economy, although Rambøll has a great willingness and good intentions to incorporate circular economy.

The company positions itself as having a holistic perspective, where synergies across different disciplines are highly valued. Rambøll wishes for more sustainability in their projects where they want to move from a linear economy towards a circular economy: "*improving and increasing our efforts to recycle and recover energy will help us move from a linear to a circular economy*" (Rambøll, 2018, p.4). It is interesting for us to investigate Rambøll's definition of circular economy and the holistic view of circular economy, seen from different disciplines as well as designing a solution which we hope Rambøll can use in the future.

1.2 Problem area

The scope of this project is circular economy within the construction industry in Denmark. We have chosen to investigate the construction industry in general and not just within Rambøll's framework. As sustainable design engineers we have been taught a holistic perspective to investigate problems and an understanding of the bigger picture. We are aware that the problems of implementing circular economy can not only be solved within Rambøll's framework, as they are influenced by many other actors of the construction industry. Therefore, we have interviewed actors both within and outside of Rambøll. However, the solution developed within this project, is intended to be suitable with Rambøll's context of sustainability. We

believe Rambøll is one of the companies that have a good potential of pushing circular economy forward in the construction agenda. Some barriers need to be solved internally in the organisation before they can change the bigger picture. For this reason, we are focusing on the process behind construction projects, the involvement of actors, and we are therefore not concentrating on the component/material level or the legislative level, even though legislation plays a major role in implementing circular economy.

1.3 Problem statement

"Which barriers needs to be challenged in order for circular economy to be implemented in the construction industry and what design solution has potential to promote circular economy within Rambøll?"

Research objectives

- How do actors relate to circular economy?
- What barriers hinder the implementation of circular economy in regard to the construction industry in general and within Rambøll's context?
- Which barriers are most relevant to focus on in Rambøll in order to implement circular economy?
- How can circular economy be implemented in Rambøll?
- Develop a definition of circular economy for Rambøll
- How can a translation process be initiated in Rambøll in order to increase circular economy projects?

Chapter 2
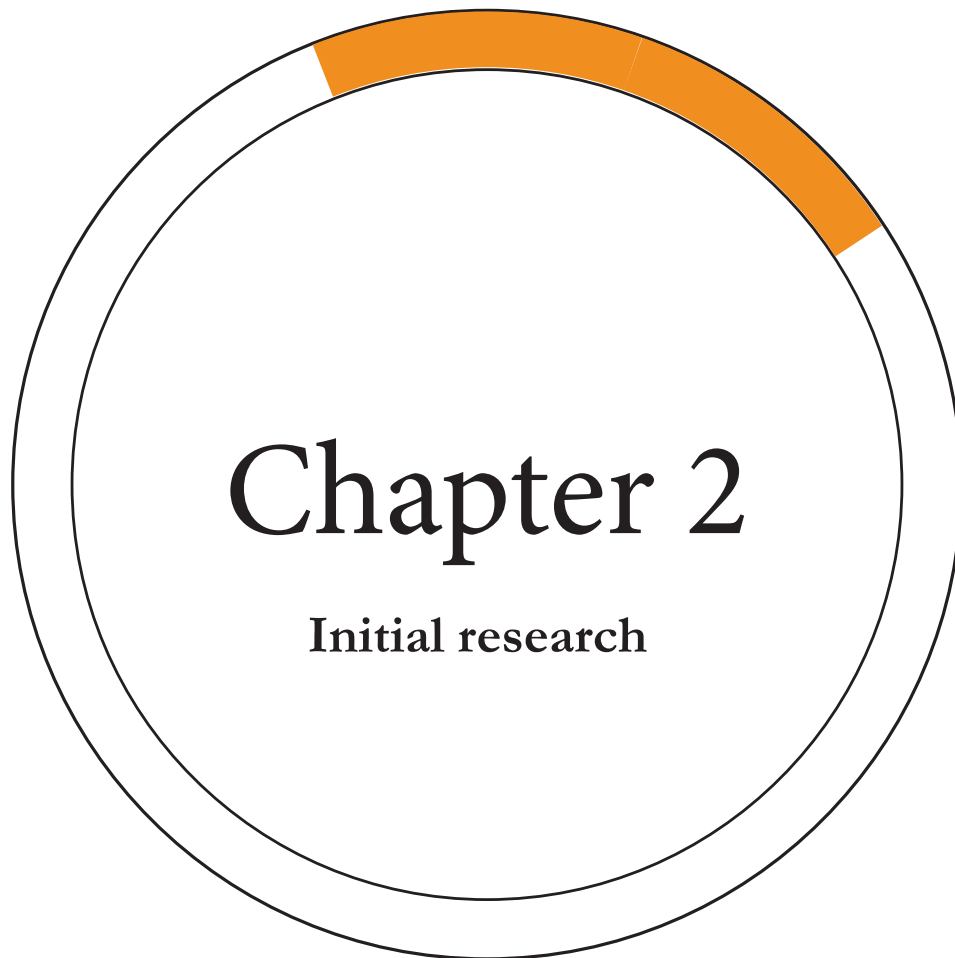
Initial research

This chapter provides a brief description of the phases of construction and the actors involved during the phases. Additionally, this chapter includes our initial research on the problem of changing the construction industry from a linear economy to a circular economy, as well as what differences there are between circular economy and sustainability. Moreover, different definitions of circular economy are presented.

Process

We investigated the concept of circular economy and started our research phase by searching on literature on circular economy. Whenever we read an article, journal, book or website, they were noted in a shared Google Drive document with; title, a resume, reference, and notes. This document where shared between us in order to remember all the literature we have read. All the literature we read where sorted and organised into categories through an affinity diagram. In this way we could better get an overview of the large amount of literature. Moreover, we attended seminars about circular economy, to gain more knowledge of the concept and how people have been implementing it in other cases than construction. Furthermore, we searched for construction projects in Denmark that try to implement circular economy. However, we were only able to find a few projects. This gives an indication that, in Denmark, this is a rather new, unused, and unexplored field in the construction industry.
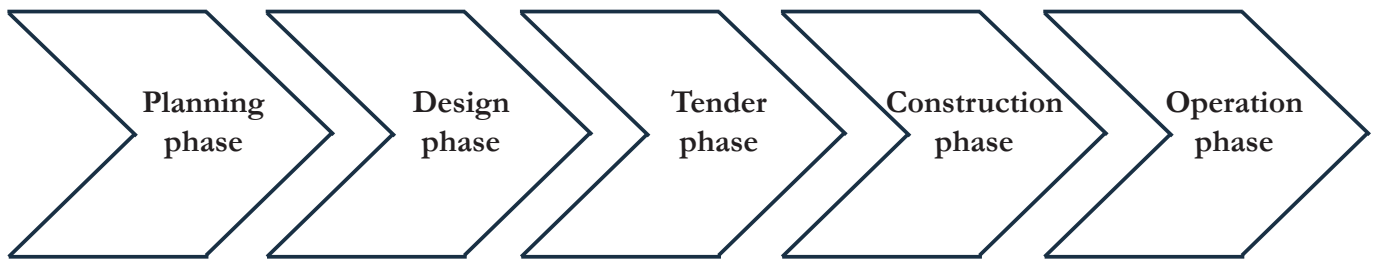
2.1 Phases of a construction project

Figure 2 - The phases of a construction project (Own illustration)

The process of construction varies from project to project. It is affected by many factors, such as the type of contract the client has chosen. These factors influence collaboration in general and determine the combination of phases within the process. In Denmark, however, the process of construction most commonly consists of the following phases (figure 2) (Naldal, 2011):

Planning phase

Programfasen*
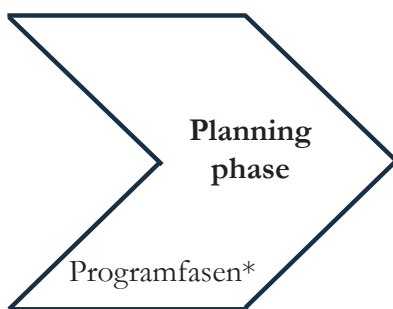
In this phase the clients define the requirements and criterions to provide the basis for contracting. The client determines the important parameters of the construction such as budget, physical requirements for construction, legal and regulatory requirements, feasibility studies, presentation of contract, tender type, overall timeframe for the project, maintenance, etc. Three factors; price, time, and quality, plays an essential role because any greater prioritization of one of these factors implies a lower priority of the others (Atkinson, 1999). The process proceeds into the Design phase when all the requirements, criteria, and parameters are defined.

Design phase

Projekterings-fasen*
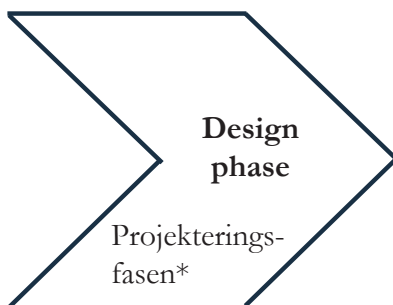
During the design phase the project proposal is processed, so that it can form the basis for regulatory approval. The project is described to such an extent that it can be used to form the basis for tendering, contracting, and execution. The architect and engineer collaborate on making project proposals. The architect describes the architectural expression and explains the choice of materials and surfaces. Moreover, the architect makes general plans, sections, and facades, which allows the client to relate to the functional value of the building. The engineer outlines the constructive principles, load assumptions, and general estimates (Naldal, 2011).

Tender phase

Udbudsfasen*
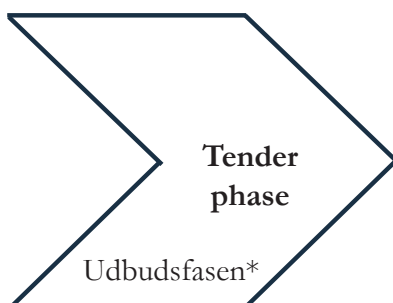
The tender phase is placed before, after, or in the middle of the Design phase, depending on what type of contract the client wishes to use (worksheet 5). In the tender phase, drawings and job descriptions are addressed and tendered to find the best suited contractor. The contractors then make an offer. They in turn might tender with subcontractors. This forms the basis for the pricing of the contract and that every tenderer bid on equal conditions, whether it is contracting, subcontracting, or any other type of contract that has been tendered. The purpose is to make it easier to compare the incoming offers with each other (Ibid.).

Construction phase

Udførelsesfasen*
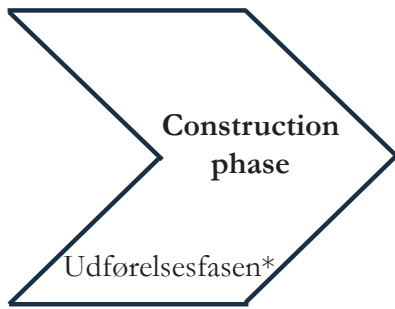
During the construction phase, the physical realisation of the construction is carried out at the construction site, by the winning contractor. The construction phase ends when the construction is handed to the client. The construction is usually reviewed after one year and five years to determine if the construction has errors or mistakes (Ibid.).

Operation phase

Driftsfasen*
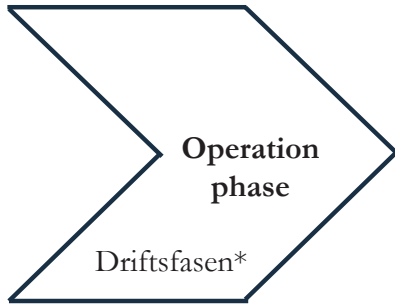
The client facilitates operation and maintenance after handover of the construction. The client might change at the onset of this phase depending on the type of contract. Operation includes activities required to ensure the normal operation of the construction, including supervision of technical facilities. Maintenance includes periodic inspection to ensure that construction is maintained to a certain quality level (Ibid.).

*The Danish term for the phase.

2.1.1 Actors of the construction industry

Naldal (2011) states that there are commonly five actors involved in a construction process; client, client advisor, architect, engineer, and contractor. In the following section we describe the roles of each actor.

CLIENT

CLIENT ADVISOR

ARCHITECT

The client is the decisionmaker and typically the person who pays for construction. The client determines what should be constructed and is responsible for the final construction fulfils the construction requirements set by the authorities (Ibid.).

The client advisor supervises the client in relation to all the other actors. The client advisor needs to be unbiased and assist with their knowledge and experiences with the construction process, ensuring that the client has the necessary prerequisites to make the best decisions. It is the client advisor's responsibility to advise the client in choosing the right type of contract and type of tender (Ibid.).
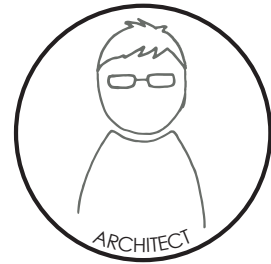
The architect helps in the Design phase with all the elements that do not have a decisive impact on the construction stability, e.g. materials, surfaces and colours (Ibid).
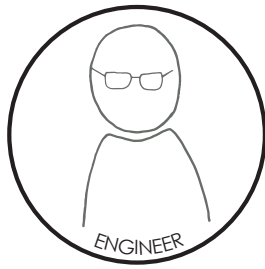
The engineer helps with the technical part of the Design phase. The engineer establishes dimension and principles for the bearing elements of the building. They are often in collaboration with the architects to find the best solution of design and stability (Ibid.).
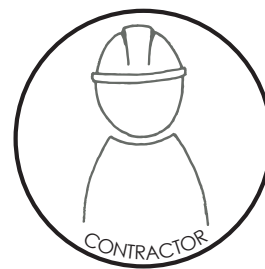
Contractor: The contractor is responsible for the physical execution of the construction. They often hire subcontractors to do specific parts of the construction (Ibid.).

2.2 Linear economy

To understand why circular economy is receiving attention, it is necessary to understand the current environmental, economic, and social problems that are the result of the present linear approach to consumption (figure 3).

Resources → Take → Make → Dispose → WASTE

Figure 3 - Linear economy (Own illustration)

The current linear model is described as: extraction of raw materials used for production of products. These products are distributed and sold to consumers before they end their lifecycle as waste.

In the linear business model, value is created by the amount of sold products, as generating profit is the aim of the business model.

This is also referred to as 'take-make-dispose'. This is a major cause for global overconsumption of resources as it predominantly relies on fossil fuels (Bocken et al., 2016). Along with overconsumption of scarce resources, the linear model also generates a large amount of waste. This results in many countries unable to handle the waste. Waste is both generated directly or indirectly because of the modern consumer habits. Consequently, waste is becoming a bigger environmental problem, a societal burden, and an economic loss if is not reused or recycled (European Environment Agency, 2014) (worksheet 6). Most of waste is generated as biological waste, construction waste, industrial waste, etc. (Ibid.). Around 60 percent of waste generated in Europe derives from demolition, construction, and mining. One third of all waste in Denmark originates from the construction industry (Advisory Board, 2017).

Problems with waste, as described and visualised above, resulted in another view on

waste and the treatment of it. Instead waste should be regarded as a valuable resource that can be reused for other purposes (European Environment Agency, 2014).

We, as inhabitants of the planet, are currently using resources equivalent to 1.7 Earths, to overcome this imminent problem. The linear economy model must be challenged and changed. It takes one year and six months to regenerate the resources equalling to what the world's population uses in a year (Global Footprint Network, 2018). The interesting part appears when questioning how to change the linear model and through what means.

2.3 Circular economy

Circular economy is gaining international attention through some of the UN's Sustainable Development Goals (United Nations Sustainable Development, 2018) (picture 3). Circular economy has the potential to enable a continued economic growth without affecting the environment. A transformation from the linear economy towards circular economy is proposed as a more sustainable model by maximizing the reuse of resources and keep the materials in a flow (Advisory Board, 2017; Ellen MacArthur Foundation, 2013) (picture 4). To change from linear economy to a circular economy a shift in paradigm is necessary. Consequently, we need to rethink the way we utilize, produce, and design.

Picture 3 - UN's Sustainable Development Goals (sustainabledevelopment.un.org)
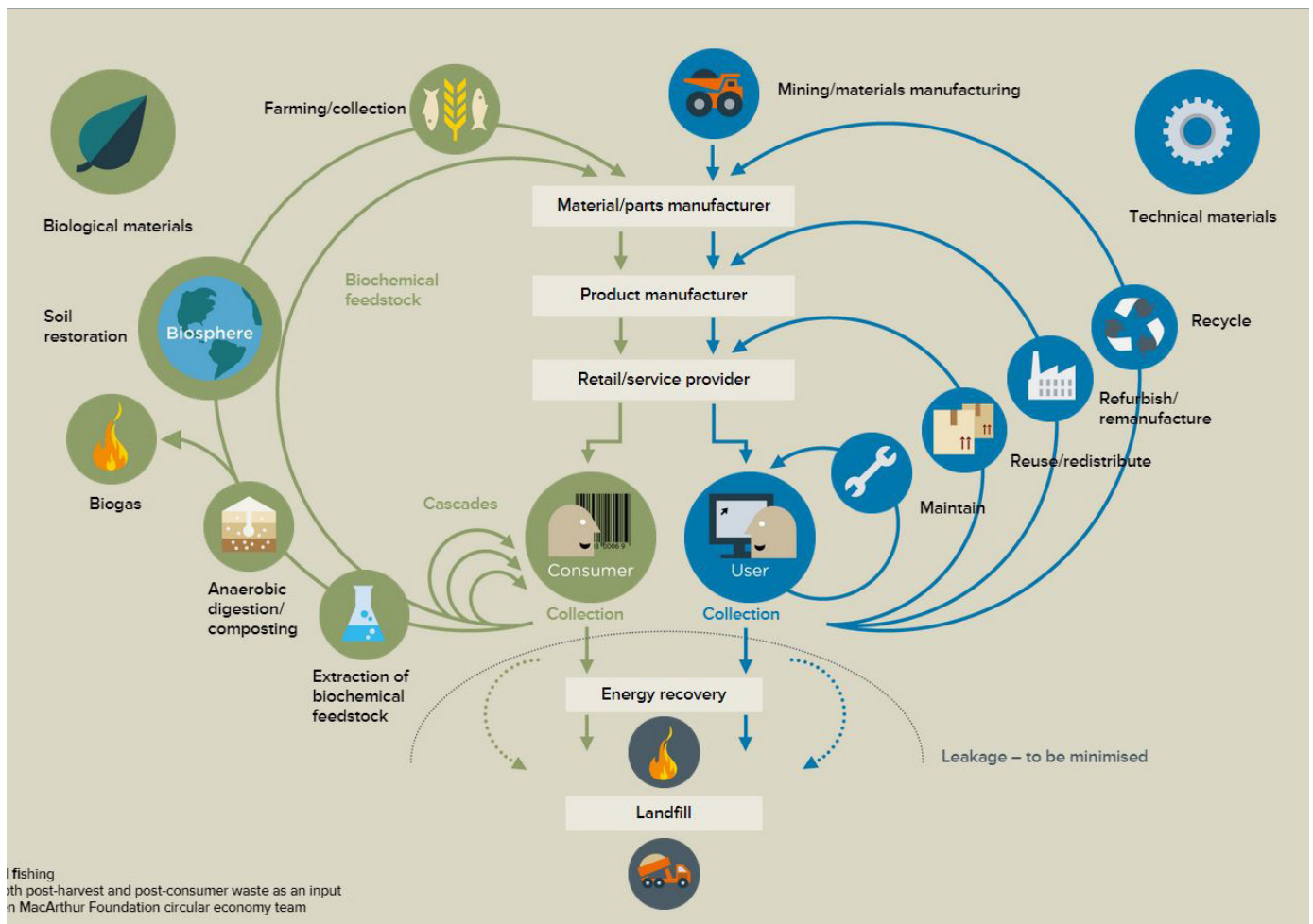
Picture 4 - The circular economy an industrial system that is restorative by design (ellenmacarthurfoundation.org)

The Danish Government's Advisory Board who has created a report about implementation of circular economy and proposed how to change from linear economy to circular economy. In the report there are 27 recommendations for companies to implement circular economy. Furthermore, they present how Denmark has the potential to be an international pioneer, in the transition towards circular economy, which will provide with new business opportunities (Advisory Board, 2017). The report outlines the necessity to collaborate between the various actors;

designers, producers, manufacturer, retailer, consumers, and waste treatment facilities. Meanwhile the transition demands for technological developments and research in smarter use of materials and resources. The report highlights that the Danish business community needs to be front runners in the field of implementing circular economy (Advisory Board, 2017). For this to happen successfully they have a guide with seven dogmas, which is meant as a common direction to those who wish to work with circular economy.

Seven dogmas for a circular economy

Advisory board have defined seven dogmas for a circular economy. They are intended as a compass to help set a common course for everyone working with the circular economy

Circular design. We seek to ensure that all materials retain their potential as a resource for something new. Nothing goes to waste.

Healthy materials. We only use materials that are healthy for the environment and the people who produce, build and use them.

Dismantable design. We produce and build in such a manner that everything can be dismantled and reused. We prefer components that retain or increase in value.

Horizontal collaboration. We collaborate in partnerships that promote the circular economy. From supplier to manufacturer and from investor to lender.

Material passport. We must always know and appreciate the most important materials in a product and in a building.

Framework conditions. We will seek to continuously develop and implement clear requirements and standards for circular development.

Better information. We will seek full transparency for the consumer on content and potential for the recirculation of any product.

Advisory Board (2017) for cirkulær økonomi. Anbefalinger til regeringen p. 15

The recommendations for circular economy are inspired from the British think tank, Ellen MacArthur Foundation, that have published reports on circular economy where they examine the potentials for Denmark, as a case study (Ellen MacArthur Foundation, 2015). The objective of the report is to identify circular economy barriers and opportunities and formulate a toolkit for policy interventions to change these barriers. The report identified potentials in five main sectors, where the main economic potential was in the sector of construction and real estate, as well in the sector of food and beverage (picture 5). The report has a profound focus on the policy makers and policy options of e.g. change in legislation and providing financial incentives to encourage circular economy, and to support new business models. In addition, it also demonstrates the benefits of circular economy to businesses and provides with a toolkit. Within the sector of construction and real estates the report points to three main opportunities;

● Industrialised production and 3D printing of building modules

● Reuse and high-value recycling of components and materials

● Sharing and multi-purposing of buildings (Ellen MacArthur Foundation, 2017).

The report has been inspirational as it investigates barriers and potentials for an implementation in the sector of construction and real estate.
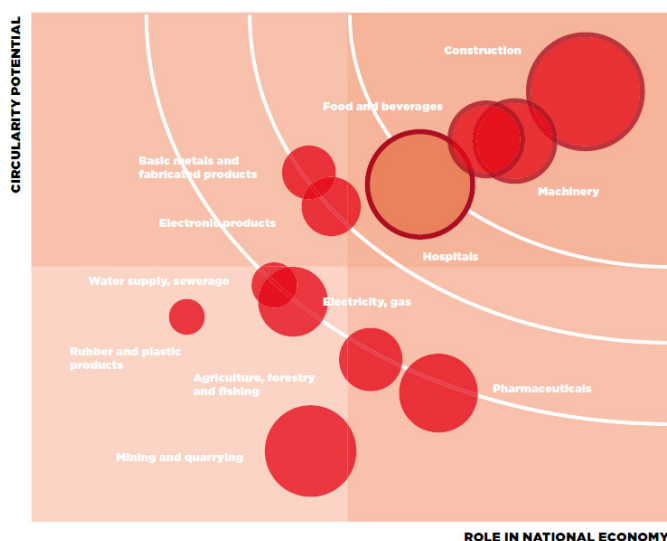
Picture 5 - Circularity potential (ellenmacarthurfoundation.org)

2.3.1 Historical overview

The traditional linear economy did not have the goal of recycling materials. As such, the environment was seen as a waste reservoir, and considered a place to discard resources that are no longer needed. In an attempt to change the linear economy, Pearce and Turner's idea of circular economy is to attach the ends of the linear economy resulting in a loop. The loop is used to describe the industrial strategies for waste prevention, resource efficiency, and dematerialisation of the industrial economy (Geissdoerfer et al., 2016). Furthermore, Pearce and Turner conceptualize circular economy with three R's - reduce, reuse, and recycle (figure 4).
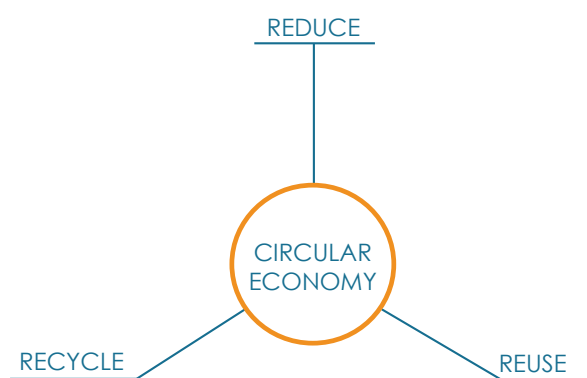
Figure 4 - Three R's (Own illustration)

Reduce refers to reduction of raw materials and the use of polluting energy resources as the primary energy. *Reuse* refers to the reuse of products and by products, as well as handling waste as a resource. Lastly *Recycle* refers to producing products with recyclable materials which also reduces the extraction of virgin materials. Other studies have supplemented the three R's with: Recover, Remanufacture, Redesign, Refurbish, Repair, and the newest R from Advisory Board - Rethink. There is no doubt that all R's promote a wish for closing the loop. In figure 5, the content of each word is described. However, some of these terms can have the same meanings as other R's and some are identified as broad categories e.g. redesign and rethink (figure 5).

REDESIGN
Thinking of repair, reuse and use of sustainable materials in the product

REDUCE
Lessen the use of un necessary materials. Avoiding disposible or singleuse products

Renewability
Places renewable energy as main energy source. E.g. reduce fossil fuel energy dependency

Appropriate design
Importance of design state in finding solutions to avoid waste discharge

RETHINK
Rethinking the current linear way of consuming

RECOVER
Taking energy or materials from waste that can not be used anymore

REMANUFACTURE
New products are made from old materials

CIRCULAR ECONOMY

RECYCLE
Processing the waste materials to make another product

REUSE
To use again, by you or others

REURBISH
Renovation and repair

REPAIR
Fixing or restoring broken items to be used again

Reclassification
Materials classified as 'tecnical' or 'nutrients'

Purple = Ellen MacArthur Foundation
Figure 5 - All R's (Own illustration)

Circular economy can be seen as a business model that challenges the linear economy, and the above terms are often used to describe and frame the concept. When investigating how the concept arose and where it originates from, it is interesting to see that circular economy is inspired by different authors and influenced by several theories. However, several studies point at David Pearce and Kerry Turner as the founders of the conceptual framework for circular economy (Winans, Kendall and Deng, 2017; Andersen 2006; Su et al., 2013; Geissdoerfer et al., 2016). Even though Geissdoerfer et al. (2016) elaborated that the concept of circular economy has gained attention by authors since the late 1970's, and since then gained political awareness, the global attention to the term is not as popular as the term sustainability.

Circular economy has its roots in several concepts such as general system theory, cradle-to-cradle, laws of ecology, looped and performance economy, regenerative design, industrial ecology, industrial symbiosis, eco-city, biomimicry, and the blue economy, all of which touch upon the idea of closing the loop (Geissdoerfer et al., 2016; Winans, Kendall and Deng, 2017; Ghisellini, Cialani and Ulgiati, 2015). The different theories have all affected and influenced circular economy in how it is perceived today. Further investigations of these theories and concepts are needed to fully understand the roots of circular economy, but that is a whole project in itself and are therefore not included in this project. As the scope of this project is circular economy within Rambøll, we will not elaborate further on the different theories and concepts in which circular economy has its roots. The theories mentioned above can all be categorised as being sustainable, which makes it relevant for us to distinguish the two terms.

2.3.2 Circular economy and sustainability

Circular economy and sustainability are used interchangeably, and many have difficulties in differentiating between the two. In order to understand the differences between sustainability and circular economy, it is necessary to understand the two concepts individually. Sustainability as a term is widely used today, and Johnston et al. (2007) estimates that there exist around 300 different definitions of sustainability. The Brundtland report from 1987 introduces sustainability as: "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987). Additionally, sustainability can be described as the three core pillars; environmental, economic, and social pillars that needs to be taken into consideration when talking about sustainability. Thus, sustainability is often referred to as a holistic approach to problems and with an overall societal focus.

Circular economy derives, as we see it, from sustainability as it touches upon elements of resource efficiency, waste treatment, and reuse. The focus of circular economy is on the economic system where the environmental and social factors are secondary. Furthermore, circular economy provides concrete tools of slowing, narrowing, and closing resource loops. However, these tools might as well promote sustainability. Therefore, when a product, service, or a combination of both are circular, it is at the same time sustainable.

The concepts of sustainability and circular economy are both given global attention. They highlight the importance of an innovation in business models as a way to transform the current consumer society. They also share a similar view of change in the systemic level, and a better integration of social and environmental aspects with economic progress (Geissdoerfer et al., 2016). Besides the similarities mentioned above, the concepts are commonly used in different contexts and for different purposes. They are diverse in goals and motivation (Ibid.).

There are also differences regarding which stakeholders that are involved in sustainability and circular economy. While it is rather unclear who has the responsibility of implementing sustainability, the responsibility of implementing circular economy is primarily on policymakers, regulators, and private businesses (Ibid.). Additionally, in the report from the Government's Advisory Board it is highlighted that citizens also needs to be included as they stand with the decision of choosing products and services, that promotes circular economy (Advisory Board, 2017) (figure 6).
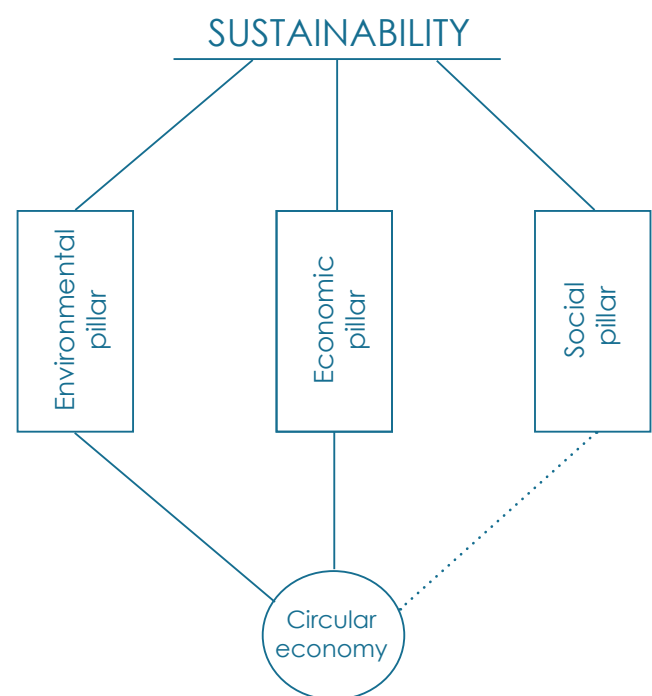

Figure 6 - Circular economy part of sustainability (Own illustration)

2.3.3 Circular economy definition

There does not yet exist a uniform definition of circular economy. However, many authors agree that circular economy frames a business model and the idea of a closed loop. Ellen MacArthur Foundation describes circular economy as "*an industrial system that is restorative or regenerative by intention and design*" (Ellen MacArthur Foundation, 2013, p.6). Additionally, Geissdoerfer et al. (2016) made a study on different definitions of circular economy and found the common elements in each definition. They then summarised it into one general definition: "*a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through longlasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.*" (Geissdoerfer et al., 2016, p.759).

Slowing resource loops, implies designing longlife goods and productlife extension.

Closing resource loops, means a circular flow of resources through recycling, by closing the loop between post-use and production

Narrowing resource loops, aims a using fewer resources per product.

(Geissdoerfer et al., 2016)

2.3.3.1 Rambøll's definition of circular economy

There is currently no agreed upon definition of circular economy within Rambøll. However, they do describe their sustainable approach similar to the definition of circular economy proposed by Geissdoerfer et. al (2016): "*The first step is of course to try to prevent waste by designing with fewer or more durable and renewable resources. Products should have a longer lifetime, with better possibilities to repair, upgrade, disassemble and recycle.*" (Rambøll, 2018, p.4)

Part of this thesis is defining circular economy together with Rambøll to help provide the employees with a mutual understanding of the concept. We propose a definition for Rambøll which is created in collaboration with Rambøll employees:

"Circular economy is an approach that breaks with the linear economy approach where we incorporate the social and the physical resources through a (sustainable) business approach. This can be accomplished by slowing, closing, and narrowing of resource loops"

In section 7.4 it will be further explained how we developed the definition.

2.3.3.2 Our definition of circular economy

Our view on circular economy changed throughout the project as we gained more knowledge on circular economy and realised that circular economy is linked with many different definitions. We see circular economy as part of sustainability, however, circular economy is a concept that is easier to comprehend as it contains some specific tools such as slowing, closing, and narrowing. When talking about circular economy the focus tends to be on waste, energy, and a healthy indoor climate. Looking at it holistically, circular economy cannot be limited to waste and materials. As such, for the purpose of this thesis, we define circular economy as:

"a regenerative system designed with a cost-effective approach that do not compromise with social and environmental aspects.
The regenerative system protects the resources by narrowing, slowing, and closing resource loops."

2.4 Seminars

As part of our initial research we have attended several seminars to collect information about circular economy from different perspectives. This made us understand that the term circular economy is perceived differently, and it generated a lot of questions, e.g. who is responsible for initiating circular economy and how should it be implemented. In several of the seminars; 'Jorden Kalder – Cirkulær Økonomi i Øjenhøjde', and 'Cirkulær Økonomi er det nye Sort', Flemming Besenbacher, chairman of the Government's Advisory Board, mentioned the importance of following the UN Sustainable Development Goals (United Nations Sustainable Development, 2018) (worksheet 7 and worksheet 8). Through the seminars he emphasised goal 17 - Partnership for the goals, as the most crucial to have in mind, as it is necessary for companies and organizations to collaborate in order to proceed in a more sustainable direction (picture 6).
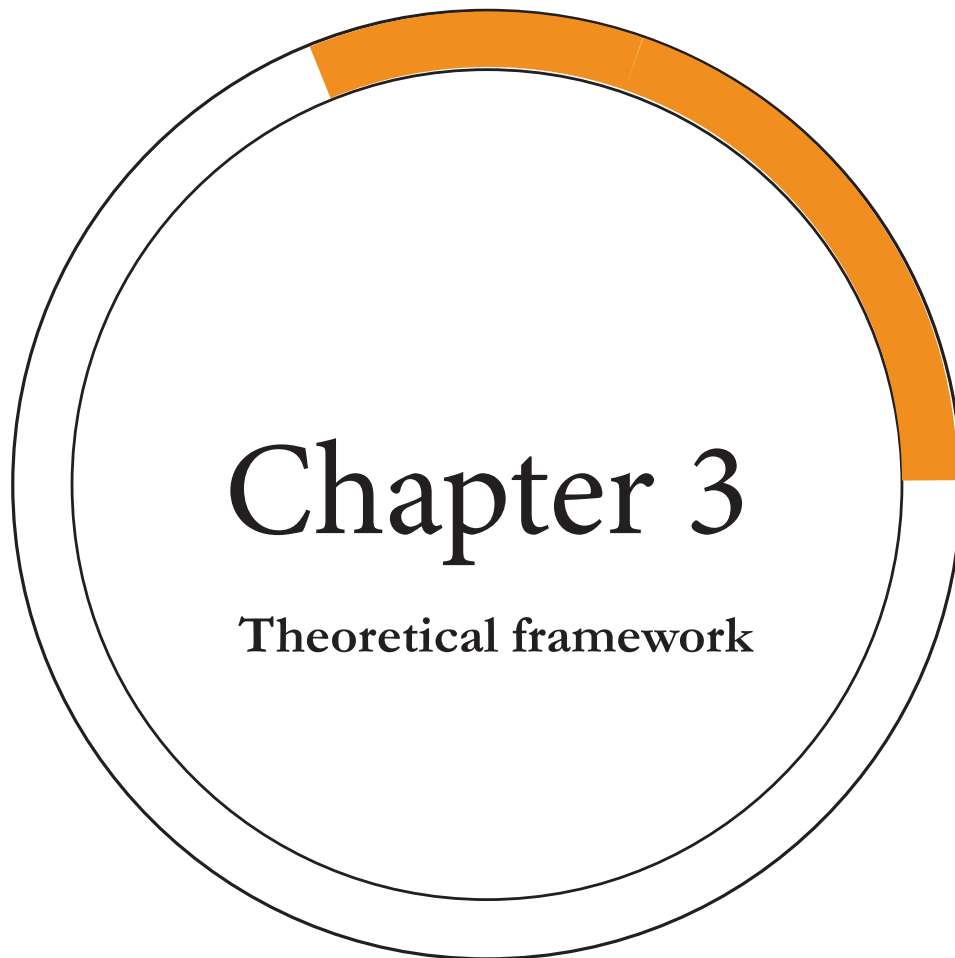
Picture 6 - 17th sustainable goal, Partnerships for the goals (sustainabledevelopment.un.org)

Key points

•The common phases of construction include: Planning phase, Design phase, Tender phase, Construction phase, and Operation phase.

•The common actors of construction include: Client, Client advisor, Architect, Engineer, and Contractor

•The different phases and actors involved in a construction project, varies depending on the type of contract.

•Circular economy can be categorized as a branch within sustainability.

•Circular economy is a business model challenging the linear economy model

•Circular economy can be described within the framework of the 3 R's: Reduce, Reuse, and Recycle

•The key points regarding construction are part of our problematization phase.

•The knowledge of our initial research can be used for developing a design game to support interviews.

Chapter 3

Theoretical framework

This chapter gives an overview of the two theoretical frameworks Actors Network Theory and Participatory Design. Actor Network Theory and Participatory Design are used together as the analytical approach to examine the network, necessary to implement circular economy in construction.

Process

As the process of the project progressed, we made some considerations about which theory were most suitable for our project before starting on the empirical process of the project. We had some initial discussions on whether to use Actor Network Theory, Organisational theory or Practice Theory. The advantages of deciding on a theory before the empirical process is for us to look through the 'glasses' of that particular theory when collecting the empirical data. Actor Network Theory can be seen as a method that do not just provide with a template for interpreting the reality as other theories does. Thus, we chose Actor Network Theory because we saw potential in looking at the field of circular economy in construction of which we can influence and create a new network.

In order to get an overview of the complex actor-network the theoretical frameworks Actor Network Theory (ANT) together with Participatory Design, have been chosen as our analytical approach. The purpose of using ANT is to both define the current configuration of the network involving actors and matters of concern (non-human actors), and to provide insight on how a translation process might be achieved. Using ANT exclusively cannot provide a detailed view of where the matters of concern originate as matters of concern come from different actors and are found in various spaces. Thus, participatory design can support ANT by staging spaces in which the matters of concern can be found and negotiated.

3.1 Actor Network Theory

ANT can be used to observe a configuration of actors in a network. The theory is a less traditional theory in the sense that it can also be seen as a method by which the researcher can perceive their field or research, namely the network. Proposed by Michel Callon, (1986) the core of ANT is to understand the relations between human actors and non-human actors that together constitute a network. Thus, using ANT it is possible to analyse which important relations exist in the network. It is important to note that networks are often very complex and may be constituted of many other networks. It is therefore not always possible to investigate the whole network, but rather parts of it. In such cases the researchers must specify which part or parts of the network that (s)he wants to analyse. In doing so, some actors might be 'black boxed' to simplify the network. E.g. when referring to common actors of construction as an actor they are black boxed, although in reality this actor consists of various actors and is hence a network in itself. It is possible to open up the black boxes and investigate the networks behind. As a result, a researcher should be able to navigate in the network and 'zoom' in and out to focus on relevant parts of the network.

3.1.1 Matters of concern

In the analysis, we suggest that matters of concern be considered as non-human actors which can be negotiated. Discussions of matters of *fact* proposed by Callon, is challenged by Latour's interpretation of it. The word 'fact', has implications of something that is rigid, immutable and cannot be discussed. Hence, Latour suggests using the phrase 'matters of concern' instead of 'matters of fact' because 'matters of concern' cannot be understood without a collaboration with multiple actors (Latour, 2004). Latour frames matters of concern as: "*The discussion begins to shift for good when one introduces not matters of fact, but what I now call matters of concern. While highly uncertain and loudly disputed, these real, objective, atypical and, above all, interesting agencies are taken not exactly as **object** but rather as **gatherings**. (...) A natural world made up of matters of fact does not look quite the same as a world consisting of matters of concern (...)*" (Latour, 2007, p.114). We agree with Latour's understanding of 'matters of fact' and his restraint from using the term. Therefore, we choose his suggestion of using 'matters of concern', because we need to gather the concerns around implementing circular economy in the network. We will examine the concerns of actors in the construction industry to uncover the issues with implementation of circular economy. Brodersen and Pedersen (2018), describe matters of concern as: "*(...)MoCs [Matters of Concerns] are characterised by being rich, complex, surprising and constructed. These characteristics make concerns political and open for discussion, negotiation, conflict and compromise*" - (Brodersen and Pedersen, 2018, p.2). Identifying human actors as well

as their matters of concern and grouping them in categories, can provide us with an overview of which matters of concerns exist to be negotiated. As a result, a network of human actors with their matters of concern (non-human actors) and another network of categorised matters of concern can be made in order to identify the relationships between the matters of concern. Matters of concern can be identified through interviewing and creating a dialogue with the actors of the construction industry. We will investigate how these concerns are related in a network and use them in a design specification to make sure the concerns are considered.

3.1.2 Translation

Callon (1986) describes four moments that constitute the phases of an innovation process, or 'translation'. Translation is an essential element when working with ANT because in the translation process actors can affect other actors in order to make them relate to their interests, projects, and agenda. Thus, the actors are constantly negotiating their interests. The process of translation that forms a network consists of four moments (Callon, 1986):

• Problematization - *Identifying relevant actors in the network (around the problem area) and mapping their relations*
• Interessement - *Characterizing the actors interests and their matters of concern*
• Enrollment - *Recruitment of actors in the network and create alliances between the actors*
• Mobilization - *Maintaining the relationships in order to stabilize the network*

The translation process involves "*the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited*" (Callon, 1986, p.203). Callon argues how networks are developed through a translation, which require a strong network of actors to establish a successful innovation process. However, it is important to mention that "*translation is a process, never a completed accomplishment, and it may (...) fail*" (Callon, 1986, p.196). Thus, it is often difficult to

state whether or not a translation process has or will succeed, as it requires time to interest, enroll, and mobilize the actors as well as negotiate their matters of concern throughout the translation process, in order for the network to stabilize. If the interests of actors change, a stable network may also become unstable.

The four moments of translation are used in this project, to identify which actors need to be enrolled in the network of our solution to reach our goal of establishing a network of key actors. The use of these moments of translation will aid to the successful implementation of circular economy in Rambøll.

3.1.3 Spokesperson

A spokesperson is a human actor who can speak on behalf of others because (s)he is engaged enough in the project. Choosing the right spokesperson is crucial for enrolling other actors in the network. As Latour defines it: "*(...) you have to have spokespersons which 'speak for' the group existence — and sometimes are very talkative, (...) all need some people defining who they are, what they should be, what they have been. These are constantly at work, justifying the group's existence, invoking rules and precedents and, as we shall see, measuring up one definition against all the others.*" (Latour, 2007, p.31).

3.1.4 Interessement device

An interessement device is a non-human actor that has the possibility of enrolling crucial actors to the network. It can appear in various forms depending on the context. For example, they may appear as arguments, matters of concern, design games, workshops, materialities, etc. The purpose of using interessement devices in different contexts is to get people interested so they can negotiate, agree and end up in a change. Several interessement devices have been used throughout this project to get actors interested in both the concept of circular economy and in our project.

3.1.5 Intermediary object

'Intermediary objects' are a conceptual framework consisting of non-human actors. It is a materiality that can mediate and facilitate negotiations between actors. Moreover, intermediary objects can represent the identified matters of concern. Therefore, it is essential to bring intermediary objects into a design process to help the actors with a common or new reference point (Brodersen and Pedersen, 2018). We will use intermediary objects when we collect our empirical data through design games. They create a common reference point for both the interviewee and interviewer. Furthermore, we will make use of intermediary objects in a workshop with the employees in Rambøll.

3.2 Participatory Design

Storni suggested an extension of ANT to include a perspective of participatory design (Storni, 2015). "*the participatory design process turns into an open-ended process (...), where participants with divisive matter of concern can confront one another and continue to explore design-after-design.*" (Storni, 2015, p.169). Participatory design can be used as a way for researchers to ensure a collaborative design process through the involvement of users (Simonsen and Robertson, 2013). This is also what Brandt states in her article: "*Participatory design implies active involvement of the people designed for and other stakeholders in the design work.*" (Brandt, 2006, p.57). However, Iversen, Halskov and Leong, (2012) emphasise the significance of negotiating values that might be conflicting as they emerge in a cooperation with different stakeholders. These values can in an ANT perspective be seen as matters of concern thus, when involving several actors in the design process, it is important to negotiate the

matters of concern from the various actors. The role of the designer can be seen as a navigator in negotiating matters of concern, and in the network that is going to be designed. When involving various actors, the designer or design team often needs to navigate diverse or conflicting statements or as Brodersen and Pedersen (2018) frames it: "*a key competency of the designer is the ability to navigate the design process by staging, facilitating, and learning from/ synthesising the results of engagements and interactions. The navigation style is related to the concerns of the designer and the project, and comes across in the big, small and non-decisions that take place during the design process.*" (Brodersen and Pedersen, 2018, p.2). The designer is, in this context, staging and facilitating interactions throughout the design process to support negotiations of concerns from various actors. The negotiations can be supported by intermediary objects that can, for example, show the matters of concern in different spaces. Pedersen (2016) highlights prototyping spaces in her article as: "*Drawing from the benefits of linking ANT and Participatory Design, while focusing on prototypes as means to negotiate knowledge and meaning across boundaries and interest actors, (...) I argue that 'Prototyping Spaces' might be used as a sensitising device to point to how designers, (...) might navigate a prototype to play a role in the interessement (and potential enrolment) of various actors at several moments throughout a Participatory Design process*". Thus, a prototyping space can be described as a setting, staged and facilitated by the designer. The word prototype might be interpreted differently depending on what background the interviewee has. For this reason, we choose to call it spaces instead of prototyping spaces. Moreover, the prototypes she refers to can be interpreted as intermediary objects that can negotiate matters of concern between actors and help bring the knowledge from one space to another.

Step A
A navigator stages the space

Step B
The process of interessment takes place if the interessment device is successful

1 Who facilitates

2 Who is to be interested

3 Why (The purpose)

4 Where

5 How (which objects)

Step C
The outcome is a transformation of knowledge and interessement of actor(s)
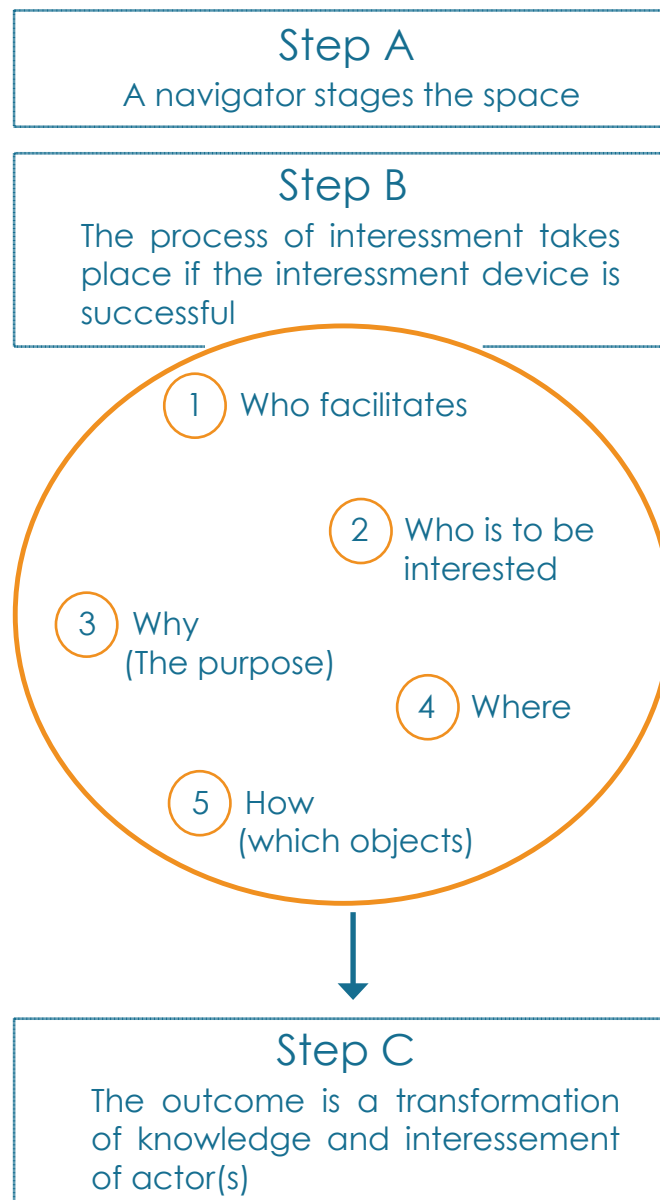
Figure 7 - Space (Own illustration. Inspired by Pedersen, 2016)

In the article by Pedersen (2016) a three-step activity in the design process is suggested when a transformative outcome is the goal (figure 7). When staging and facilitating spaces the designer needs to be aware of of three steps, and navigating with five configuring elements, which entails; "*1) A facilitator who facilitates the interaction in the prototyping space, 2) the internal or external actors to become interested, 3) a purpose (exploring, evaluating or communicating), 4) the assembly of materials and meanings that constitutes the location, and 5) an appropriate prototype format*" (Pedersen, 2016, p.6).

Participatory design is relevant in this project, as we will stage and facilitate a workshop with employees from Rambøll as part of the design process for creating a solution to negotiate their matters of concern. The workshop is staged in Rambøll so the employees are in familiar surroundings. Furthermore, we facilitate three exercises and use intermediary objects, such as cards with statements of circular economy, and scenarios that were part of the space. Moreover, we also act as navigators between the negotiations of concerns in the conducted interviews, bringing knowledge and concerns from one interview to another in order to negotiate and make compromises between the important concerns.

Key points

- Actor Network Theory can be used to understand the relations between human actors and non-human actors that together constitute a network.

- Identifying human actors and their matters of concern can provide an overview of which matters of concerns can be negotiated.

- Translation is an innovation process consisting of four moments; Problematization, Interessement, Enrollment, and Mobilization.

- A spokesperson is an actor who is engaged in the project and can speak on behalf of other actors.

- An interessement device is a non-human actor can enroll actors to the network by making them interested.

- An intermediary object is a materiality that can mediate and facilitate negotiations between actors.

- The role of the designer can be seen as a navigator in negotiating matters of concern.

- Participatory Design can be used as a way for researchers to ensure a collaborative design process through the involvement of users

- A space can be described as a setting, staged by the designer.

Chapter 4

Methodology
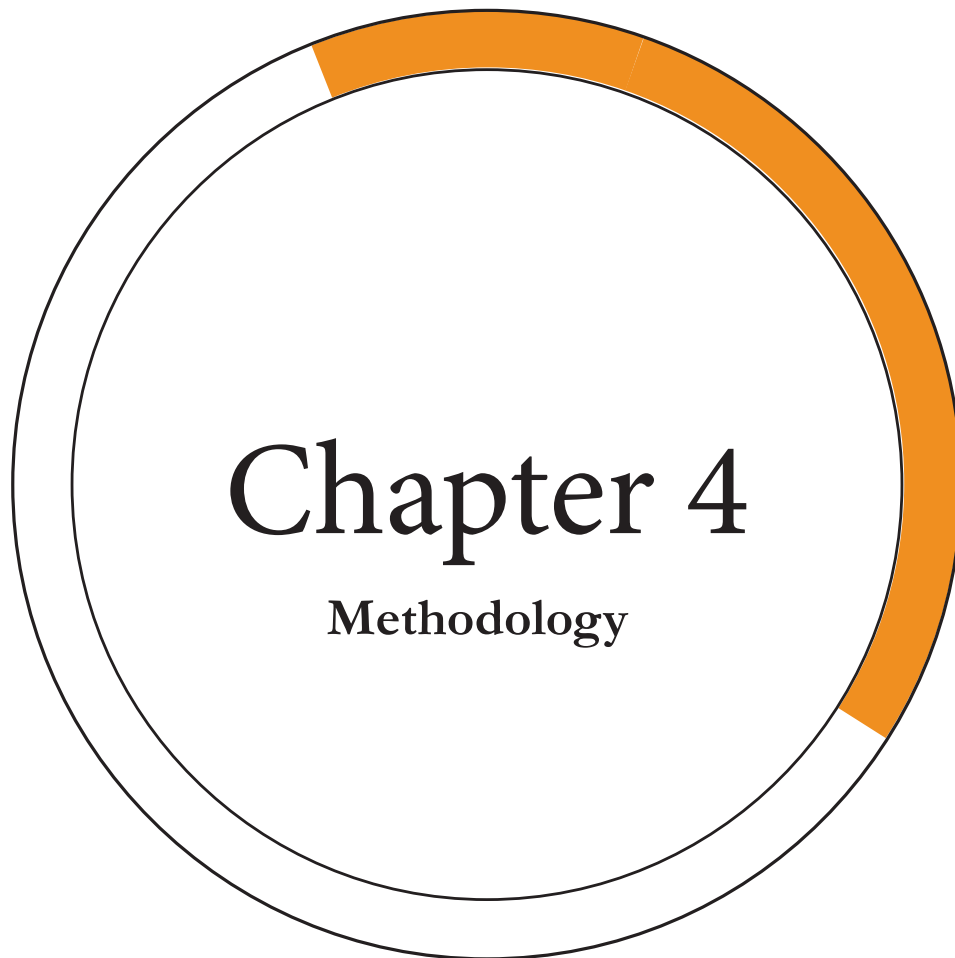
This chapter gives an overview and a description of the different methods and approaches chosen to collect the empirical data.

Process

Moving on to the empirical process of the project, we used several methods to collect our empirical data. First, we developed a semi-structured interview guide with four topics and sub-questions in order to create a structure of the interview. Then, we created a design game, to assist the interview, consisting of two parts; actors of construction and the phase of a construction project. The purpose of the design game was to create a dialogue with the interviewee and create a non-formal interview setting. Moreover, after each interview, we would ask the interviewee if they knew other interesting people we could talk to in order to expand our list of interviewees. The interviews were transcribed and compiled in a Google Drive document to make it manageable for the process of coding and processing the knowledge. We used coding to 'read between the lines' of what the interviewee said as well as sorting their statements into categories that constituted 15 barriers. This was done by writing the interesting statements from all interviews and group them. We chose to write on post-its as they are easier to move around. Furthermore, we interviewed several interviewees again to prioritise the identified barriers through a prioritisation game.

4.1 Rolling a snowball

Metaphorically speaking rolling a snowball, implies a process where it's initial state are small and while rolling, it becomes larger. Bijker (1995), introduces the method, Rolling a Snowball, in relation to identifying 'relevant social groups'. Asking a group, who they think would be relevant to talk to, leading the interviewer to the next group, until there are not any new groups presented. However, this method has been criticized by Klein and Kleinman (2002), for its lack of completeness meaning that there is guarantee of comprehensiveness of actors using this method and some relevant actors may be unnoticeably excluded.

Taken out of the context of relevant social groups, we allow us self to use the very core of this method, namely expanding the network of people relevant for the project. When interviewing people, some naturally/indirect mentions other interesting actors to pursue. If not, we would ask them if they knew some actors relevant for the project or who they think we are missing, in the end of an interview.

We prepared a semi-structured interview guide consisting of four topics; presentation of the interviewee, actors of the construction industry, phases of construction, and circular economy (worksheet 9). Within each topic, we prepared a few questions to help and direct the interviewer. The intention of the interview was to understand the interviewee's thoughts about each topic (Kvale and Brinkmann, 2009).

In order to establish thorough and relevant answers we wanted to be open minded. The interviews was conducted at the interviewee's office to ensure that they felt comfortable. During the interviews we became aware of not taking too many notes, but rather concentrate on being present and attentive.

Interviews were conducted primarily with Rambøll employees, representing different disciplines in order to collect data from employees with various backgrounds and comprehensions of circular economy as a concept. Outside of Rambøll, interviews were conducted with relevant actors of the construction industry typically not represented in Rambøll in order to get thorough information of the construction industry Interviews were conducted with the common actors of construction.

4.2 Interviews

A semi-structured interview enables the interviewer to adapt the interview structure according to the dialogue and ask detailed questions during the interview (Kvale and Brinkmann, 2009). A semi-structured interview is open and allow the interviewer to deviate from the guide according to the interviewee's answer. The guide was not intended as a manuscript. Moreover, the interviewer has the opportunity to adapt the questions in relation to the received answers which allows for the interviewer to follow up with questions and receive elaborated answers.

4.3 Coding

Coding as a method can be used to analyse interviews and organize the data. Coding can be used to sort the data into categories. The method of organizing and condensing the amount of data into categories aids the organisation of knowledge, as it becomes more digestible. Conduction of coding is related to data simplification, where data are reduced to categories. However, coding are also used for data complication of going beyond the data and 'read between the lines' (Røpke, 2016).

Coding has the possibility to change during the analysis and transform into new subcategories (Coffey and Atkinson, 1996).

We coded the transcript of the interviews on what the interviewee said directly as well as indirectly and then extracted multiple subcategories. This worked as an organising tool throughout the process of analysing interviews.

4.4 Affinity diagram

Affinity diagram serves a creative process in order to gather and organize extensive amounts of data by revealing the natural correlations between the data. The data can be sorted in groups for creating overview and for later analysis. This method was used in relation to scientific papers as a manageable organisation of the big amount of data we collected in the initial research process (Servicedesigntools.org, 2018)

4.5 Design game

There do not exist a clear definition of a design game, however Vaajakallio and Mattelmäki (2014), describe the commonly characteristics of an design game as: "*(...) design games are about staging participation, that there is seldom competition over who wins the game, and that there are rules and tangible game pieces that guide the design moves*" (Vaajakallio and Mattelmäki, 2014, p.64). Design game is often used to provide a common platform where participants can share past and current experiences (Brandt, 2006). Thus, the intention with design games is to create a dialog between participant and interviewer which is one of its strengths as design

game has the possibility to interrupt the formal structures of an interview. In order to do so, it is necessary to create easy understandable game pieces that can bridge the different knowledge boundaries of both participants and interviewer or as Brandt (2006) states "*(...) game playing is recommended as a good basis for mutual learning between designers and users.*" (Brandt, 2006, p.57).

We have used design game as a method to gain an understanding of the actors of the construction industry by making a two-part design game that deals with the phases behind a construction project and its actors. We knew that the interviewee possesses useful knowledge of his/her own field and we wanted to create a dialog crossing the borders of a formal interview. While playing the game we asked questions and deepened the dialogue, taking advantages of the actor's expertise and skills. Furthermore, we kept on developing and refining the game as we also got useful feedback on it.

The participant got an introduction of the game and we made it clear that there is no right or wrong or win or lose in this game. The purpose of the design game is to create a dialogue with the participant and make it easier to relate to the subject of the interview.

First part: The actors of a construction industry

The purpose with the design game was to understand the different actors involved in a construction industry and how they work. By doing so we could get an understanding of how the actors see themselves in comparison to others.

The first part consisted of a board with the most common actors of a construction industry (section 2.1.1). We included a blank circle, so the interviewee was not limited to the common actors we presented (picture 7). The interviewee gets a pen and post-its and it is up to him/her to write down what characterises the different actors, what the actors do, and what their task usually is.

Picture 7 - First edition: First part of the design game (Own picture)

After testing the first edition on an interviewee, we wanted to make the board bigger as there was not enough room to stick the many post-its. Moreover, we assigned different background colours to the actors, so the design game became more user friendly and easier to recall the different actors based on their colour (picture 8). We also experienced that a few interviewees did not want to write their thoughts on post-its and asked if we could do it instead, while (s)he talks. Therefore, it became clear in the further interviews that it was important to clarify that they could write on post-its if they wanted and they should not feel forced to write.

Picture 8 - Second edition: First part of the design game (Own picture)

Second part: The process behind a construction project

The purpose with the second part of the design game, was to get an understanding of the phases in a construction and the process behind. It was also relevant to investigate when the actors are introduced in which phase and when they collaborate with each other.

The first edition consisted of a board with empty arrows fixed at the paper and small game pieces with the different actors on (picture 9). The intention was to get the interviewee to write the phases on the empty arrows in a chronological order and place the actors on the different phases to see when the actors collaborate with each other.

Picture 9 - First edition: Second part of the design game (Own picture)

When playing the second part of the game we experienced that it was difficult for the participant to differentiate between the actors as they looked similar to each other. Moreover, it became clear to us that the gaming pieces were too small. The interviewee also mentioned that she wanted to move the arrows into a circle to emphasize the circular flow of the construction process. However, as the arrows were drawn onto the paper she could not move the arrows. Therefore, we became aware of making the arrows as individual movable gaming pieces and bigger in size, so the actors could be placed on them. Furthermore, we gave the actors the same background colour as in the first part to make them easier recognizable (picture 10).

Picture 10 - Second edition: Second part of the design game (Own picture)

4.5.1 Prioritisation game

From the knowledge we had been analysing in the design games we made a prioritisation game which we introduced to different Rambøll employees as well as other actors of the construction industry. The purpose of the game was to understand which barriers the employees of Rambøll weighted as the highest within Rambøll as well as which barriers they saw most potential in changing.

We made a board with numbers ranging from 1-15 and with 15 cards explaining the different barriers (picture 11). The employees then prioritised the barrier cards, where 1 is the biggest barrier and 15 is an insignificant barrier. While the interviewee prioritised the cards, we asked them to elaborate on their choices. We found that there were several understandings of the barriers, however, the answers helped us narrow down to significant barriers for implementing circular economy within Rambøll as we challenged the understandings of the barriers.

4.6 Brainstorm

Brainstorming is important in the design process in order to create a large variety of ideas. When brainstorming ideas, it is essential to focus on quantity over quality in order to bring out as many ideas as possible. It is important to be open to all ideas and possibilities (Tucker, 2017).

We used brainstorming in the initial phase of our design process in order to create ideas for concepts.

4.7 Morphological Chart

The purpose of using a morphological chart is to establish essential aspects that must be incorporated in a solution (Cross, 2008). These aspects can also be considered as functions. A morphological chart is a grid where the functions are placed in the first column. In each function there should be generated subsolutions. The subsolutions from each function are combined and form the overall design solution.

When developing our solution, we use the morphological chart method to organise and combine subsolutions from each function into four concepts.

Picture 11 - Prioritisation game (Own picture)

Key points

- The method, Rolling a snowball enable one to expand the network of people, relevant for the project.

- A semi-structured interview is open and enables the interviewer to adapt the interview structure according to the dialogue.

- The method, Coding can be used to analyse interviews and organize the data from the interviews, into categories.

- Affinity diagram can be used as a tool to gather and organize extensive amounts of data.

- Design game can be created in various ways and open up a dialogue with the interviewee.

- Brainstorming can be used to generate ideas for a solution

- Morphological chart help organising essential functions of the solution as well as ideas.

Chapter 5
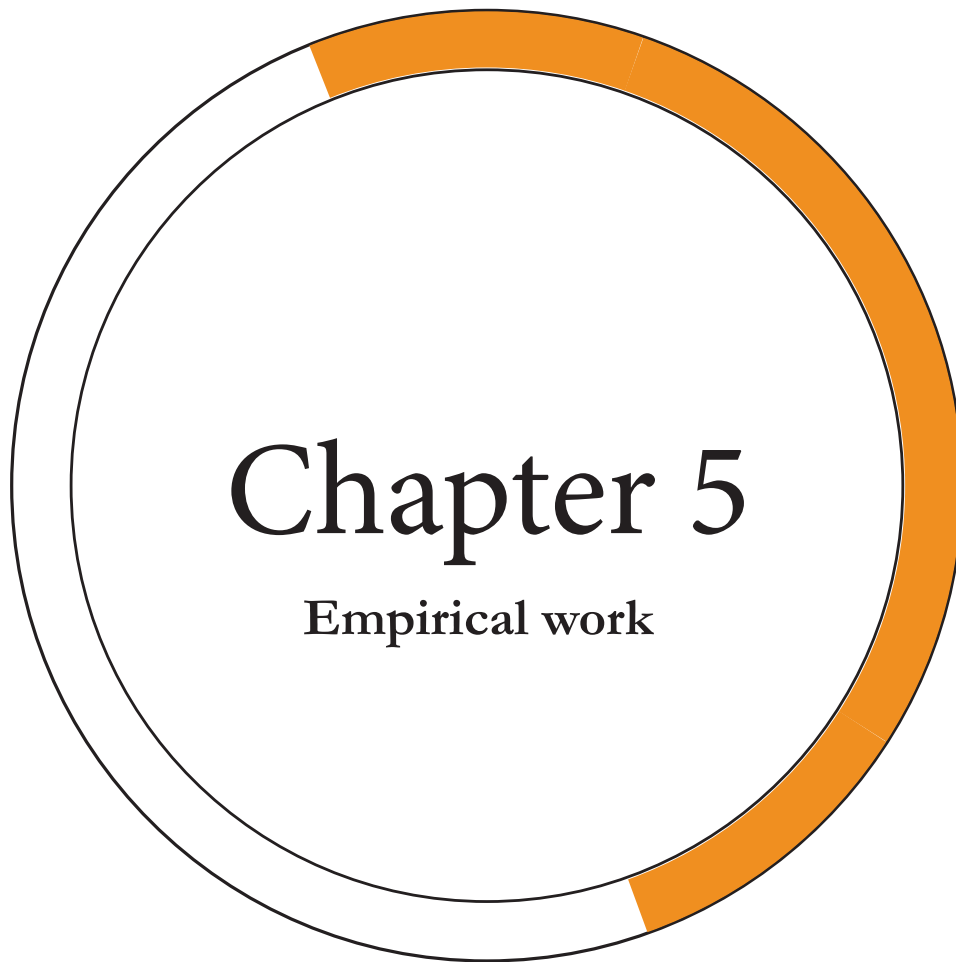
Empirical work

This chapter presents how the empirical data was collected through interviews, Vinterakademi, and from the staging of spaces. Furthermore, examples of spaces are shown.

Process

Gitte recommended us to apply for this year's Vinterakademi concerning circular economy in the construction industry as she thought it would benefit the project. We applied to be part of Vinterakademiet, because we planned on starting our empirical process by interviewing those who attend the academy. We spend five days in Aarhus learning about circular economy and the problems related to implementing circular economy in construction, together with other postgraduate student and the organisers of the academy. We met interesting lecturer and actors of construction whom we interviewed. After Vinterakademiet we planned how to stage further interviews with the common actors of construction. We created spaces to stage the interviews and used design games and an intermediary object that could be brought into various spaces, to let the interviewees negotiate their matters of concern. We as researchers functioned as navigators that creates spaces, as the 'journey' of the interview was prepared beforehand but also changed during the facilitation. The experiences from the interviews at Vinterakademiet was used in developing the first edition of the design game. However, after using the first edition of the design game it became clear that it needed some adjustments. We then redesigned the first edition of the design game to enable each game piece to be moveable. Furthermore, post-its and pen were used as an intermediary object in the space and we invited the interviewee to write on post-its. Several readjustments were made according to the interviewee. We experienced that a few interviewees did not want to write on post-its and then we had to renavigate by writing on the post-its ourselves, while the interviewee talked. The design game, pen, and post-its were brought into the space of the following interview in order to negotiate the matters of concern from previous interviews. This process of bringing matters of concern from space to space for it to be negotiated, continued until we identified a pattern. The pattern led us to the barriers of implementing circular economy in the construction industry. Later, we designed a prioritisation game functioning as an intermediary object. The prioritisation game concerned the implementation of circular economy in Rambøll and was part of a space where employees could prioritise the barriers. Five interviews were carried out using the prioritisation game.

5.1 Interviews

Throughout the empirical process of the project, we conducted many interviews, in order to gather insights from the various actors of the construction industry. The interviews were recorded, transcribed and then coded into several topics (Appendix Interviews). Figure 8 shows the various interviews we have conducted, with whom and in which company they work in.

Date	Name	Discipline(s)	Company
05.01.18	Gitte	Sustainability consultant / Engineer	Rambøll
23.02.18	Gitte	Sustainability consultant / Engineer	Rambøll
02.03.18	Torben	Sustainability consultant / Engineer	Rambøll
02.03.18	Agustine	Architect / Engineer	Rambøll
08.03.18	Andreas	Sustainability consultant / Engineer	Rambøll
14.03.18	Inge	Architect	Aarhus Arkitekter
14.03.18	Jesper	Contractor	Kingo Karlsen
14.03.18	Sussanne	Contractor / Architect	NCC
15.03.18	Mette	Contractor / Architect	NCC
20.03.18	Jeanette	Sustainability consultant / Engineer	Rambøll
21.03.18	Lene	Architect	Lendager Group
22.03.18	Laura	Sustainability consultant / Engineer	Rambøll
26.03.18	Annemette	Working environment consultant / Engineer	NCC
28.04.18	Gitte	Sustainability consultant / Engineer	Rambøll
03.04.18	Stefan	Product Manager / Contractor	RIB
03.04.18	Ofri	Architect	Rambøll
04.04.18	Christine	Sustainability consultant / Engineer	Rambøll
04.04.18	Nikolaj	Architect	Lendager Group
06.04.18	Anders	Client Engagement Manager	RIB
13.04.18	Christine	Sustainability consultant / Engineer	Rambøll
17.04.18	Ingrid	Client Advisor	Rambøll
17.04.18	Laura	Sustainability consultant / Engineer	Rambøll
18.04.18	Andreas	Sustainability consultant / Engineer	Rambøll
19.04.18	Jens	Client	Pension Danmark

Figure 8 - Overview of interviews (Own illustration)

5.2 Vinterakademi 2018

As part of our research phase we attended an academy, called Vinterakademi. It is a five-day academy in Dome of Vision located in Aarhus, and arranged by NCC, Concito, and Center for Bygningsbevaring i Raadvad. The programme of Vinterakademiet were a combination of lectures and case visits. We visited several circular construction cases in Aarhus during Vinterakademiet. The aim of Vinterakademiet is to create awareness about the construction industry and educate postgraduate students and newly educated in the direction of a sustainable development (vinterakademi.dk, 2018). They hope that the students are able to make innovative solutions towards a green transition. The focus of this year Vinterakademi was on circular economy in the construction industry and several speakers were invited to give lecture about the subject (worksheet 10 - 14). Moreover, the academy encourages the participants to collaborate interdisciplinary.

From the academy we learned about problems of the current way of constructing and discussed possibilities for how to implement circular economy in the construction industry. We learned about waste problems, circular economy elements such as; disassembly, how reused materials are not always the most sustainable choice, the importance of having a long-term perspective in designing new buildings, regulations, social aspects, the importance of an interdisciplinary collaboration, and much more.

It gave us the opportunity to examine and learn about circular economy from various point of views and from several cases. Moreover, we expanded our network and got to know many new interesting people, which gave us the opportunity to interview several actors in the construction industry, e.g. a demolisher, architects, students, a client, and contractors.

5.3 Knowledge gained in spaces

When we stage spaces we both act as a facilitator in the space. We wanted to create a space where the interviewee would feel comfortable to communicate their respective matters of concern. We staged and facilitated a temporary space for each interview, at the office of the interviewee. The matters of concern we gained from one space was challenged in the next space.

Space example 1

A space was staged in Rambøll in an initial meeting, with our company advisor. In this space we as navigators negotiated with Gitte about the overall concern of the project in order to get her interested. The purpose of the space is to frame the scope of our project. We brought worksheets into the space functioning as an interessement device. The worksheets were used as a tool to communicate our understanding and knowledge about circular economy (figure 9).
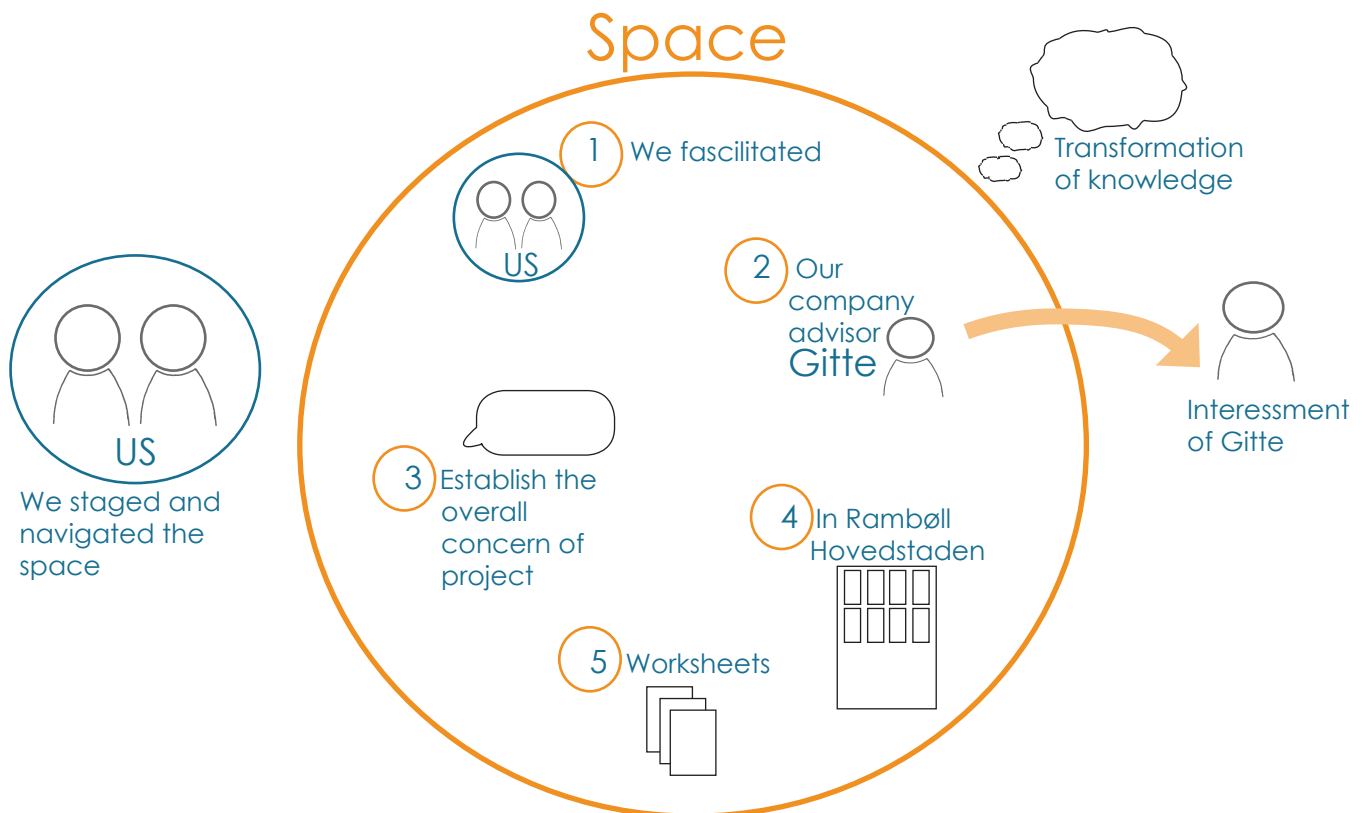

Figure 9 - Space example 1 (Own illustration)

Space example 2

Another example of a space was staged in the office of an architect company, Lendager Group. We wished to interview employees from Lendager Group as they primarily work with circular economy projects and have experiences in the field. The purpose of the space was to explore the concept of circular economy. The space was staged in one of their meeting rooms in order for the interviewer to feel comfortable in familiar environment. In the space a design game functioned as an intermediary object with the purpose of representing ideas and the actors 'concerns. The knowledge gained from Vinterakademiet was challenged in the space, through a design game. The design game worked as intended because the knowledge from Vinterakademiet were negotiated in the space. For example, we discussed our as well as their understanding of circular economy (figure 10).
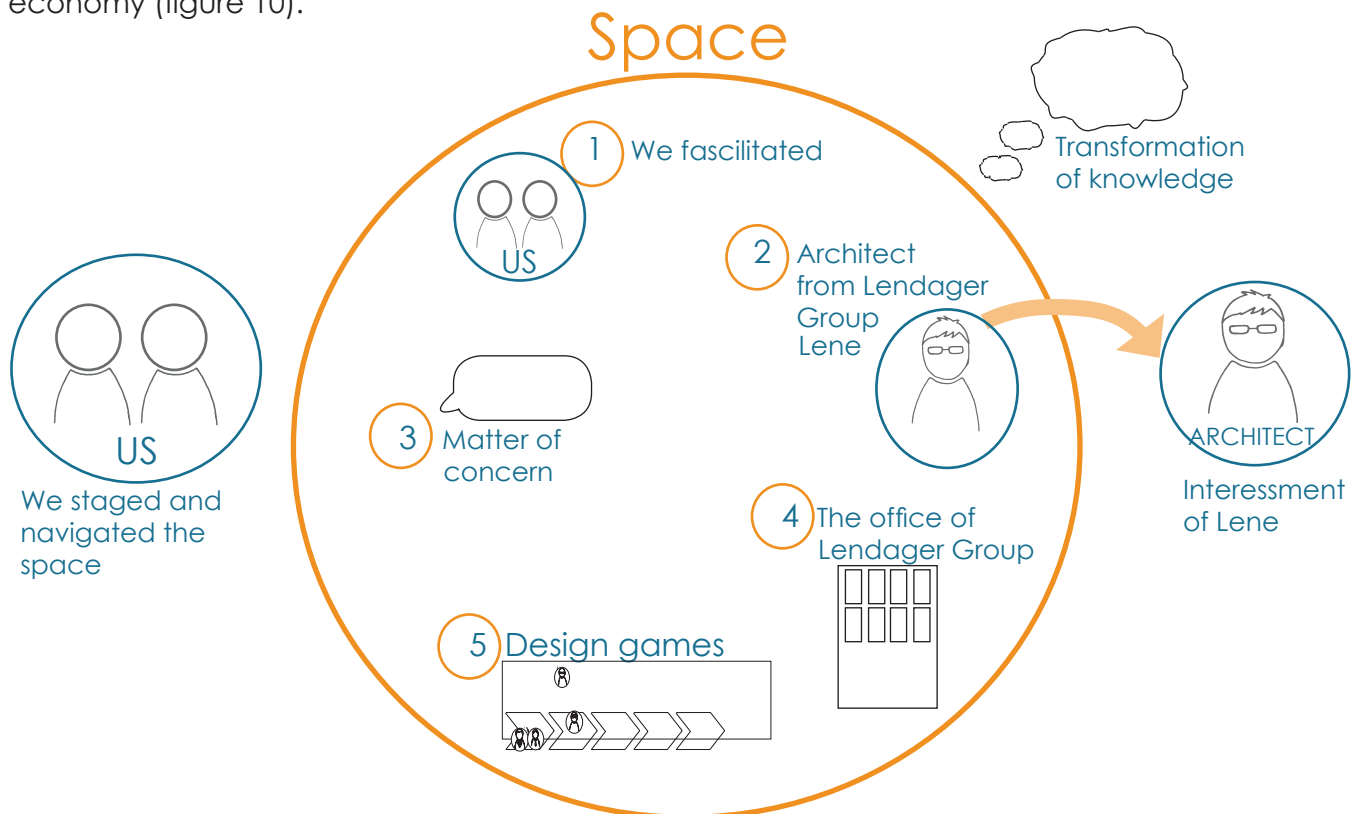
Figure 10 - Space example 2 (Own illustration)

Space example 3

Another example of a space was in our initial phase of interviewing. The space was staged in Rambøll with an engineer from the sustainability department. We staged the space in one of the meeting rooms near the engineers usual working settings to make the interview less formal. We functioned as the navigators and facilitators of the space. In this space we negotiated the matters of concern from several interviewees through a prioritisation game. The prioritisation game functioned as an intermediary object in which the interviewee could negotiate and prioritise the identified matters of concern. For example, the interviewee did not agree with the barrier of transparency and we explained that the barriers were overall barriers. (Christine, SC, Rambøll) (figure 11).
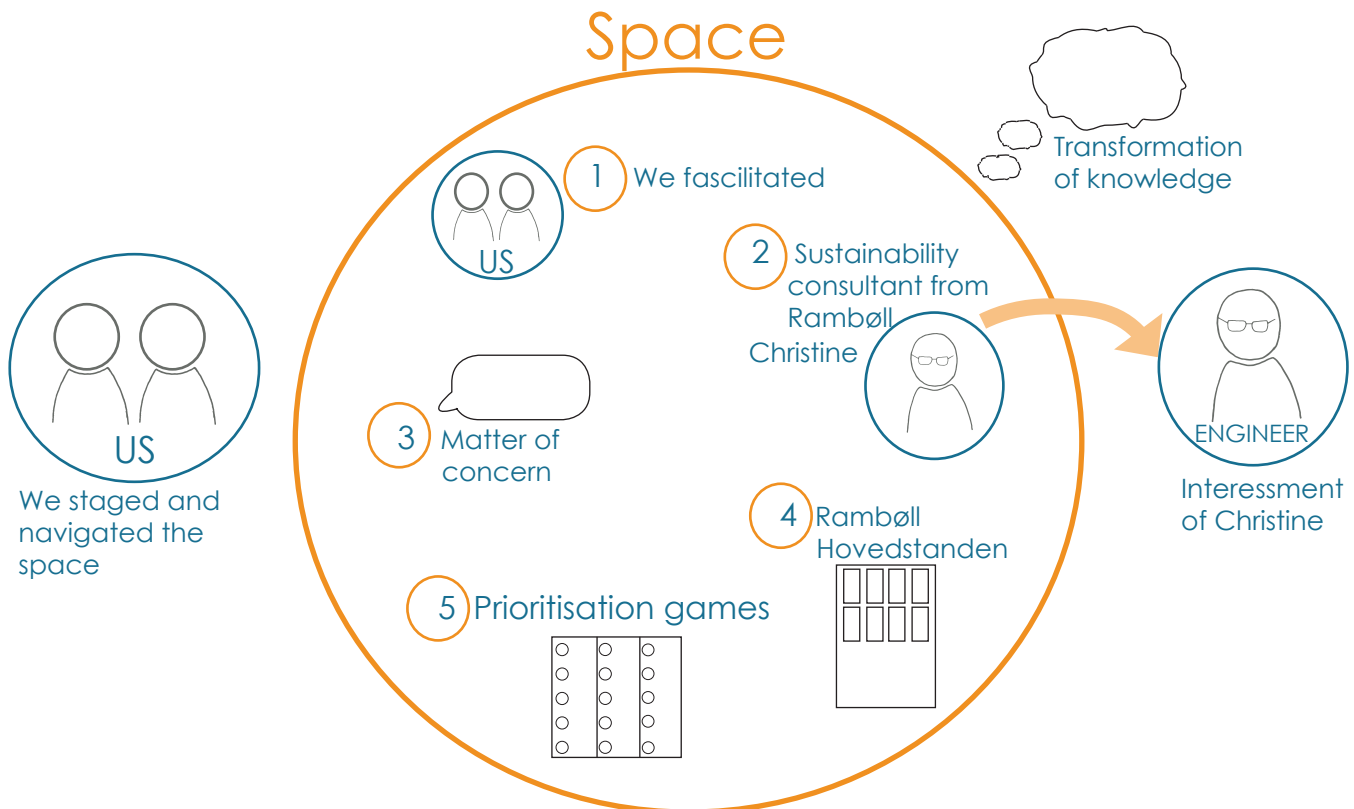
Figure 11 - Space example 3 (Own illustration)

Key points

- Vinterakademi of 2018 focused on circular economy in the construction industry.
- The knowledge gained from Vinterakademi was used to develop a design game.
- The design game was used in the staged spaces of the interviews with actors.
- The actors' matters of concern where negotiated from space to space.
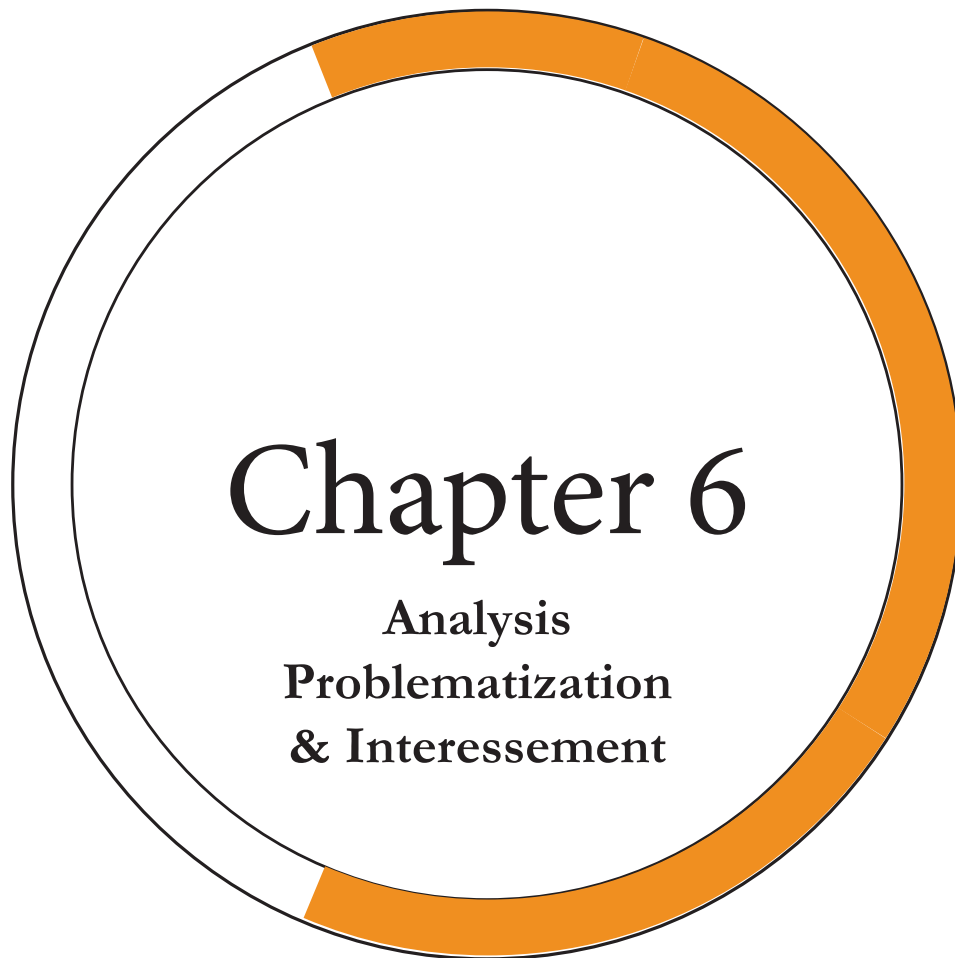
Chapter 6

**Analysis
Problematization
& Interessement**

In this chapter an analysis of the empirical data is carried out. An overview of the overall network and the network of Rambøll are analysed. The analysis is viewed through the lens of ANT supplied with staging spaces from Participatory design. Furthermore, the identified barriers as well as their relations are described.

Process

As the process of this project progress we identified several actors of the construction industry in order to understand 'the overall network' of actors and their matters of concern. We have chosen to apply ANT on our design process thus, our project is described as a translation process. Starting with the analysis, we see how it can be perceived as a problematization phase and an interessement phase. In the problematization phase we start by determine which actors are in the overall network of implementing circular economy in construction projects and describe their identities. Before interviewing the actors, we thought of how to navigate in the network and stage spaces in which we could collect their matters of concern. When staging the space, we developed a design game to function as an intermediary object that could mediate negotiation. Numerous interviews were conducted to gather knowledge, with various actors related to the construction industry. We identified an overall network with human and non-human actors based on the empirical data. Furthermore, we saw how an interessement phase started when actors became interested in our project through the interviews. Hence, the interview in itself functioned as an interessement device for those who wanted to read our report. Furthermore, from the conducted interviews and transcript of those, we used coding to identify matters of concerns, which is the barriers that hinder implementation of circular economy. We divided the matters of concern into 15 categories of barriers (further on written as barriers) for implementing circular economy in the construction industry. While we identified the 15 barriers we also realized how strongly interlinked the barriers are. To make a natural limitation of the project, we decided to focus on 'the Rambøll network', as the size and complexity of the network makes it difficult for us to navigate. We developed a prioritisation game for Rambøll employees to prioritise which of these 15 barriers that primarily hinder implementation of circular economy in Rambøll. However, while playing the prioritisation game, the number of barriers changed in line with the knowledge gained in the process and it was possible to reduce the barriers from 15 barriers to 12 barriers. The prioritisation game showed 4 key barriers within Rambøll.

(Own picture)

6.1 The overall network

The network exists of both human and non-human actors who play a significant part, as "*the role played by the nonhumans in the social order as being as significant as the role that humans play*" (Callon and Law, 1997, p.168). Looking through the lens of ANT as we map and visualise the network, we include human and nonhuman actors in the networks. Non-human actors include, for example, our project and the actors' matters of concern. A mapping of networks helps with understanding the relations between the actors.

The main human actors are identified on the basis of the construction industry, encompassing clients, client advisor, architects, engineers and contractors. Throughout the report the five main human actors are seen as the common actors of construction. Rambøll employees are the actors who we see as being necessary to enroll, and Statens Byggeforskningsinstitut (SBi) and RIB are actors in the network who we have interviewed and gained useful knowledge from.

Through the research phase and the interviews, it became clear that there is a big variation in construction projects in terms of contract forms and tendering phases, which also have an impact on the relations in the actor-network. This means that the network varies according to the structure of the construction form. In figure 12 we exist as a link between the different actors of the network. Despite the differences, we chose to not only focus on one branch in the construction industry as we have identified main issues related to the industry as an entity. As the project evolves it was natural for us to focus on Rambøll.

Below follows a description of the main actors of the construction industry, their crosswise relationship as well as why and how they are part of the network. It is essential to note that the actors can be interested and enrolled at various times during the project. In addition, it is also possible for different actors to be in different moments of the translation process at the same time. E.g. when we faciliate a workshop, the participants might be interested but Gitte however, is enrolled. Furthermore, interessement devices can interest some actors while it does not function as an interessement device for others. Thus, an interessement device only functions as an interessement device if it interests its receiver. Later on, in the project this supports the development of the solution.

"if you imagine them [the actors] as a human, then the architect is the heart, the engineer is the brain and the constructor is the hands"
(Susanne, Arc, NCC).

Throughout the analysis several citations will be used and referred by the name and discipline of the interviewee.
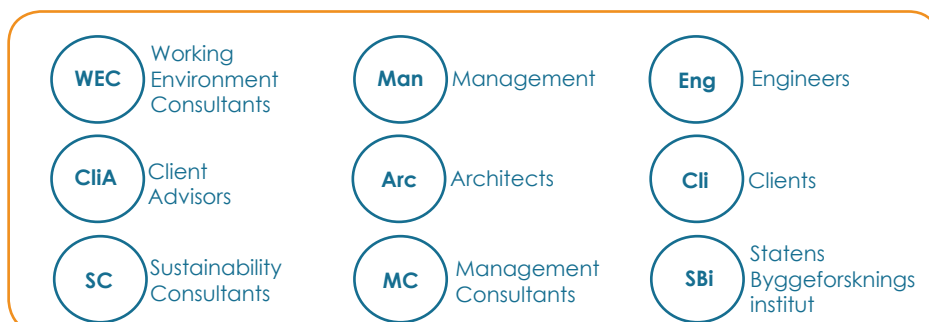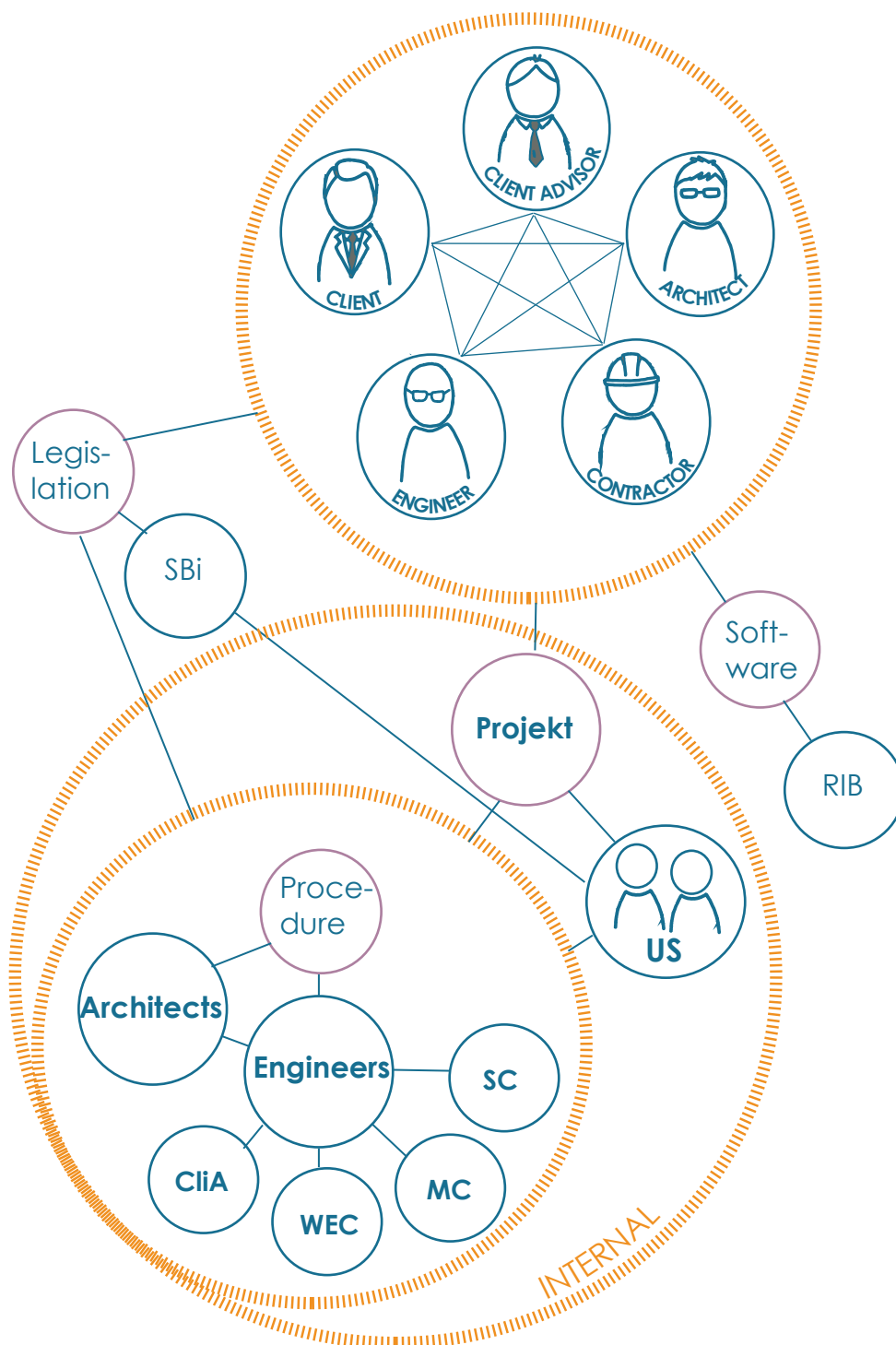
CLIENT ADVISOR

CLIENT

ARCHITECT

ENGINEER

CONTRACTOR

Legis-lation

SBi

Soft-ware

Projekt

RIB

Proce-dure

US

Architects

Engineers

SC

CliA

WEC

MC

INTERNAL

WEC	Working Environment Consultants	**Man**	Management	**Eng**	Engineers
CliA	Client Advisors	**Arc**	Architects	**Cli**	Clients
SC	Sustainability Consultants	**MC**	Management Consultants	**SBi**	Statens Byggeforsknings institut

Figure 12 - The overall network (Own illustration)

US

We, as researchers in the network, are interested in understanding the interests of the actors as well as translating a new network through our project because at the moment, there is not enough focus on circular economy in construction. Creating a new network requires a successful translation. We will do it by acting as navigators and facilitators that stage spaces in which the interviewee's matters of concern can be negotiated. Furthermore, as navigators we develop intermediary objects e.g. design games, prioritisation game, etc. that can mediate the negotiation of matters of concern. Knowledge gained from these spaces can transform and interest other actors of the network.

The Project

Our project is a non-human actor in the network. It is through our project - interviews, design games, report, prioritisation game, workshop, and our proposed solution, that the actors in the network can be interested and enrolled into a new network.

Rambøll

Several employees from Rambøll found an interest in the project because they wish to work with circular economy or sustainability "*we work with sustainability in our team*" (Andreas, SC, Rambøll). They were introduced to the project through design games which both functioned as interessement devices and intermediary objects. Their interessement will be further elaborated in the following section concerning the Rambøll network.

Client

Clients are the ones to initiate the construction and are connected to the remaining actors of the network because the clients decide the nature of the outcome of the construction and therefore are influencing and influenced by the other actors. Thus, they are a key actor to mobilize because if they decide to implement circular economy in construction, the rest of the actors of construction have to follow the client's decision.

In this project the clients are represented by Pension Danmark (a large Danish pension company) with a strong economic foundation (Pensiondanmark.com, 2018). Furthermore, insights on clients are gained from the interview and design games with actors of construction. An important insight gained from the interviews was that clients have different ideas on the importance of implementing and using circular economy in their projects. "*It is not enough to just call it green, because this is too narrow. I prefer sustainability. We think that sustainability embraces better*" (Jens, Cli, Pension Danmark). In the interview with Jens we staged the space for the interview at Pension Danmark. In the end of the interview, Jens asked us to send our report once we were finished writing it, indicating that he was interested in our project. In the interview Jens refers to economic, environmental, and specifically social resources, "*We do not support child labour and moreover the workers need to be treated well*" (Jens, Cli, Pension Danmark). The client, Pension Danmark has a large focus on sustainability in their construction projects, however not all clients have the same focus and mindset. As such clients may fall into different categories and are as such described as "*visionary green profiles. But there are also the conservative profiles*" (Laura, Eng, Rambøll). Laura frames larger clients as less likely to take sustainability into consideration as they have too many things to focus on, where economy plays an important role.

The client's matters of concern are concentrated on how constructing sustainable buildings often increases the price. Thus, in order to get the client

interested, they should understand that sustainability not necessarily result in a more expensive project. In addition, the branding value of constructing sustainable can be an interessement device in itself as to enroll the client in to a new network of implementing circular economy. The client also mentions how social factors cannot be measured economically. Moreover, it is mentioned that there is a lack of circular materials and that reused materials are often more expensive than virgin as you need to certify them.

The client draws attention to a matter of concern which has not been mentioned by any other actor, maybe due to that it mostly affects the client. This matter of concern is regarding how it is time consuming to fulfil the requirement set by the authorities, for example of incorporation of district plans.

Client advisor

The client advisor often functions as a mediator between the client and the rest of the actors in the construction industry. Hence the client advisor is important to enroll as their job is to advice the client and they can interest and convince the client to implement circular economy in future constructions projects. We found, through the interviews, that each actor has a different understanding of the client advisor's role. One of the architects describes client advisors as: "*a lawyer who thinks, 'I want to make some money on the construction' (...) In my opinion you could just remove this [client advisor] role(...) it could just as well be the client who did this himself*" (Lene, Arc, Lendager Group). Moreover, the client advisor is described as "an inspector" (Lene, Arc, Lendager Group), controlling all the other actors of construction. Several actors highlighted that the client advisor's role seemed unnecessary and therefore can be disregarded or substituted. The architect suggests replacing the client advisors with other actors such as architects. "*it is kind of the architects who are successful in putting ideas into the client head*" (Jesper, Con, Kingo Karlsen).

In the interview with the client advisor we presented knowledge which we had gained

from previous spaces. This concerned how some actors mentioned that the role of the client advisor was not an important role. The client advisor kindly refused the statements concerning the view of them having a controlling role and argued that the client advisor functions as a check-up, both with regards to the contract and if the wishes from the client are fulfilled. The client describes the client advisor as "*necessary as they ensure the quality of the construction*" (Jens, Cli, Pension Danmark).

Furthermore, the client advisor mentions that salaries can hinder the implementation of circular economy as the actors are concerned with fulfilling only the necessary requirements of the contract. "*they only want to do what is required of them and nothing more*" (Ingrid, CliA, Rambøll). Besides this, knowledge about materials, sustainability, and circular economy were mentioned as a concern by the client advisor. "*They [client and contractor] say they are constructing sustainable buildings however they do not have any knowledge about sustainability or sustainable materials*" (Ingrid, CliA, Rambøll).

Architect

Several interviews were undertaken with architects inside and outside of Rambøll. They all agreed on moving towards a green transition, though some architects focused on the environmental benefits and others on the economic advantages of portraying themselves as frontrunners of circular economy. "*Circular economy is for us a business model. It is a way to run a business (...) But we are not Messiah so for us it is a method in our business*" (Lene, Arc, Lendager Group). Another architect focused mainly on environmental correct materials, made without use of toxic compounds, in order for the materials to be part of a biological circulation or technological circulation. "*We have the biological flows, where every biological thing decomposes and becomes food (...) If we can achieve that with the technological cycle, then I really thing that we have achieved something good.*" (Inge, Arc, Aarhus Architects).

The architects can be enrolled in the network if they see a branding value of implementing circular economy. We see architects as an actor in the network who can persuade the client in implementing circular economy. E.g. in Lendager Group, working sustainable is a necessity, which is why the clients hiring Lender Group knows they must work with sustainability. "*If a client is not interested in working with circular economy or sustainability, then they should not work with us.*" (Lene, Arc, Lendager Group).

As mentioned before, some architects were concerned about the general use of poor materials used in the construction industry and mention a lack of innovation in the area of large scale use of circular materials as it is expensive to work with, "*at the moment there are no companies, which in a large scale offers reused materials*" (Inge, Arc, Aarhus Arkitekt).

Another general concern highlighted is related to problems in communication and collaboration between actors. If many actors are involved it becomes difficult to communicate with all parties. "*as an ideal attitude I think that you should solve it collectively. Diverse types of actors should be involved but I have not seen any big projects where you are determined to solve it [problems behind circular economy] (...) after all it requires money*" (Inge, Arc, Aarhus Arkitekt).

There are concerns from several architects that the engineers and contractors are included too late in the construction project. There are also concerns about a general lack of involvement of actors early in construction project, which could give better insights into how the different actors work together to solve problems before they become too big.

Engineer

The role of the engineer varies depending on type of contract and organisational setup, therefore the relations between the engineer and with other actors might change. The engineers' fields of work may include that of statics, building technology, constructional support, fire, ventilation, electricity with more (Lene, Arc, Lendager Group). Engineers are typically described by other actors in the following way: "*the engineer makes everything stabile. Well the static part (...) and details about strength*" (Annemette, WEC, Rambøll). The engineer is part of the network as they collaborate with the architects in framing the dimension of a construction. Moreover, the engineers are described as a stereotype, who clashes with the creative architects. This is further supported with statements by the architects: "*Because the architects have a feeling that they lose their creative environment when they leave their offices and have to sit and work with some zero- and one digits [non-creative and mathematical] engineers who maybe get really disturbed by those creative and dynamic architects*" (Mette, Arc, NCC). The view of the engineers being 'mathematical' in their approach, is somewhat confirmed when an engineer states the following, "*this is how we have always done it [the work] and we should continue doing it this way*" (Christine, Eng, Rambøll).

While coding interviews, we found that there is a general matter of concern about communication hindering collaboration, both interdisciplinary collaboration and collaboration among actors of the same occupation, regardless of whether they are employees of the same company or between different companies, "*Even between engineers and engineers who works in the same company, they are maybe even sitting next to each other, and are not able to communication about plumbing (...) They can't talk together*" (Mette, Arc, NCC).

Furthermore, architects have a perception that engineers often are involved too late in the construction project due to the fact that their labour is considered too expensive. There is also a belief between the architects

that if engineers were introduced earlier in the construction project, it could potentially improve collaboration in between actors.

Contractor

A relevant actor in the network is reflected in the role of the contractor, who collaborates with and influences the entire network. The contractor is in charge of completing the physical construction and affects actors in the network with their insights on materials. The choice of materials affects the perception of circular economy. The contractors are described as having a large influence in relation to the choice of materials, they often single-handedly pick and choose the materials required. It is often mentioned that they are involved too late in the construction project and should have a more significant role in the collaboration of the project. "*The contractor is normally involved too late. But we [architects] would like to e.g. talk to the demolishers so that we can begin to interrupt the value chain*" (Lene, Arc, Lendager Group). The contractor highlights the necessity to strengthen the network, collaboration and knowledge sharing between actors to improve implementation of circular economy: "*you [people] are too specialized in your discipline e.g. demolisher concentrates on one thing and the carpenter concentrates on another thing, but if you really need something circular, we can't keep thinking in this way. Then you need to know how a carpenter can reuse their materials and that, in my opinion, requires a vast knowledge sharing*" (Jesper, Con, Kingo Karlsen).

The contractor highlights some matters of concern similar to the architects' concerns, namely a lack of recycled materials and someone taking responsibility for producing sustainable materials. They think actors should be appointed as a dedicated and wise counselor team on the aforementioned topics in each construction project whose intention is to promote circular economy.

Another important concern of the contractors is related to the economic outcome of the projects. "*if there is a business in making it*

in this environmentally correct way then we will of course do it" (Jesper, Con, Kingo Karlsen). This is further supported by another contractor: "*circular [economy], I think is more about that it is a good business for the contractors*" (Susanne, Arc, NCC).

Statens Byggeforsknings institut - SBi

SBi affects the many actors in the network, as they provide construction specifications in accordance with Danish building regulations. The actor of construction is obliged to know the recommendations and can choose whether or not they want to follow them. If they choose not to follow the recommendations, they must substantiate that their choice of solution is still legal. SBi state a matter of concern related to problems with old and reused materials. The actors of the construction industry must meet present construction standards. Moreover, the reused materials must be competitive with virgin materials and cheaper international products. The main matters of concern expressed by representatives from SBi target national and international building regulations concerning, which actors should undertake the responsibility, risks and consequences of implementing circular economy, and sustainable materials.

Regulations

Laws, regulations, SBi's recommendations, is a non-human actor in the network related to the common actors of construction. If circular economy was incorporated in the regulations for constructing, it would be a necessity to construct sustainable. However, recent construction legislation hinders parts of a circular economy development, for example seen in regard to used materials which do not meet present construction legislation (Kim, SBi).

RIB

As part of the research phase, we interviewed RIB, a software company that specialises in end-to-end software as a service (SaaS) for the entire value chain in construction projects and reduce the overall cost and time consumption of the projects. They have a special focus on software to support and improve internal and external communication, collaboration, knowledge sharing, documentation (RIB, 2018). RIB is, through their software, part of the network as they are in contact with different construction companies and share their concerns with difficulties related to collaborations both within and across different companies. Through the staged space of interviews, RIB was interested in how the design game and the method behind it worked. Thus, is was more the interessement device itself that were interesting for them rather than the project.

RIB have experienced that there is a concern regarding transparency when companies use their software. "*If there is not transparency in the collaboration then it becomes problematic. Many thinks that transparency is dangerous, however, we would like to challenge that [to create more transparency]*" (Stefan, RIB). In the interview he talked about how actors see disadvantages in being transparent as it may reveal their working methods to competitors. Moreover, he believed the problem with transparency to be related to that people do not wish to change working habits, which is required if changing working methods to more transparency. However, Stefan states that being transparent can enhance the collaboration and knowledge sharing between the actors of construction (Stefan, RIB).

Software

RIB's software is a non-human actor in the overall network that can promote more transparency in the process behind construction. Hence, enhancing the collaboration between the common actors of construction.

Figure 13 represents matters of concern from several of the actors. The figure shows that the same matters of concern reoccurs among many of the actors.

In the following section we use the approach of 'zooming-in' on the network of the interviewed Rambøll employees. We ignore and black box the network behind the common actors of construction in order to focus on the network of the interviewed Rambøll employees.
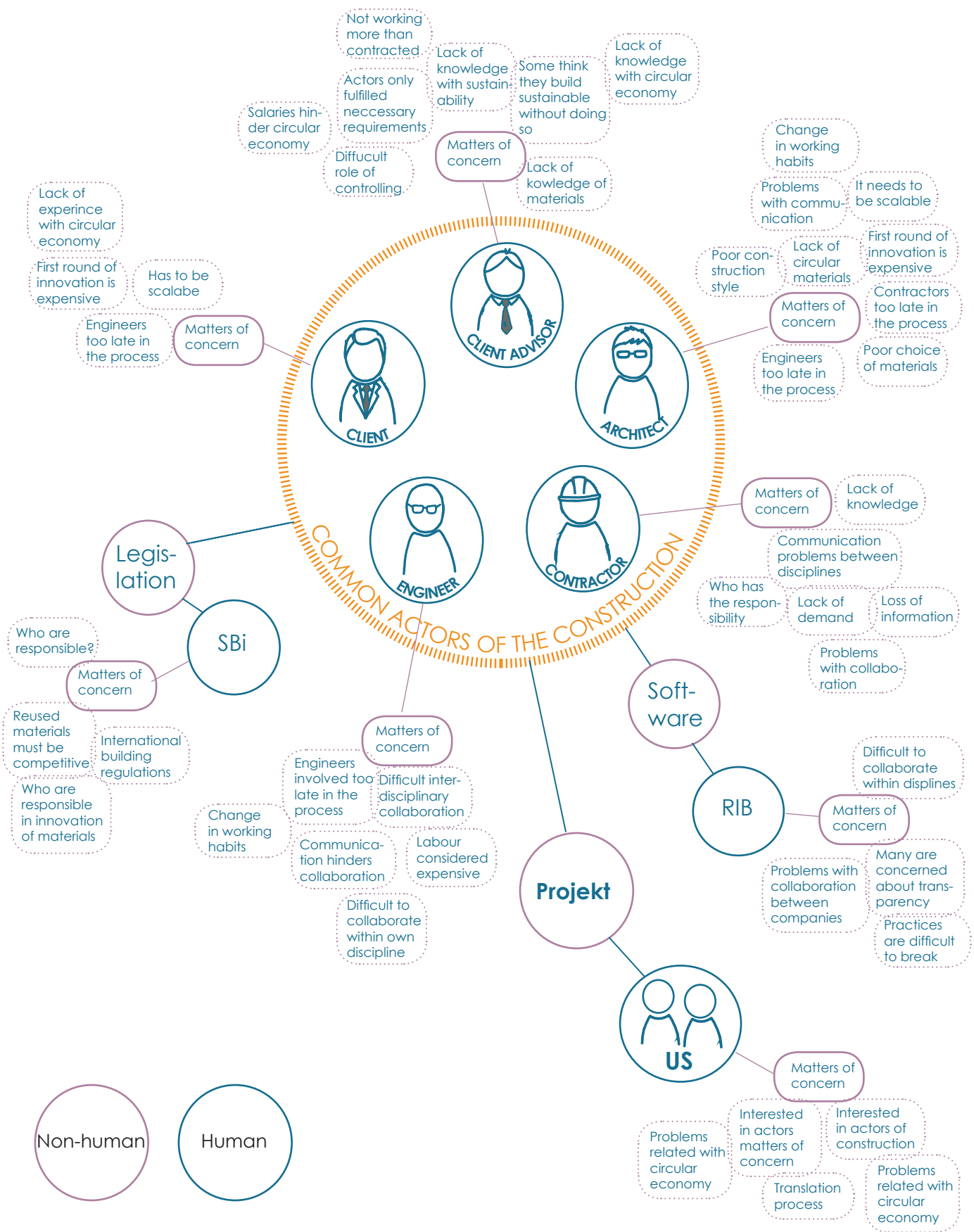
Non-human   Human

Figure 13 - Network with matters of concern (Own illustration)

Key points

- The overall actor-network consist of human actors (the common actors of the construction industry, us, SBi, Rambøll and RIB) and non-human actors (the project, regulations, software).
- Varieties in contract forms and tendering phases have an impact on relations in the actor-network.
- We are researchers in the network, acting as navigators and facilitators of the temporary spaces that are created.
- Clients initiate the construction and decides the nature of the outcome of the construction.
- The interviewed client from Pension Danmark has a sustainable focus on construction project.
- The client advisor often functions as a mediator between the client and other actors.
- The role of the client advisor is often to check if the contract and wishes from the client are fulfilled.
- An architect disregards the need of the client advisor.
- Architects have the possibility to persuade the client in implementing circular economy.
- Engineers are typically described with the view of a stereotype of being 'mathematical'.
- Engineers are often involved too late in the construction project.
- The contractor completes the physical construction and has the possibility to affect the. construction with their choice of materials, whether it should be circular or not.
- The contractor is often involved too late in the construction project.
- SBi provide construction specifications in accordance with Danish building regulations.
- Change of regulations can help promote a development towards circular economy.

6.2 Rambøll network
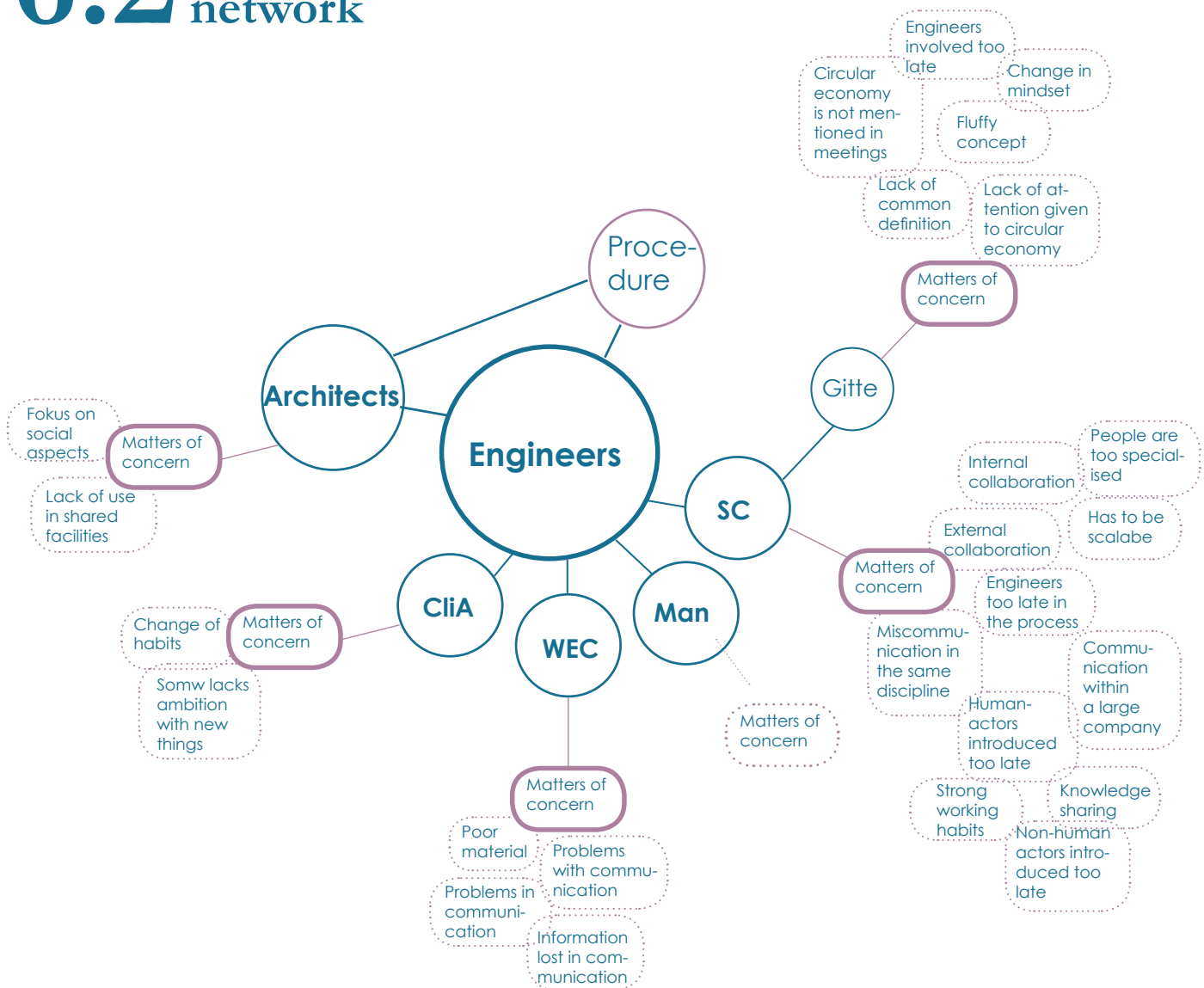
Figure 14 - Rambøll network (Own illustration)

We found the amount of matters of concern are so numerous that we need to focus on one part of the network, we are not able to embrace every matter of concern within the time limits of this project. Therefore, we focus on finding and solving problems within Rambøll. We interviewed Rambøll employees from various departments and we use their individual matters of concern to represent their respective departments.

It is important to mention that the conducted interviews were mainly conducted with Rambøll employees from RHO, Rambøll Hovedstad in Copenhagen. RHO is the largest unit in Rambøll Denmark. It is therefore important to note that some of the responses from the interviewees are concerning problems that may only exist in such a large unit and that these problems might vary depending on the size of the unit.

Rambøll Denmark have more than 3000 employees. The size of the company, and lack of overview of the employees and their discipline made it difficult to identify which employees were interesting for us to interview. As such our company supervisor in Rambøll, Gitte provided us with a list of interesting Rambøll employees to talk to. Furthermore, we searched for projects regarding circular

economy and sustainability in order to find further relevant employees connected to the cases. Unfortunately, we were not able to find any circular economy projects on their website, instead we found projects regarding sustainability. Moreover, due to the tight schedules of the employees, some were occupied elsewhere and did not have the time for interviews at the moment.

Moreover, after interviewing Rambøll employees, we used the method of 'rolling a snowball' by asking the interviewee if they knew other interesting employees for us to interview. Thereby we kept on expanding the list of interviewees until we identified the same matters of concern repeated by various interviewees.

Interviews were conducted with employees from the following; Sustainability Department, Engineers, Architects, Client Advisor and Working Environment Department. It was important to interview a broad range of Rambøll employees to develop our understanding how circular economy is perceived by each discipline.

Our interviews functioned as an interessement device to disseminate the message about circular economy and get the employees interested in our project. This was clarified as some of the interviewees asked to read our report once we were finished with it. Their interest was also shown as some of the employees mentioned a wish to get insights on how other employees responded about circular economy, because they feel a lack of mutual understanding of the concept between employees.

In the following sections, matters of concern are divided in the departments from which we interviewed employees.

Engineers

Rambøll is an engineering consultancy company, where the engineers are divided in different departments. The insights gathered from the interviews of engineers are elaborated below.

Sustainability Consultants

As a group the sustainability consultants are a key actor in the network, as they can be important spokespeople for enrolling and interesting other actors. Moreover, sustainability consultants find the topic of circular economy, important and interesting, thus they are already interested. When we staged a space of interviews using prioritisation game as interessement device, the sustainability consultants became interested in how the other sustainability consultants have prioritised. This indicates that they got interested in the prioritisation game.

In the Rambøll network Gitte is a spokesperson who can speak on the behalf of our project as we initiated the project with her.

From the interviews with the sustainability consultants they mentioned, an essential matter of concern regarding external and internal collaboration: "*A great amount of miscommunication happens. Even within your own department. People with just a little difference in their backgrounds can have difficulties in communicating. Even when they are both engineers, they talk past each other. People are so specialised in their disciplines that they have trouble understanding people with another background. People who do not have the same background have difficulties with explaining their own knowledge in a comprehensible way to others*" (Christine, SC, Rambøll).

Communication and knowledge sharing are difficult as some employees are too specialized and have strong working habits. "*it is almost a cultural thing you need to change or a practice that you should change to a different path (...) And it is very difficult*

for the individual" (Laura, SC, Rambøll).

A related concern is about how difficult communication is within a large company. It is difficult to have an overview of the various areas of specialization for all employees when the company gets too large.

Like other actors have pointed out, there is a problem with actors being introduced too late in the construction project, which both includes human and non-human actors. "*We would prefer to have certifications from the beginning, so that we can take informed design decisions, to follow along the entire process*" (Christine, SC, Rambøll). Gitte share similar matters of concern and thinks that the engineer is involved too late in the process of construction projects (Gitte, SC, Rambøll). As a non-human actor DGNB certifications and commissioning are generally introduced too late in the process.

Furthermore, several consultants highlight that circular economy is not mentioned at project meetings, which they believe is due to a lack of knowledge on the subject. This is highlighted by Gitte who states that circular economy is a "*fluffy concept*" which only few knows how to handle. "*No one dares to work with circular economy because it can be many different things*" (Gitte, SC, Rambøll). Gitte highlights a lack of a common definition of the concept and suggest on giving more attention to the concept of circular economy, in order to find better way to work with the concept. She states how it is linked to a lack of experience with the concept in the construction industry. However, this needs a change of mindset and more articulations on the subject. Moreover, she compares some of the mindsets from circular economy with the approach people had to produce 100 or 200 years ago. "*The focus is on resources*" (Gitte, SC, Rambøll) and she encourages to include design for disassembly when talking about the concept.

Working Environment Consultants

From the department of Working Environment, we interviewed an employee to gain insights in their field of work, their knowledge, and get an understanding of their focus on circular economy. As working environment consultants, they bring the social aspect into their work e.g. ensure that the employees have a proper working environment. The matter of concern outlined by the working environment consultant is regarding materials related to proper working environment, "*If you use poor materials you need to e.g. constantly repaint them, which is bad for the economy, the people performing the work and their working environment.*" (Annemette, Wec, Rambøll). Thus, they are an important actor in the network as they can ensure proper working environments when implementing circular economy in construction. In the staged space of interview, it is rather unclear if the interessement device, the design game succeeded in making her interested in our project as she did not ask for reading our report.

Furthermore, Annemette also mentions misunderstanding in communications as a matter of concern that occur between actors. She talks about how the type of contract can hinder the collaboration and instead create miscommunication between actors. "*Some information may be lost in the communication. Because the more people you include in the communication the less information will reach the correct people*" (Annemette, WEC, Rambøll). The loss of information continues to increase as information flows through more actors.

Client Advisors

Client advisors from Rambøll are actors who needs to be in the Rambøll network as they advise the client in the overall network. If client advisors gets interested and enrolled in our project, they might try to promote the circular agenda and advise clients to implement circular economy. In the staged space for the interview, the client advisor did not show any interest in our project. However, in the end of the interview we invited her to a workshop which she was willing to participate. This can indicate that she might be interested in our project or in circular economy in general.

A client advisor from Rambøll framed her matters of concern regarding habits and a need for change of these. She mentioned how habits can be more difficult to change the older you get. "*There is probably a difference between if you are an old or young engineer. The young are probably more willingly to try new things*" (Ingrid, CliA, Rambøll). This is supplied with the concern on lack of ambition to try new ways; the common way is the often just the easiest way.

Architects

Through an interview with an architect we discovered a new concern regarding circular economy, namely the social aspect. The social aspect regarding social resources has not been elaborated from other Rambøll employees before. In the interview with the architect, matters of concern are about social sustainability in common housing. The architect mentioned sharing of facilities and how this can support a circular economy development. Moreover, she compares the sharing of facilities with leasing systems: "*With circular economy and sharing economy in a residential area, this [sharing of facilities] is something that can help to create a community. Because they have a shareable laundry, then they come and wash their clothes. So, they get to meet each other and learn one another. This creates a better neighbourliness*" (Ofri, Arc, Rambøll).

It was interesting to see that the focus of the Rambøll architect was much more on social resources and shareable areas enhancing social communities, than engineers. However, her concern regarding the shareable facilities is that they are sometimes not used.

If many architects from Rambøll share similar view on circular economy it serves to highlight how different the comprehensions of the concept are between architects and engineers, as the engineers do not highlight social resources to the same extent. Thus, architects can be an actor that helps promote the social aspect of circular economy in the network.

Key points

- Sustainability consultants became interested in our project through intermediary objects.
- Gitte is spokesperson who can speak on behalf of our project.
- Non-human actors as DGNB and certifications are introduced to late in the construction process.
- There is a lack of a common definition of the concept circular economy.
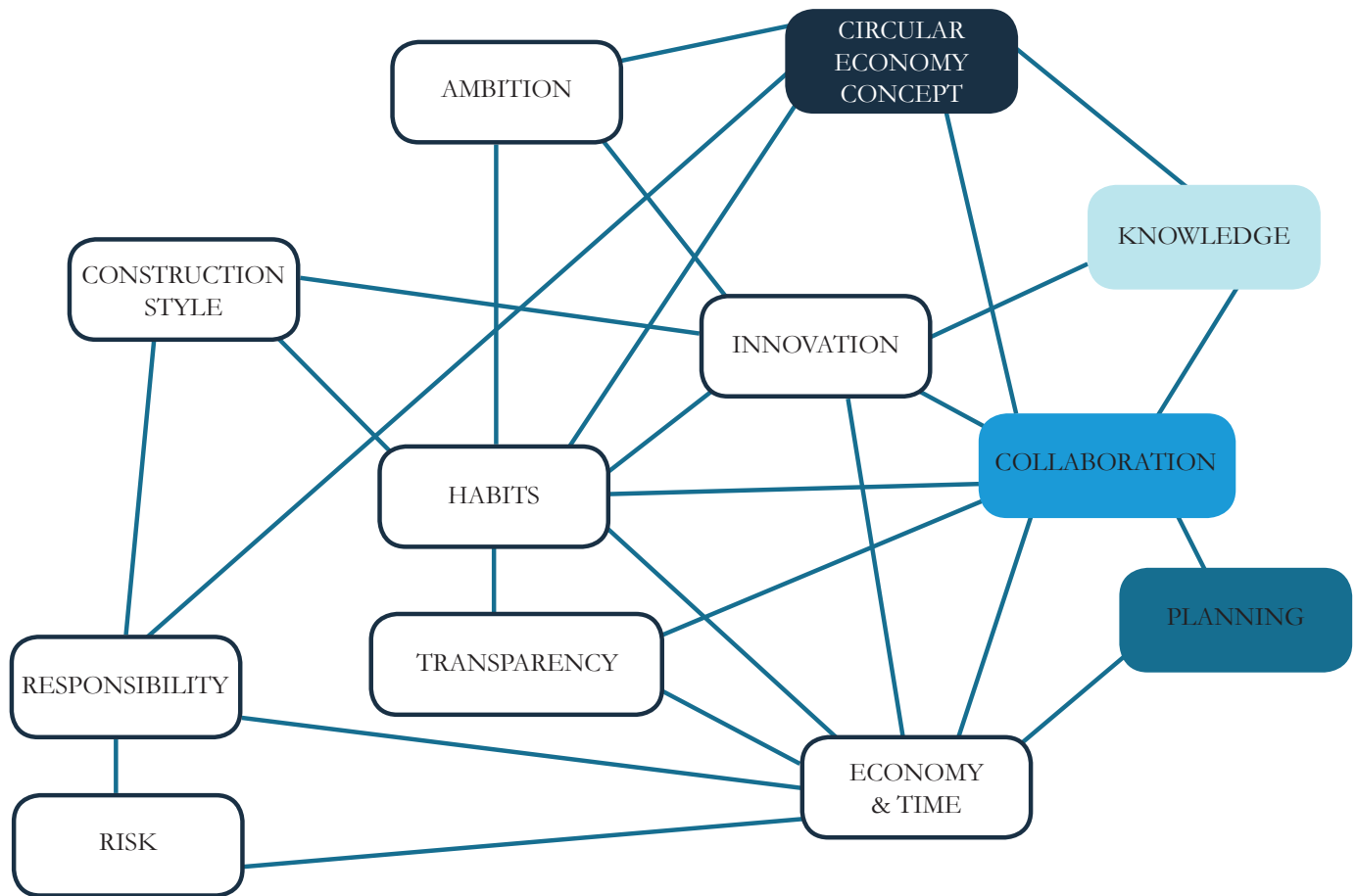
6.3 Barriers

Figure 15 - Barriers network (Own illustration)

We have mapped the network behind the barriers and their relations. The 12 barriers are strongly interrelated. Therefore, it might seem that some barriers can fit under other barriers depending on the situation (figure 15). The identified relationship between each barrier will be further elaborated below and highlighted in brackets [...]. The relation between the barriers will be elaborated in either one of the barriers referred in the brackets.

Since we have interviewed all the common actors of construction, the barriers are not solely affecting Rambøll employees. However, we have identified that the barriers are interconnected and part of a larger network deriving from the analysis of the interviewees matters of concern.

The 12 barriers

Collaboration

"*Collaboration is the key*" (Jesper, Con, Kingo Karlsen). Several interviewees find it challenging to collaborate with their colleagues due to conflicts in interests. Instead of thinking about what is best for the project, actors often think in terms of their own best interests, thus it can hinder the collaboration. This might be because of hidden agendas behind their interests "*(...) some make sure they deliver only the necessary to complete a tender, because they want to maximize their profit, it is about spending the least time as possible*" (Stefan, RIB). Hidden agendas deals with economy and time. Most actors only do what is required from them otherwise they want to be paid more, which in the end hinders the collaboration [Collaboration - Economy & Time].

Communication is essential when it comes to collaboration. It is difficult to communicate across disciplines especially in larger groups. In addition, more knowledge is lost each time is passes through a new layer and the knowledge will not be shared if the actors are not interested in collaboration. Actors may also be too specialised in their discipline, to be able to effectively communicate their knowledge with people from their own discipline as well as to other disciplines [Collaboration - Knowledge]. "*It is divided in silos. Each person only focuses on their own little box*" (Anders, RIB). Consequently, lack of communication hinders cross-disciplinary collaboration. Moreover, some actors do not want transparency and keep their knowledge for themselves [Collaboration - Transparency].

Some interviewees stated that specific working tools can hinder proper knowledge sharing e.g. excel sheets. "*excel sheets (...) is a dead file you pass on because when you want to update the excel sheet, you will have to make a new excel sheet and start over*" (Anders, RIB). It is challenging to change the fixed working methods due to strong habits and difficulties associated with changing mindsets, which leads to problems with adaptation and new ways of working [Collaboration - Habits]. Besides fixed ways of working, collaboration can be hindered by cultural differences, regions, external and internal between companies, and disciplines (Figure 16).
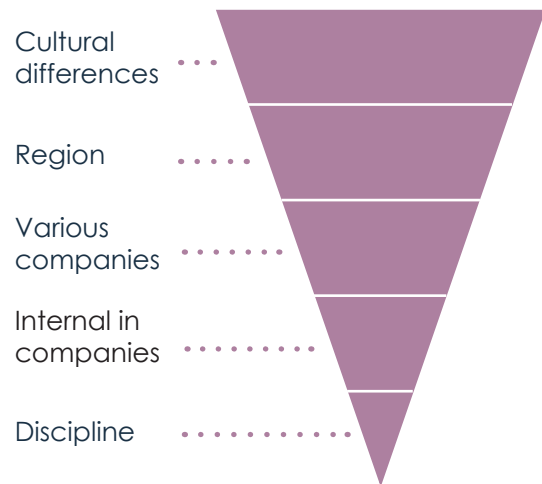

Figure 16 - Barriers for collaboration (Own illustration)

Collaboration also requires the relevant actors to be involved early in a construction project. Actors such as the contractor, users, and engineers are important to include as early as possible. Furthermore, non-human actors should be visible earlier in the phases e.g. commissioning and certification [Collaboration - Planning]. "*We prefer to incorporate certifications from the beginning in order to make good design decisions, so the certifications should follow from the design process to the construction of the building*" (Christine, SC, Rambøll).

It is difficult to collaborate in a new field as circular economy [Collaboration - Innovation]. "*It [circular economy] is so new that there is not much experience with it. Therefore, it is difficult to collaborate*" (Inge, Arc, Aarhus Arkitekter). Circular economy, as a concept, is for many a new and perplexing concept, making it difficult to collaborate as the client often often focuses on more tangible parameters [Collaboration - Circular Economy Concept]. One of the engineers mentioned how this results in circular economy not being mentioned at meetings (Laura, SC, Rambøll).

Responsibility

Some of the actors states that it is rather unclear who should take the responsibility of implementing circular economy and be the frontrunners and be innovative [Responsibility - Circular Economy Concept]. Should circular economy be implemented at a national level, meaning all the actors should embrace it, or should the responsibility be imposed upon one specific actor involved in construction e.g. the client. "*Who is it that should be the frontrunners with this [circular economy]. I do not know if you can force municipalities or pension funds to be the frontrunners. It requires a lot of money to invest and still it is very diffuse because there is no specific way to apply it*" (Laura, SC, Rambøll). There are both pros and cons when taking the responsibility of implementing circular economy. It can be a branding value and a way to promote a business, but responsibility often implies extra costs and hence actors do not want to take responsibility [Responsibility - Economy & Time]. "*Why is it that we are afraid of using new materials if you take the perspective of the contractor. Because there is the responsibility, that the building still stands and after one year the building is evaluated and you have the responsibility*" (Susanne, Con, NCC). Furthermore, lack of responsibility in a project may reduce how connected the actors are to a project.

Risk

The barrier 'risk' is connected to the barrier 'responsibility', actors want to minimize their risks and therefore disclaim their responsibility [Risk - Responsibility]. One interviewee highlighted that the client advisor is especially good at disclaiming responsibility and reducing their risk. "*By the way the client advisor does not have any risk. Those who formally take the risk is the client, architect, engineer and contractor*" (Lene, Arc, Lendager Group). Moreover, risk depends on the type of contract e.g. turnkey, general and trade, the client has chosen. By paying more, the client can give the risk to others [Risk - Economy & Time] (figure 17). For example, in turnkey contracts the client has little risk and the contractor

has a higher risk. If the client chooses general contract (s)he has a higher risk.
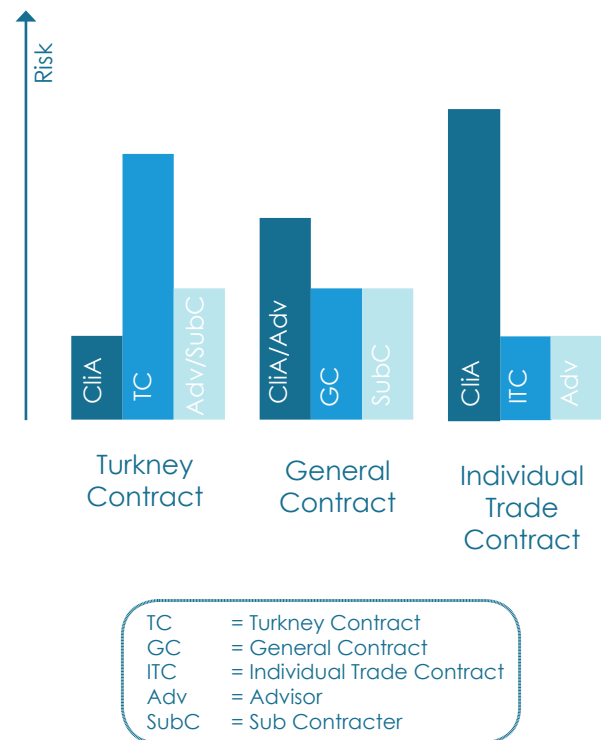

TC	= Turnkey Contract
GC	= General Contract
ITC	= Individual Trade Contract
Adv	= Advisor
SubC	= Sub Contracter

Figure 17 - Risk (Stefan Bruhn, RIB)

Planning

The planning barrier is about lack of involvement of the right human and non-human actors in the early phases of construction. A lot of interviewees stated that it is important to include the contractor in the planning phase, when implementing circular economy because the contractor possesses useful knowledge regarding demolition and recycling of materials. "*You also need to consult the contractor to see if it is even constructible. The challenge is whether they have any experience. So, it is necessary to include them because they have a lot of building-related knowledge.*" (Laura, SC, Rambøll). Non-human actors, such as commissioning and certifications can support a circular agenda if they are included in the early phases as well. Interviewees have stated that one problem is that the client believes it will be more expensive when involving more or all actors in the early phases, because the client has to pay for their time. However, Christine stated

that involving the actors in the early phases can also result in unexpected costs in the end (figure 18). Likewise, careful demolition requires extra time thus, it becomes more expensive [Planning - Economy & Time].
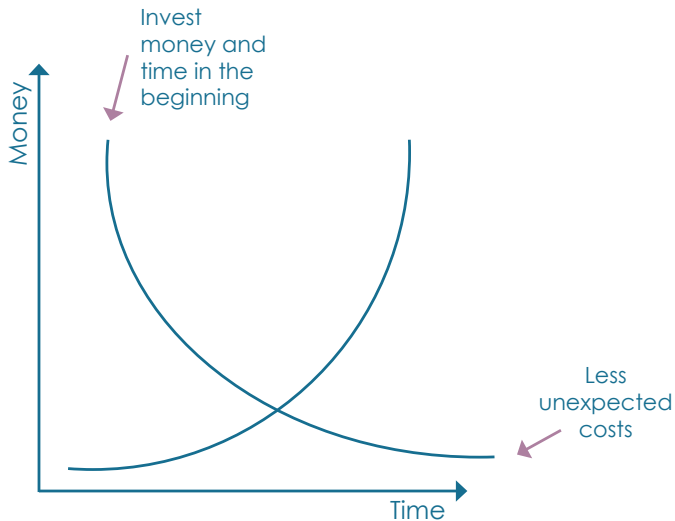

Figure 18 - Invest time and money in the begining of a project (Christine, Rambøll)

Innovation

Circular economy requires innovation and innovation requires time and money [Innovation - Economy & Time]. "*It also depends on what force of innovation is put into the work (...) in making a new product like when you have to work with upcycling as we do and get it in the regenerative loops it becomes an innovation. And the first time you make an innovation, it is more expensive*" (Lene, Arc, Lendager Group). It takes many years before actors know whether a recycled material correspond to their purpose which requires proper planning and involving the relevant actors [Innovation - Planning]. Moreover, the market for sustainable solutions are limited, resulting in fever possibilities to use circular economy materials and actors needs to realize the potential in trying new concepts [Innovation - Ambition]. Only few firms offer services and materials that are upcycled.

Habits

Some interviewees stated that the construction industry is very conservative, meaning that actors tend to construct in ways that they are used to. Old mindsets are hard to change, slowing innovation [Habits - Innovation]. "*One keeps with the usual solution, because then we know how it is to work with and we know how it should be done*" (Susanne, Con, NCC). "*You can say, if you look at the construction process, in many cases it is very traditional. That means you do the things as you always have and one of the reason for that is not so stupid. It is because you know it works and doing new things can be difficult*" (Stefan, RIB). Consequently, fixed working methods hinder the implementation of circular economy because it requires a transition in the way of thinking and working [Habits - Circular Economy Concept]. Breaking routines can be more expensive because it requires time to adapt to new processes [Habits - Economy & Time].

Ambition

Our research indicates that in the current state of the construction industry there is lack of ambition on implementing circular economy in projects and trying new methods and approaches [Ambition - Circular Economy Concept]. "*We must be aware that even though we are here and think circular economy is interesting, then how many actually thinks it is interesting and works with it (...) You have to have an ambition to do it*" (Susanne, Con, NCC). This can be a barrier because in order to change the present way of doing projects, the actors have to be open to try new and other ways of doing things. "*You just have to think in other ways and be open to do it in other ways*" (Lene, Arc, Lendager Group) [Ambition - Habits].

Economy & Time

Economy and time are two main factors in every project and these elements indirectly influence many of the other barriers. Generally, a project is bound by a budget and a specific time frame and these often influence whether there is room for implementing circular economy [Economy & Time - Circular Economy Concept]. "*You are always bound to a timeframe and economy*" (Laura, SC, Rambøll). Therefore, circular economy must be included in the program before the budget and time are set for the project. Moreover, the longer time a project takes, the more expensive it becomes the less time there is for the projects. Furthermore, expensive labour and people focusing on maximizing profits and spending less hours, can be a barrier.

Knowledge

This barrier was mentioned by almost all interviewees and relates to a general lack of knowledge of sustainable materials in the industry [Knowledge - Innovation]. Additionally, there is little experience with using circular economy, because it is a relatively new concept [Knowledge - Circular Economy Concept]. This barrier also deals with the knowledge-sharing aspect, as it is fundamental that the knowledge is shared across disciplines, so everybody can learn from it, "*the earlier you can get knowledge into play, the more value, you could argue, come into the project*" (Lene, Arc, Lendager Group). However, some interviewees also highlighted that if the knowledge must pass through many people, some of it will get lost along the way. Furthermore, people are too specialized in their discipline leaving it difficult to share their knowledge or communicate it to others. "you [people] are too specialized in your discipline e.g. demolisher concentrates on one thing and the carpenter concentrates on another thing, but if you really need something circular, we cannot keep thinking in this way. Then you need to know how a carpenter can re-use their materials and that, in my opinion, requires a vast knowledge sharing" (Jesper, Con, Kingo Karlsen) [Knowledge - Collaboration].

Transparency

This barrier deals with transparency in the working methods. Actors do not want to show others how they work because they can increase their chances of earning more. This means that they do not want to be transparent, as they are concerned that their mistakes and actual amount of hours used on certain tasks will be discovered by other actors [Transparency - Economy & Time]. In other words, they keep their cards close to their chest, and consider how they can optimize them for their individual gain. "*Then there are many who thinks transparency is dangerous (...) because if you take a big part of the risk, you also want a big part of the profit and it can be an advantage to hide how you reached the profit*" (Stefan, RIB). Additionally, the actors are not used to transparent working methods [Transparency - Habits]. This barrier can hinder the implementation of circular economy, because the actors must look beyond their own needs for the good of the project, and "*convince a person to work differently by letting go of the things he thinks is good but for the greater good*" (Anders, RIB).

Construction style

This barrier is about the way buildings are typically constructed. Many of the actors have a traditional approach to construction, where the construction methods and techniques, choices of materials stay the same for long periods of time [Construction style - Habits]. Focus is on fast construction with cheap materials and no one has taken the responsibility of the poor materials used in construction [Construction style - Responsibility]. "*historically seen, we have constructed fairly reasonable up until World War Two. After World War Two we had a period where we constructed in a bad way by constructing fast, cheap and maybe a bit poor*" (Nikolaj, Arc, Lendager Group). Moreover, previous experiences in projects are often not evaluated before a new project, making it difficult to learn from previous mistakes and therefore the actors continue constructing in the same traditional ways, "*But also, because it is construction and it is just an insanely conservative business, we do the things in one way and we know what kind of materials work*" (Susanne, Con, NCC). Introducing circular economy requires a completely new approach to construction rather than the traditional linear way [Construction style - Innovation].

Circular Economy Concept

When considering the concept of circular economy itself, there are also some challenges around the fact that the concept is seen as being quite abstract. "*it is too abstract to say that we have to think more sustainable*" (Laura, SC, Rambøll). A lot of actors do not understand what circular economy involves and what specifically should be done to implement circular economy. As for now, the concept is primarily verbalized as a combination of energy, indoor climate and waste. Therefore, discussing circular economy in other contexts is missing and needs to be investigated more, in order for the concept to disseminate successfully.

- The barriers were limited from 15 to 12.
- The barriers are highly interconnected.
- There is a lack of collaboration both across disciplines.
- It is challenging to change fixed working methods and habits.
- It is unclear who should take the responsibility of implementing circular economy.
- Some are afraid of taking more responsibility as it often implies extra costs.
- Some wants to minimize their risks and disclaiming their responsibilities.
- Many human and non-human actors are introduced to late in the construction project.
- Circular economy materials need to be innovated which requires time and money.
- Habits are hard to change which is a challenge when implementing new things, like circular economy.
- Two main factors in every project are economy and time as a project are bound by a budget and a time frame
- Many interviewees mention a lack of knowledge about sustainable materials
- Many mention a lack of knowledge-sharing, and knowledgesharing is essential in order to learn more
- Many actors in the construction industry have a traditional approach to construction methods, techniques, and materials which makes it difficult to implement circular economy
- The concept of circular economy is seen as abstract or 'fluffy'

6.4 Barriers within Rambøll

The 12 identified barriers are overall barriers regarding the different actors of construction and the different phases. However, as we wanted to work with Rambøll and are to design a solution together with them, we have chosen to focus on the barriers that are relevant for Rambøll. To understand the barriers from Rambøll's point of view, we developed a prioritisation game and made encouraged the employees to prioritise 15 barriers because the prioritisation game was developed, and some interviews carried out before we reduced the barriers to 12. It is important to note that, at this point we had already gathered a couple of results using 15 barriers in the prioritisation game and decided not to change the prioritisation game to include 12 barriers instead of 15, as we sought to make the results comparable. The prioritisation game consisted of a board with 15 numbers and 15 barrier cards with the name of the barrier and a short description of the barrier (picture 12).

The prioritisation game was played in two rounds. In the first round, they had to prioritise which barriers they thought were the biggest when implementing circular economy in Rambøll. During the second round they had to prioritise which barriers they thought would be the easiest to change within Rambøll. Throughout the design game concerning actors of construction and the phases of a construction project, we asked questions while they prioritised the barriers to understand why they prioritised as they did. The interview using prioritisation game can be seen as a space which we facilitate. The purpose of the space was to understand the barriers in relation to Rambøll. Moreover, we wanted to interest the interviewee with our findings and project. We use the prioritisation game as an interessement device in which we could mediate negotiation of the barriers. The material arrangement was in Rambøll. We brought the matters of concern from one space to another e.g. one interviewee interpreted the barrier card 'Transparency' in relation to materials. This concern was brought into the next space and challenged as we asked the interviewee how (s)he interpreted transparency. All the prioritisations of barriers were then collected and compared in a table (figure 19). Furthermore, we played the second round of the prioritisation game ourselves to compare our point of view with the employees, as we had collected a big amount of knowledge from the Rambøll interviews.

Figure 19 gives an overview of what the individual employees prioritised. The table helped us find the four key barriers with the biggest potential to change in Rambøll.

Picture 12 - Barrier cards (Own picture)

Prioritisation table

Figure 19 - Prioritisation table (Own illustration)

Prioritisation table

Figure 19 - Prioritisation table (Own illustration)

Prioritisation table

Employees in Rambøll / Barriers	Barriers SC. 1	Barriers SC. 2	Barriers SC. 3	Barriers CL.A.	Barriers SC. 4	Potential changes Us	Potential changes SC. 1	Potential changes SC. 2	Potential changes SC. 3	Potential changes CL.A.	Potential changes SC. 4
Habbits											
Collaboration											
Collaboration 2											
Time											
Knowledge											
Planning											
Economi											
Innovation											
Circular econom-concept											
Specialised											
Ambition											
Responsibility and risk											
Construction style											
Attachment											
Transparency											

Range of colour in barriers
- Biggest
- Medium
- Smallest

Range of colors of the potentials to change barriers
- Easiest
- Medium
- Most difficult

Figure 19 - Prioritisation table (Own illustration)

4 Key barriers

Knowledge

"The bigger team, the more knowledge is gained"
- Christine, SC

"It is important to be able to find the knowledge again"
- Christine, SC

"People do not know how to construct sustainable"
- Ingrid, CliA

"Knowledge on circular economy is missing, how can it be used etc."
- Laura, SC

Circular Economy Concept

"It is essential to provide specific working methods to implement circular economy"
- Christine, SC

"Some people think it is difficult to disassemble the materials, but it is possible if it is included in the early phase"
- Ingrid, CliA

"It is not incorporated in people's mindset because it is so new and fluffy"
- Laura, SC

"Right now, circular economy is verbalized as something visionary and that is all. (...) There needs to be a clear definition"
- Andreas, SC

Collaboration

"Collaboration is fundamental in order to introduce circular economy"
- Christine, SC

"There is a big potential in strengthening the collaboration, but it is very difficult"
- Christine, SC

"Collaboration between disciplines and out of Rambøll is difficult"
- Ingrid, CliA

"If the actors are too divided and it is difficult to collaborate then it can hinder circular economy"
- Laura, SC

Planning

"Actors is often involved too late in the process"
- Christine, SC

"Sustainable consultants in Rambøll is trying to get involved earlier in the process"
- Christine, SC

"Get the actors involved as early as possible"
- Ingrid, CliA

"If we are only a small part of the project, we do not know what happens with the task we hand over to another actors"
- Andreas, SC

Chapter 7

Conceptualisation
Interessement &
Enrollment
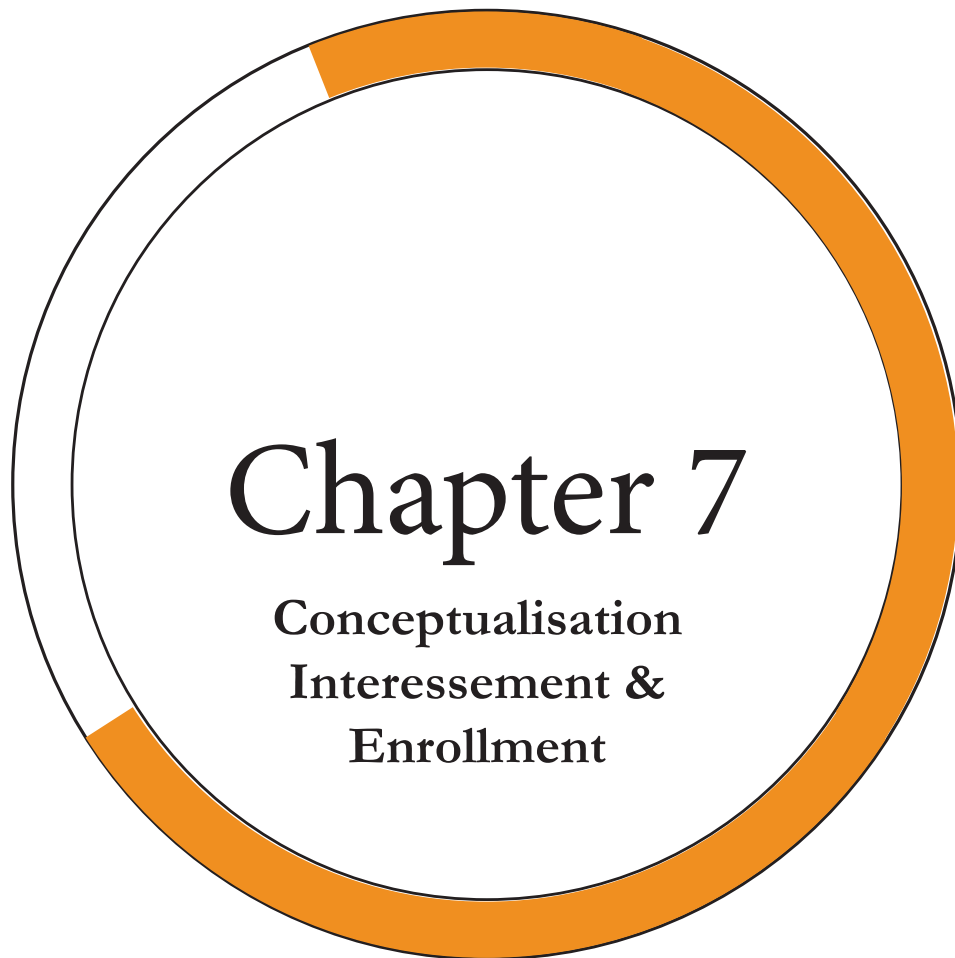
In this chapter, an overview of the conceptualisation process ranging from the design specification, idea generation, morphology chart and a workshop held with the employees of Rambøll is described. Furthermore the final solution is presented.

Process

After identifying the four key barriers, we started our conceptualisation process of the project where our intressement and enrollment phase happened (figure 20). Before starting our 'journey' of finding a solution that could suit Rambøll, we asked Gitte, to help us invite Rambøll employees to a workshop as we already experienced that they have a tight schedule. Gitte is interested in our project and can speak on our behalf in order get the other employees interested in attending our workshop. We then started our 'journey' by making a design specification that served as a framework for the solution. To get the Rambøll employees interested in our solution we find it necessary to follow the key barriers which they have prioritised themselves. We brainstormed subsolution for each of the key barriers and placed them in a morphological chart to organise the subsolution. The four barriers served as functions in the morphological chart and we combined several subsolutions from each function to four scenarios. We planned to use the scenarios as part of an exercise to evaluate the subsolutions in the scenarios and create new concepts with inspiration from the scenarios. In the workshop we gave a presentation of our project before doing exercises with the employees. Gitte got enrolled when we explained our method of using design game, as she asked us to develop a design game which she could use in a meeting with a client. Some participant at the workshop got interested in our project through the exercises of negotiating a circular economy definition and creating new concepts. Furthermore, from the workshop three concepts with subsolutions were developed. We combined several of the subsolutions from the concepts with the subsolutions in the morphological chart into one final solution.

Design specification

Ideageneration

Morphology chart

Circular Economy Concept								
Knowledge								
Planning								
Collaboration								

4 Concepts rewritten to scenarios

Concept 1

Concept 2

Concept 3

Concept 4

Evaluated at the workshop

Concept 1

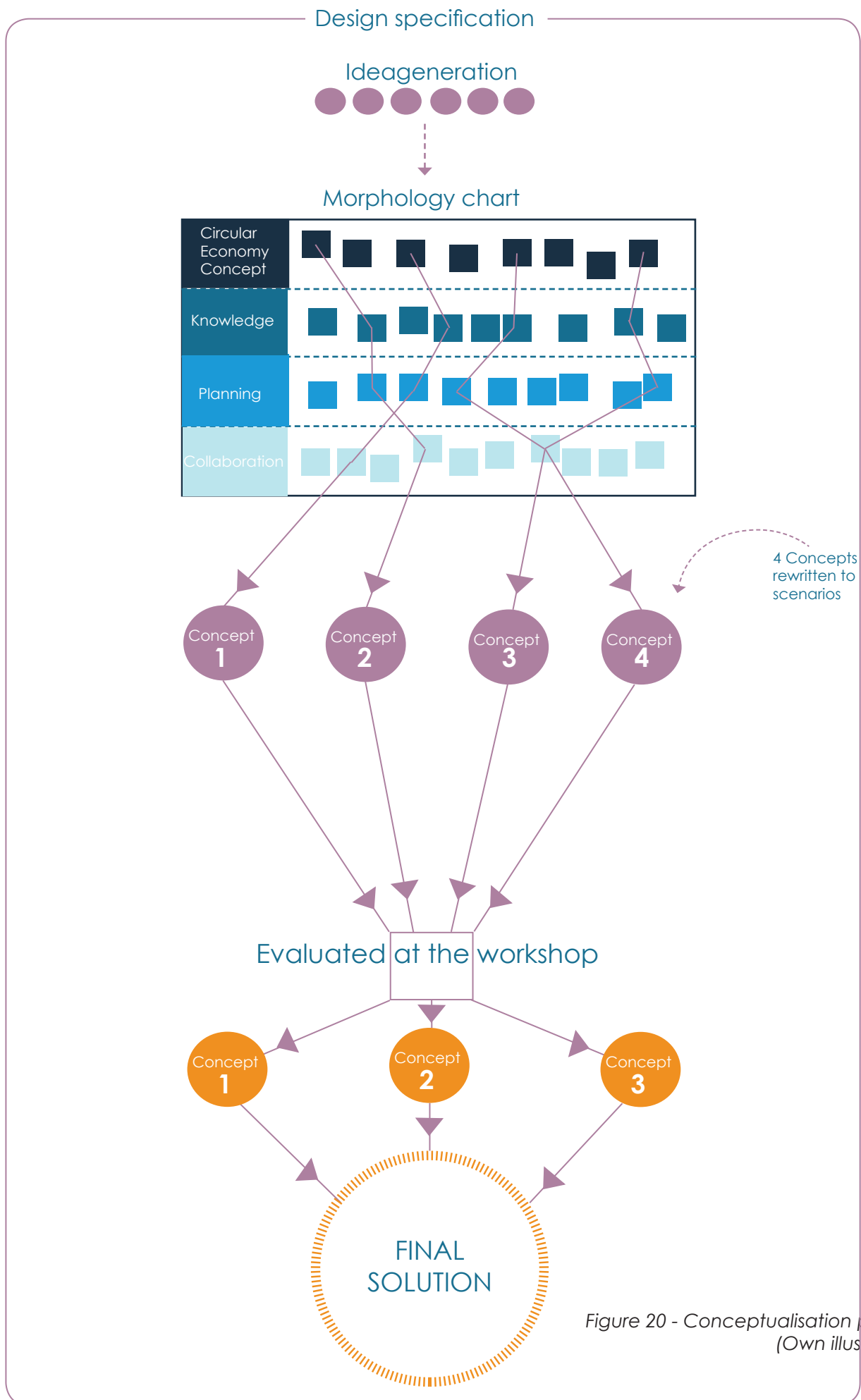Concept 2

Concept 3

FINAL SOLUTION

Figure 20 - Conceptualisation process
(Own illustration)

7.1 Design specification

We made a design specification with requirements and criterions, based on the four key barriers that hinder implementation of circular economy namely; Knowledge, Collaboration, Planning and Circular Economy Concept (figure 21). The design specification serves as a framework for the solution. All requirements must be fulfilled when designing a solution, whereas criterions and wishes are elements that is nice to have, but not necessarily has to be included. Each requirement, criteria and wish has an identification number which will be referred to in section 7.5, for the reader to get an overview of how the requirements have been fulfilled and if the criterias and wishes have been fulfilled.

Figure 21 - Design specification
(Own illustration)

7.2 Morphology and idea generation

We made a morphological chart with the four key barriers. Each barrier serves as necessary functions in the solution. Then, we started an idea generation process and brainstormed on ideas for each function. We sat a timer for two minutes and started writing ideas on post-its for the first key barrier. When the time has passed we moved on generating ideas for the next key barrier. These idea where then organized in a morphological chart (figure 22). Some ideas originates from proposals of subsolutions to a barrier given by the interviewees in the conducted interviews, the rest of the ideas were created by us. The ideas were then collected and combined into four concepts as we wished to keep focus on the key barriers. The intention of creating four concept was to use it in a later workshop where we stage the space by using the concept as intermediary objects. The aim of these concept was for them to be negotiated and evaluated by the participants. These concepts acts as scenarios in a workshop we stage as a space. The aim of the scenarios was to present the participants to intermediary objects, which we hoped would be negotiated (Section 7.4).

Theme	1. Requirement (need to have)	2. Criteria (nice to have)	3. Wishes (nice to have)

A. Knowledge	- Experiences with circular economy must be shared within Rambøll. (A1.1)
	
	- Experiences from previous projects must be shared within Rambøll concerning circular economy. (A1.2)
	
	- Education about circular economy must be offered to relevant disciplines. (A1.3)
	
	- The solution must contribute to knowledge. sharing within Rambøll (A1.4)
		- Employee's working hours can be dedicated to:
		  - networking
		  - education
		  - workshops
		  - working with other professional interests. (A2.1)
			- The employees who are interested in sustainability can have the opportunity to participate in courses concerning circular economy. (A3.1)

B. Collaboration	- The solution must be able to accommodate many disciplines. (B1.1) - The solution should provide opportunities to communicate across disciplines. (B1.2)	- The solution can contribute to a strengthened working environment. (B2.1)	- The employees are offered different cooperation techniques. (B3.1) - The interests of the project might be weighted higher than the interests of the individual department. (B3.2) - Teams can be mixed across disciplines and departments. (B3.3) - The employees can work cross disciplinary. (B3.4)
C. Planning	- All relevant disciplines must be included early in the process. (C1.1)	- Non-human actors can support circular economy in the early phases. (C2.1)	
D. Circular Ecnonmy Concept	- There must be a mutual understanding of the concept of circular economy within Rambøll. (D1.1)	- Circular economy can be challenged and verbalized to a higher degree, not only dealing with materials, energy and indoor climate. (D2.1)	

Categories	Subsolutions
A. Knowledge	Educate employees to promote circular economy • Transparent software for knowledge sharing • Provide a catalogue with an overview of sustainable materials • Lecture or education • Knowledge sharing through screens in the canteen • Database with an overview of sustainable materials • Database with an overview of sustainable materials • Weekly meetings • Online forums • Knowledge sharing through screens in the canteen • External speakers educating employees
B. Collaboration	Joint design *Samrojektering, employees working together in the same room in the design phase • Room devoted for collaboration • Cross disciplinary collaboration • Good experiences and successful stories should be shared • Open offices • Top-down approach • Full days allocated to collaboration • Matching the correct employees for each team • Teambuilding • Switching workstations • Speed dating, discover the others competences
C. Planning	Involve contractor early as they have material knowledge • Online database providing overview of disciplines and what projects the employees are part of • Involving LCA in the early phases • All actors should be involved in the design phase • Certifications are incorporated in Rambøll procedure • Commissioning and certification should be incorporated in the early phases • Sustainable consultants becomes a specialist team • Workshops that unify employees • If a cost of a project exceeds a certain amount, an advisory board with relevant competences is attached to the project • Sustainable consultants should be involved early
D. Circular Ecnonmy Concept	Create a common definition of circular economy • Find employees that will promote circular economy • Provide the employees with concrete methods for implementing circular economy • Certification to make the concept more relatable and tangible • Provide the employees with concrete methods for implementing circular economy • Physical posters about circular economy • Newspaper about circular economy projects and materials • Show TED Talk on circular economy

Figure 21 - Morphology chart (Own illustration)

7.3 Concepts

We saw a relation between the four key barriers; Knowledge, Collaboration, Planning and Circular Economy Concept and decided to merge them into two; Knowledge and Collaboration, in order to make it more manageable and less confusing for the participants in the workshop. Planning can fall under the category of Collaboration and Circular Economy Concept can fall under the category of Knowledge. Thus, the concepts originated from the two categories. We made four concepts mixing several ideas from each of the functions. These were planned to be part of an exercise in a workshop we held with Rambøll employees. The concepts were framed as extreme scenarios with the purpose of challenging, provoke and invite the participants to think creatively. We made sure to include familiar elements from the Rambøll environments so it was easier to relate to the scenarios even though they were extreme. Moreover, the scenarios were written as a letter from either the management (top-down approach) or employees (bottom-up approach). It was relevant for us to get the four concepts evaluated by Rambøll employees because the solution is intended for them. By having them evaluating and generating new concepts gives us the possibility to design our final solution based on their ideas.

Scenario 1 Knowledge

Dear Rambøller,
In the management team, we have decided that everyone needs to be educated in circular economy, regardless of what you are currently working with. This course will be held every Saturday over the next 6 months. You will be tested after the course ends and there are prizes to those of you who best incorporates circular economy in future projects. Moreover, we are working on a online platform where all future communication between employees must take place. You are no longer allowed to talk to each other because we are trying to create a more transparent working process. Furthermore a RamBlog will be created, which is a weekly newspaper focused on circular economy and successful stories about the concept. The stories will be printed as posters in every office. The editorial staff of RamBlog are responsible for making a catalogue with the newest sustainable materials and you are only allowed to advise about these materials in the future.

We are looking forward to your written input. Thanks for your understanding.

Scenario 2 Knowledge

Dear Management team,
We have for some time been noticing that the screens in the canteen have not been used. Therefore, we suggest that whenever the screens are not used for other purposes, TED Talks and other informations about circular economy should be shown on the screens. Furthermore, we will have meetings every Thursday at 8am, where international researchers gives lectures, to provide more knowledge on the subject. We think that, it is such a good idea that it should be incorporated in Rambøll's procedure to create a better internally understanding of circular economy.

We hope that you will help us gain more knowledge on circular economy.

Scenario 3 Collaboration

Dear Rambøller,
In the management team we have decided that all employees should be sitting in one big open office to enhance the collaboration between you. Every hour you must switch seats with the colleague to the left and continuing their tasks. Every Friday an obligatory workshop will be held with the focus on current projects in Rambøll. In the end of the day there will be team building exercises out in the nature. Furthermore, it is required that in every project must be included a holistic approach to collaboration so every discipline is involved.

We look forward to your inputs on how the collaboration can be strengthened.

Scenario 4 Collaboration

Dear management team,
We feel that the collaboration between the employees should be strengthened. We do not know who sits in the office next to us or what they are working with in the department above. Therefore we suggest speed-dating in the canteen where every employee should present themselves and their competences for the rest of Rambøll before starting a project. Moreover, we suggest an establishment of 'RamBølle of the month', which is an employee who can contribute with unique competences in every project. In the future we only want to follow Platin certification guidelines and request that every employee have the competences to do so.

We are looking forward for your response on our request for a stronger collaboration.

7.4 Workshop at Rambøll

We arranged a workshop based on a participatory approach in Rambøll in order to interest the employees in circular economy and to challenge our knowledge achieved from the previously interviews. A participatory approach towards workshop meant that we could collaborate on designing a final solution by presenting our subsolutions as scenarios to get the employees to evaluate, negotiate and design new concepts. Taking on an ANT approach of the design process it is necessary for a successful translation process to get the actors interested and enrolled. The workshop aimed at interesting employees in the project if they were not interested from previous interviews. We hope to get more employees interested and enrolled through the workshop. It is arguable that only employees interested in the subject attended the workshop. Rambøll employees from different departments of Denmark were invited to discuss circular economy and address it from different perspectives. 10 Rambøll employees participated from departments of Management Consultancy, Sustainability Consultancy, Environment and Health, Client Advisor and Architects. We staged a space for the workshop located in Rambøll RHO, and made a program for the day with a combination of presentations and activities (Worksheet 15). We chose to stage the space by using several intermediary objects such as inspirational cards of circular economy and the aforementioned four scenarios in order to; share our findings throughout the project, explore the concept of circular economy, and further develop the concepts. In the space, the employees could negotiate their interpretation of circular economy definition in groups. Moreover they could negotiate the subsolutions from the scenarios in order to create their own concept. The exercises in the workshop can be seen as several sessions in the space of workshop. Each of these sessions have a purpose which can contribute to the overall goal for the workshop namely to get the employees interested or enrolled in our project. We staged the sessions in such a way that the employees incrementally gained more knowledge about circular economy. Thus, the workshop started with the participants presenting themselves and their knowledge about circular economy. The intention of the presentations was for us to get an overview of how familiar they were of the concept, and to introduce the employees to each other, it they did not already know one another. Then, Gitte presented the basics of circular economy and how it had been used in former Rambøll projects. This gave an insight into how circular economy can be approached in the construction environment. We followed with a presentation on our project, how we approached it, and the identified four barriers of the construction industry and in Rambøll to set the programme for the day. Then, we proceeded to the first session in the space called Weighting, which was intended to prepare the employees for collaboration and giving them insights into the benefits of working together even though they come from various disciplines (Read Weighting). We then proceeded to the next session called speed definition. Based on the knowledge they gained from Gitte's presentation, our presentation, as well as the weighting exercise, they collaborated in groups on making a definition of circular economy within Rambøll (Read Speed definition). When they in groups have negotiated and established a common understanding of circular economy from session two, they had a better foundation of evaluating the subsolution in the last session called Scenarios (Read Scenarios). These scenarios were as well negotiated with the other participants of the workshop, which resulted in elaborations of some of the subsolutions as well as several of the participants agreeing on subsolution to be relevant for Rambøll.

Weighting

The first exercise we planned was named Weighting. The purpose was to activate the participants and give them energy as they had been sitting and listening to the presentations. The aim was to get the participants to understand how different and alike they are and how different competences can be useful. Two conflicting statements were presented and the participant should move towards the site of the room (left or right) accordingly to which statement they agreed with the most. (Worksheet 15). This was repeated a few times which resulted in a flow of movement between the two sites of the room.

From this exercise we learned among other things that the participant are interested in knowing more about circular economy despite the fact that most of them have been in contact with the concept before. Furthermore they agreed on the collaboration between employees needed to be strengthened.

Speed definition

The purpose of the next exercise was to create a discussion of circular economy definitions as we have identified a missing unified definition and understanding from the Rambøll employees we have interviewed. Prior to the exercise we prepared 10 cards with different understandings of circular economy from different employees. The intention of the cards was to inspire and to initiate the discussion. The participants were divided into three teams with different disciplines in each. The teams were given pens and cards where they could write their definition of circular economy, which they then elaborated on to the other groups.

It was interesting to observe how all the three teams spontaneously arranged the small inspiration cards into a sequence of how they perceive the concept and that the result was three different sequences. This indicated how the approach to circular economy differed between the groups, however they also agreed on some aspects of the concept. It also points to that the participants used the cards as intermediary object from which they could negotiate their perceptions.

The result of this exercise provided us with three definitions of circular economy which we comprised into a common definition for Rambøll:

Sustainable circular business model

Circular economy is in Rambøll viewed as an economical and cost-effective method of thinking sustainability through business models while benefiting environmental and social aspects. Vi need to change our take-make-dispose culture and instead protect the resources we already have. We have to change our mindset as a paradigm shift is necessary to break with the modern consumption patterns. Instead reuse and recycling are viewed as a resource which can be supported with the following methods:

Slowing: Repair, Leasing, Designing a longer lifetime for the product.

Narrowing: Redesign, Design with fever resources per product

Closing: Reuse (and Upcycle), Recycle, Design for disassembly and reassembly, Design for biodegradability in the biological circulation.

We assembled their definitions into one:

"Circular economy is an approach that breaks with the linear economy approach where we incorporate the social and the physical resources through a (sustainable) business approach. This can be accomplished by slowing, narrowing and closing of resource loops"

Scenarios

The last exercise was based on the four concepts derived from the four key barriers - Knowledge, Collaboration, Planning and Circular Economy Concept. The four key barriers was compiled into two main themes of Knowledge and Collaboration as they have some parable aspects. They were then described as four scenarios, two in the category of Knowledge and two in the category of Collaboration. The scenarios are described in section 7.3. The participants were divided into the same three groups, two of the group were given the scenarios of Knowledge and one was given the scenarios of Collaboration.

The aim of the exercise was for the participants to create a realistic scenario for implementing circular economy in Rambøll. They had the possibility to be inspired or provoked from the scenarios. The outcome of the exercise are viewed below.

7.4.1 The proposed concepts from each group

Group 1 - Knowledge

This concept is based on the 'learning how to learn' approach. In order to do so, informal meetings will be organized so the employees can talk with other employees from other departments about their experiences in the different projects. Moreover, you can use the screens in the canteen to disseminate the message on circular economy. RamTalks that functions as TED Talks can be used to educate the employees without them spending more hours. The team leaders or someone from the staff needs to be educated in using circular economy. The experiences with circular economy must be shared internally through a manageable platform because the current platforms e.g, JAMA and Rambla are too confusing and needs to be optimised. Knowledge sharing

within Rambøll is essential. Additionally, there should be held info meetings every quarter, reviewing the good and the bad elements from every projects. It is important that it becomes an integrated process so you do not make the same mistake twice.

Group 2 - Knowledge

In Rambøll there should only be one platform for internal communication and knowledge sharing which promotes transparency in working processes. Moreover screens showing the positive messages on circular economy should be placed near coffee stations. The messages should be digital and not analogue so it is easy to update. Furthermore, a RamCast similar to a podcast should be created so the employees can listen to the topics they find interesting when they commute. Finally, there should be created a digital catalogue of sustainable materials that are regularly updated.

Group 3 - Collaboration

An advisory board should be established to help promote collaboration across disciplines. Rambøll is a resource house, therefore a mapping of all employees and their competences, should be created. Additionally it should contain a mapping of sustainability agents. The employees should be nudged to use circular economy tools in BIM models (Bygnings Informations Modellering). Moreover, sustainability should be part of the 'Rambøll procedure'. The employees should be educated in circular economy and Rambøll should have a common definition of circular economy. Finally, to create a better collaboration, and get the employees to meet each other across disciplines and departments, 10% of the working hours should be allocated to innovation, networking and workshops. In addition the chargeability level needs to change so the employees do not have to register their working hours.

7.5 Enrollment after workshop

Through the workshop Gitte was successfully enrolled which she indicated when asking for our game pieces and insights to use our design game in a new context. This proves that she felt that we had supplied her with enough knowledge for her to interest other actors through the design game.

7.6 The final solution

The concepts from the three groups contained many subsolutions which we took into consideration when developing our final solution for Rambøll. We chose to combine some of the subsolutions in each concept as it is the employees who have proposed what they saw as a realistic idea. Thus, when combining their subsolutions we hope for a higher chance of interesting the employees in our solution. Moreover we looked back on our morphology chart to see if there were any subsolutions that could naturally be combined with some of the proposed subsolutions, in order not to neglect the subsolutions in the morphology chart. However, most of the subsolutions were already covered in the employees proposed subsolution, thus we added one extra besides theirs. In order to change the bigger network, we propose that Rambøll start by changing their own working methods, by enhancing knowledge sharing and the internal collaboration in order to implement circular economy. First we hope our solution can interest and enroll sustainability consultants and they can interest other employees in Rambøll. The most optimal situation would be for the management team to be enrolled in our solution so it can be implemented in 'Rambøll procedure'. If the solution is incorporated

in 'Rambøll procedure' a mobilisation has happened and the translation is successful because the employees have to follow the procedure. However, as it is still on a strategic level it is unsure whether or not a translation will happen. Nonetheless we see potentials for the solution and project to interest and enroll employees.
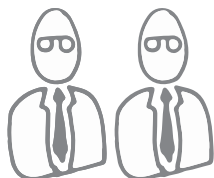
We chose the following subsolutions:

Platform

Specialist team

Circular economy Courses

Info meetings

Innovation time

Digital material catalogue
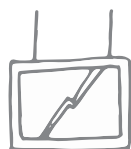
Joint design

Screens in canteen and coffee station

The solution is a combination of several ideas proposed from the groups

Group 1:
• learning how to learn approach (info meetings)
• Informal meetings where employees can talk between disciplines (info meetings)
• Screens in canteen (screens)
• RamTalks functioning as TED Talk used to educate (not implemented in solution)
• Experience with circular economy shared in a manageable platform (platform)
• Info meetings every quarter, reviewing good and bad things from project (info meetings)
• Circular economy education of the teamleder (not implemented in solution)

Group 2:
• One platform for internal communication and knowledge sharing which promotes transparency (platform)
• Screens near coffestations with positive messages of circular economy (screens)
• Digital messages (platform)
• RamCast (not implemented in solution)
• Digital catalog (digital catalog)

Group 3:

• Advisory Board to help collaboration across disciplines (specialist team)
• Mapping of all employees and competences (platform)
• Mapping of sustainability agents (platform)
• Nudged to use circular economy tools in a Bim-model (not implemented in solution)
• Sustainability should be part of Rambøll procedure (not implemented in solution)
• Education of employee in circular economy (courses of circular economy)
• Common definition of circular economy in Rambøll (framing of a common definition)
• 10 % allocated to innovation, networking, workshops (Innovation time)
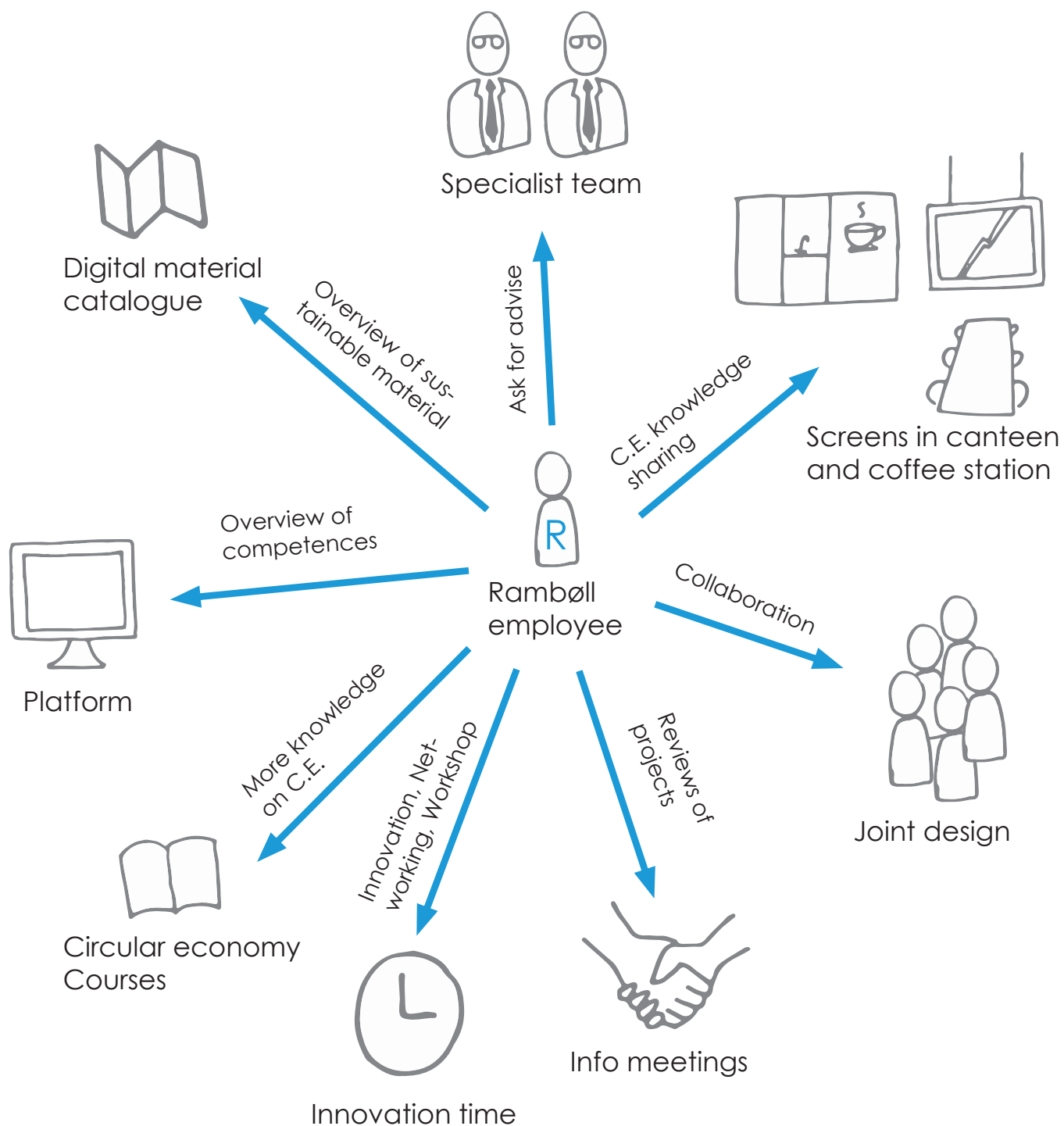• Change of chargeability level (not implemented in solution)

Presentation of solution

An overview of all Rambøll employees, their competences and which projects they are involved with is provided through a platform called RamBro (B1.1, B1.2, B3.4). The employees can access RamBro and find an employee who can assist with their competences, if they e.g. have a question for a specific topic. To make RamBro user friendly there should be a search function that makes it easier for the employees to find each other by searching for a specific word or topic. RamBro is as a communication tool where employees can message one another or participate in debate forums, which can help knowledge sharing across disciplines (A1.1, A1.2, A1.4). In RamBro there will be a specialist team dedicated to give advice on circular economy and frames a common understanding of circular economy (D1.1). The specialist team consist of sustainability consultants and other employees with experiences in using circular economy. If a project exceeds a certain amount of money the specialist team must be involved. If the project does so, it is required to use joint design, where all relevant employees are gathered and involved in the project (B3.1, B3.4). Joint design must be used in the beginning of a project to include as many disciplines as possible (B3.3). Moreover the relevant employees needs to be involved in the early phases of a project (C1.1). The employees are provided with a digital catalogue of sustainable materials through RamBro, which are continuously updated with the newest materials (C2.1). Info meetings every quarter should be held across departments, to ensure that experiences with circular economy and successful use of the concept are discussed (A1.1, A1.2). The employees should take the time to review the collaboration in each project. Moreover the employees should have X% of their working hours dedicated for Innovation Time, where they can innovate, participate in workshops and networking (A2.1, B2.1, B3.1). This could take place the following day of the Info meetings as an entire innovation day or whenever it is suitable for the individual employee. In this way the collaboration can be enhanced in the next project and create more knowledge sharing. The positive experiences with circular economy are shared across the screens in the canteen and coffee stations, which enables employees and Rambøll guest to read when they take a break (A1.1, A1.2). Every time a project ends the experiences are shown on the screens. Finally, circular economy courses held by either employees with circular economy competences or external speakers are offered to the employees (A1.3, A3.1, D2.1). These courses can be found in the RamBro platform.

The above solution is a combination of subsolutions however, it is up to Rambøll to choose whether they want to use the whole solution or pick out the subsolution they see most potential to implement. We suggest the whole solution as many of the subsolutions can support each other. We will leave it to Rambøll, to estimate how much money the project needs to exceed before the specialist team are involved as well as whom are part of the specialist team. Further development of the subsolutions; RamBro, Digital catalogue, and a Specialist team needs to be done in order to refine the solution. We suggest that RamBro can be developed in collaboration with students studying IT to get details on the platform and how this platform can support a digital catalogue of the materials. The manufacture of materials possess useful knowledge on materials and might as well be involved when designing the digital catalogue. Moreover, it is up to the sustainability consultants to find other employees with experiences in circular economy and establish a specialist team. It is necessary to promote the specialist team in order for other employees to be aware of and seek advice from them.

Furthermore our solution depends on Gitte's enrollment in the solution and if she can get other actors enrolled and mobilised as well. If Gitte manage to get the management team enrolled, our solution can become part of the Rambøll procedure which enhance the collaboration between disciplines and share the knowledge about circular economy. It can affect the overall network if the consultants can advise actors of construction in implementing circular economy. Therefore we hope by implementing our solution in Rambøll it can affect the overall network.

Specialist team

Digital material catalogue

Overview of sus-
tainable material

Ask for advise

C.E. knowledge
sharing

Screens in canteen
and coffee station

Overview of
competences

Platform

Collaboration

Rambøll
employee

More knowledge
on C.E.

Innovation, Net-
working, Workshop

Reviews of
projects

Joint design

Circular economy
Courses

Innovation time

Info meetings

Implementation guide

In order to establish the best conditions for the solution to be implemented, we have formed an implementation guide to be followed, by Gitte or other interested employees. We have identified that Gitte is already interested and enrolled in our design game, which indicates that she has the potential to be enrolled in the solution. This creates better prerequisites for the translation process to succeed and for a new network to be mobilized. If other employees wish to work with our solution, we assume that they, as well, are already interested. However as we have identified Gitte to be a spokesperson we have developed an implementation guide intended for her:

The first step for Gitte is to be enrolled in the project. Therefore it is necessary that she read the report.

The second step for Gitte is to understand the subsolutions and through a negotiation the subsolutions are evaluated on how she understand that they fit into Rambøll.

The third step is for the Gitte to get in contact with the other sustainability consultants and agree on the proposed solution (or alternatively on the subsolutions) to be implemented. It is essential for the enrollment of the sustainability agents to establish some sort of relation to the solution.

The fourth step is for the sustainability consultants (including Gitte) to agree on an approach of how to create the new network which includes getting the management team interested.

A suggestion of how to get the management interested, is by using Rambøll's own sustainability goals as an interessment device to be discussed and negotiated.

The fifth step is for the management team to be enrolled in the solution, which can happen if they agree with some of the subsolutions.

The sixth step is for the management team to establish a specialist team or decide if the sustainability team should form a specialist team.

The seventh step of the implementation is to develop the RamBro platform with an overview of the employees their disciplines, their competences, and which cases they are connected to. Before the platform can be developed it requires further investigation of how the current platforms in Rambøll works. The aim is to make one platform that contains some of the functions from their current platforms. Rambøll could e.g. collaborate with IT students in developing the RamBro platform.

The eighth step of the implementation is for a group of employees (selected by Rambøll management or the specialist team) to investigate the market of circular materials and make a digital catalogue which can be incorporated in the RamBro platform.

After the hand in of this project, the implementation guide will be negotiated in a meeting with Gitte, where it functions as an interessment device. The aim is for her to evaluate on the guide and give us feedback both in regard to the solution and in terms of the implementation guide. Furthermore, through the negotiation she will be more prepared to initiate the implementation guide.

Key points

• Design specifications, with requirements and criterions were made as a framework for the solution

• Morphology consisted of four key barriers - Knowledge, Collaboration, Planning, Circular Economy Concept

• Several subsolutions were combined and framed as scenarios which were used in a workshop

• Workshop were held to evaluate the subsolutions from the scenarios

• Three concepts were formed from the workshop

• A common definition was made through an exercise in the workshop called Speed definition

• The subsolutions from each of the concepts were combined into one solution

• The final solution consist of Platform, Specialist team, Screens in canteen and coffee stations, Info meetings, Innovation Time for Innovation or networking or workshops, Digital catalogue with sustainable materials, Courses on circular economy, Framing of a common definition of circular economy, Joint design

• An implementation guide consisting of eight steps is part of the implementation process of the solution

Chapter 8
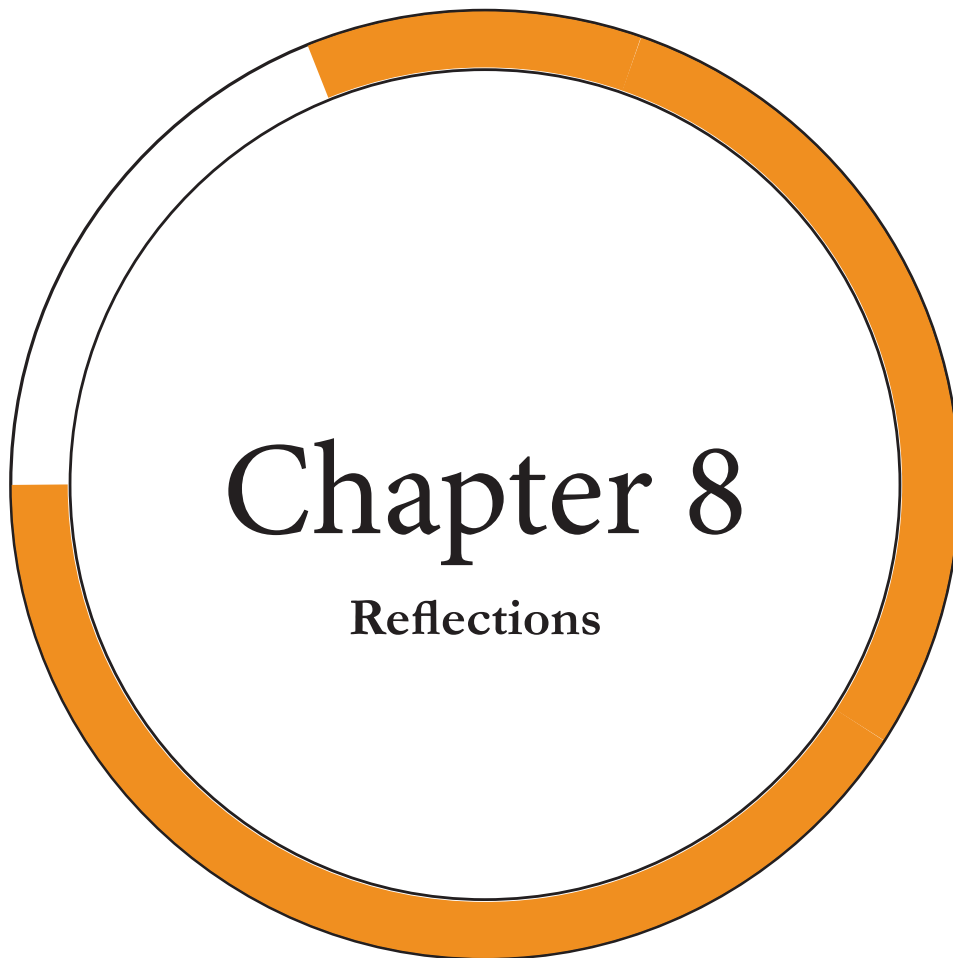
Reflections

In this chapter an overview of the reflections made during the project are described.

8.1 Circular economy perceptions

From the literature research and interviews it became clear that circular economy and sustainability often are treated synonymously. As a result it has been difficult for our interviewees to discuss circular economy without mentioning sustainability, resulting in sustainability and circular economy are used indiscriminately. However as sustainable design engineers we understand how circular economy has the potential to support a sustainable agenda. Nonetheless some associates sustainability with a cost which can have a negative impact as it adds cost to their project. We have identified that the advantages of using the term circular economy is due to the word economy, which actors understand as a potential business model. Thereby they can use the term as a means to persuade a client while having environmental and social aspects in mind. However, if sustainability and circular economy are associated, and sustainability is considered an extra expense, this view can affect how actors understand circular economy and have a negative influence on the implementation of circular economy.

8.2 Methods

The design games and prioritisation game were used as intermediary objects working as a communication tool and showed the matters of concern from the different interviewees. This provided us with new knowledge which we challenged in the next space, as we explained how some of the game pieces were perceived in the previous interview. However we did not change the design game, as we aimed to compare the answers. If the design game and prioritisation game were refined after each interview, the matters of concern might have been easier to negotiate in the next space. Moreover, some of the interviewees placed only one game piece on each number and others placed several game pieces on the same number. It is arguable whether the outcome of the prioritisation game could have been different if we were more clear on staging the space, so the participants were applied with the same rules. This made it an uneven comparison, and could potentially have influenced the prioritisation table and resulted in a different outcome of key barriers. Moreover we learned that the text on the game pieces were perceived differently, which also affected the results. Each game piece contained a short description to help clarify the headline of the game piece, but the headline was not understood the same way. E.g. the game piece with the headline 'Transparency' interpreted as transparency in relation to material, that non-sustainable materials are not transparent as it is difficult to tell what material they are made of. However, another interviewee interpreted transparency in relation to working method, that the working process should be more transparent. Furthermore one interviewee proposed changing the intermediary object (barrier cards) in the space by completely discarding the description, leaving only the headline. In doing so, it would give us a better understanding of which elements the different game pieces contain from their understanding of the barrier and leaving out our own perception. However, doing so the participants might not understand all of the proposed headlines, and thereby we would still have to assign our understandings to the headlines. Consequently, we might unintentionally leave out some important aspects behind the barrier.

Another way to stage the space of the game could have been to gather all the interviewees, who participated in the prioritisation game, and offer them the opportunity to negotiate their matters of concern with each other. Then they would negotiate upon the understandings of the game pieces, but they would possibly also have been influencing each other in their answers.

8.3 ANT

In our analysis one might argue that our visualisation of the network does not contain any non-human actors besides our project. However, as our analysis is mainly based on the branch of Actor-Network concerning matters of concern, we suggest that the identified matters of concern might as well be considered non-human actors, which can be negotiated. When negotiating these matters of concerns we let different employees, including the sustainability consultants in Rambøll, prioritize which barriers were the biggest as well as which barriers had the most potential in changing and thereby negotiate.

We could have combined the two networks, however we intentionally separated them because both of the networks were complex in themselves. Thus, we also decided to black box the common actors of construction. Even though our focus was on Rambøll, it was important to highlight that in order to implement circular economy in future construction projects, these actors must not be taken for granted. Likewise we also limited the interviews of employees in Rambøll because of their numbers in the organisation and the many different disciplines.

We chose to involve the sustainability consultants as we saw them as crucial actors who can enroll other actors in the network. Especially Gitte has the potential to change the network in a desirable direction as she is a well-known sustainability consultant among the employees. We are aiming to use Gitte as a spokesperson to speak on our behalf, as she already sees great potential in implementing circular economy as well as being able to enroll the other actors and hopefully has the potential to mobilize the network. Only then a successful translation can happen.

The method of ANT has great potentials in order to understand and establish the network. However the method are dealing with networks that often takes a lot of time to move through the four moments of translation, where the mobilization can be a comprehensive and a time-consuming process, and as a result the network sometimes work at a hypothetical level. As the spokesperson undertake the project of guiding the network and mobilize the new network, it also leads to that the navigator or researcher take a step back, and consequently does not have the opportunity to accompany the process. Moreover if the mobilization of a network becomes too prolonged, some of the interested and enrolled actors can end up losing their interest in the subject. In relation to this project, the mobilization phase can potentially happen through the spokesperson of Gitte, who has the responsibility of involving and enrolling the relevant actors. We have formed a desired guide of how this might happen, however we can not know if this is the desired way of implementing circular economy in Rambøll. Moreover we have no prerequisite to foreseen if this will take place. As such the method of ANT has the disadvantage of being somewhat hypothetical. Furthermore the notion of the implementation guide of circular economy is considered as a desired scenario and is not necessarily the approach Gitte nor the management team of Rambøll choices. Therefor it is essential to evaluate the implementation guide with Gitte, in order to create the best possible guide of implementing circular economy in Rambøll.

8.4 Collaborating with Rambøll

Through our collaboration with Rambøll employees, we were allowed to work on our project in some of their rooms, making it easier for us to communicate with the employees, which was beneficial for the project. As a natural outcome of working in Rambøll, we got to observe their working environment and how busy the employees were. Planning interviews was challenging, as it needed to fit into the employee's tight schedule. Even the workshop we held had to be planned months in advance, which is a challenging factor when collaborating with a big company. The employee's tight schedule along with the timeframe given to finish this project meant that it was not possible to interview all relevant actors in Rambøll e.g. the management team, to understand their matters of concern or their interests in the field. However, if we were able to reach the management team we might have had a chance of interesting them in our project by using interessement devices, such as their own sustainability goal as an argument to implement circular economy. By enrolling the management team and making them interested in our network they can help to implement our solution in the Rambøll procedures, making it a top-down strategy.

We see how there is a potential for this intressment and enrollment in a new network to happen through the involvement of Gitte, as we have already identified that she is enrolled in the design game. However it is questionable whether Gitte will be enrolled in our solution, as we have not yet presented the final solution to her. It is moreover questionable whether she will be enrolled in the project, though we know that she is interested in the project. For Gitte to mobilize a new network it requires that she can represent the solution without our interference.

The collaboration with Gitte, our supervisor in Rambøll, was great. She was interested in our project from the beginning and directed us to employees relevant for us to communicate with, as well as helping us gather participants for the workshop. However Gitte, as anyone else in Rambøll, was very busy and sometimes had to prioritize her time elsewhere. Nevertheless, we were always able to call her and ask for advice. As mentioned earlier it was challenging for us to reach the management team, and the focus of our project and the network are influenced by whom we were able to interview. Moreover the project might have taken another direction if we were assigned to a specific project or a specific case, which was the intention from the beginning. However the project did not move in this direction as we met some problems concerning a lack of circular economy projects within Rambøll. At one point in the process the focus changed and we hoped to be connected to any project in order to observe meetings between different actors. Due to a time limit of the project it was not possible to be included in these meetings.
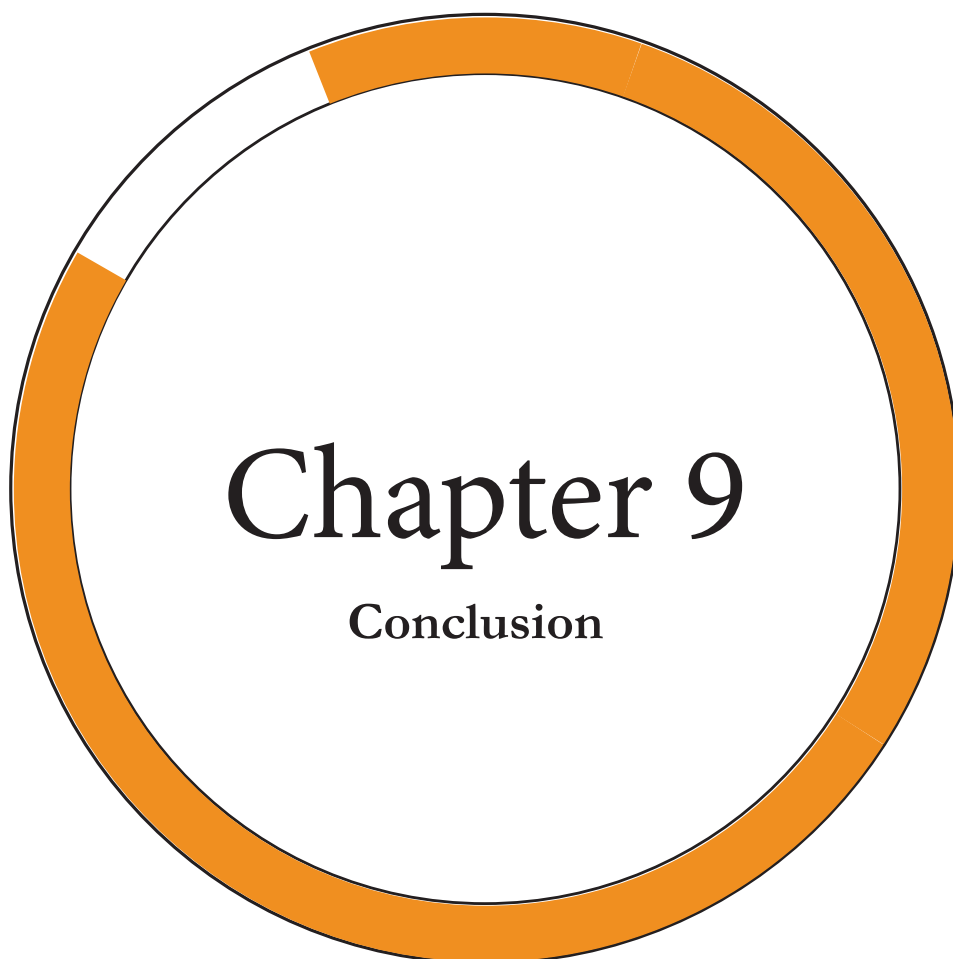
8.5 Solution

The solution is intended for Rambøll Hovedstad as it is the largest unit in Denmark where collaboration between a big amount of employees can be challenging. It is questionable whether the other units handle collaboration differently within the units, however at the workshop one employee from Rambøll Aalborg informed us that info meetings were held with the Aalborg unit each quarter, and info meetings with a smaller team were held each month. Therefore it is not unthinkable that other Rambøll units in Denmark may benefit from the same solution and improve their collaboration and knowledge sharing as well. However the structure of the info meetings needs to account for the size of the attending employees. The solution are scalable because other companies can choose to implement the whole solution adjusted to their needs or choose the subsolutions suitable for them.

It is up for discussion whether implementing the solution can have consequences for the current network, as there can be weaknesses in several of the subsolutions. E.g. the subsolution, Joint design where all relevant employees needs to be gathered and involved in the beginning of a project to include as many disciplines as possible. The weakness of this subsolution is that it can be more time consuming, hence more expensive to involve the relevant actors early in the project. On the other hand it is also arguable that more time invested in the beginning of the project results in less unexpected expenses at the end of the project (Christine, SC, Rambøll). In terms of the platform, it can have weaknesses in the form of employees not wanting to be transparent, and therefore do not want to use the platform, even though it can enhance the collaboration internally. However, in the prioritisation game the employees did not prioritise transparency as a big problem within Rambøll, and thus we do not believe that transparency presents a big part of the employees' concern within Rambøll. The weaknesses of having a specialist team is if the employees with the right competences do not want to be part of a specialist team. It is essential to note that at this moment in our design process we cannot with certainty tell if the subsolutions have more weaknesses. Moreover, it is essential to note that each subsolution requires to be further refined. Hence, there should be dedicated more time on refining the solution, some of the employees in Rambøll needs to plan in according to their tight schedule.

It is arguable whether the solution can help with implementing circular economy in the construction industry or in the overall network, as it is directed for Rambøll. However, in order to change the bigger picture, Rambøll must start within and change the way they collaborate internally as well as how they share their knowledge internally. Collaboration and knowledge sharing touch upon the social aspects in circular economy. Therefore it is arguable that we address the social aspect through our solution, which within literature appears to be a lack of as it usually concerns the economical and environmental aspects. We chose to concentrate on the social factor as this was prioritised as the barriers easiest to change in relation to implementing circular economy in Rambøll. It is interesting to see that the employees from Rambøll ranked social factors as the most potential in changing. This corresponds to the 17th Sustainable Development Goal - Partnerships for the goals, which Flemming Besenbacher (Chairman of the Government's Advisory Board) mentions as the most important, which also has a social aspect. We have identified from several interviewees how circular economy is a business strategy, however we have also identified from the prioritisation game that it is necessary to start by promoting social aspects.

Chapter 9

Conclusion

Working on a project as sustainable design engineers, the relevant problem(s) needs to be identified before a solution can be developed. Hence the goal of this project was to firstly identify the barriers in the construction industry that hinders implementation of circular economy, and secondly design a solution for our collaborative partner, Rambøll, that could promote circular economy. The initial research showed that the phases of the construction industry as well as which actors involved in the different phases could vary depending on the project. However for this project it was not essential to differentiate between the various actors as well as the phases in the construction industry, as it became clear that the same problems occurred when interviewing the various actors, inside and outside of Rambøll. These interviews were supported by a design game and a prioritisation game, that worked as an intermediary object helping with staging a space in which the actors' matters of concern were found, as well as their comprehension of circular economy. Actor-Network Theory was used to identify the network of matters of concern as well as their relations, which were categorized into 12 barriers of implementing circular economy. Four out of the 12 barriers were key barriers to Rambøll, namely Collaboration, Knowledge, Planning and Circular Economy Concept. The four key barriers were interlinked with the other identified barriers. Thus, by solving one barrier it may alleviate the other barriers. The outcome of the project is a solution to solve the key barriers. The solution contains subsolutions for implementing circular economy within Rambøll. The solution is proposed to enhance the collaboration between the employees in Rambøll as well as allowing knowledge to be shared across disciplines.

Through a workshop held with Rambøll employees it was highlighted that the workshop had provided them with a stronger internal collaboration and knowledge sharing across disciplines. Thus, it became evident that one of the proposed subsolutions, a workshop, could assist in solving the key barriers, Knowledge and Collaboration. Moreover, a common definition of circular economy within Rambøll was discussed with the participants of the workshop and defined after the workshop in order to provide the same understanding of the concept. This supports requirements for the solution, as a common and concrete definition is already established on the basis of the employees' perception of circular economy, whom participated in the workshop.

Furthermore, another aim was to get Gitte interested and enrolled in the project, and we identified her enrollment when we presented the design games because she asked to use it in another project. This shows her attachment to the project. Furthermore, the proposed solution as well as this report both have the potential in translating the network through Gitte's enrollment in the project.

We believe that the solution frames the key barriers and composes a strong response to our problem formulation which is, at this point of development, supported by enrollment of Gitte.

Chapter 10

Future work

In order for the translation process to evolve and be successful it is essential for us to enroll Gitte as a spokesperson whom will be able to mobilize the network based on the knowledge we have provided. This requires further work from her side and requires that we step back and allow the process to continue with the work from Gitte. Several meetings are arranged with Gitte after the hand in of the project in order to discuss the solution and supply her with the relevant knowledge. We believe that it is relevant for her to interest the management team as they have the ability to change the system and implement our proposed solution. Additionally, this process could either be initiated from the management team or by the employees, e.g. in the sustainability department.

After the workshop a circular economy definition for Rambøll was created which is interesting to discuss with Rambøll employee in order to maintain an interessment and examine if the employees agree with the definition. This is essential as several of the participants were highlighting a need to establish a coherent and concrete understanding of the concept in order for circular economy to expand within Rambøll.

Moreover the solution was specifically addressed to Rambøll but as we have investigated a broader area of actors in the construction industry and located matters of concern from different actors, it is relevant in the future work to focus on implementing circular economy in a network of the construction industry outside of Rambøll. This would be mutual beneficial for the expansion of circular economy. If Rambøll becomes a key actor (and frontrunners) in the field of circular economy their knowledge can help other companies to initiate the concept.

Our solution requires an external strategy and a collaboration between Rambøll and the other actors of construction to implement circular economy.

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