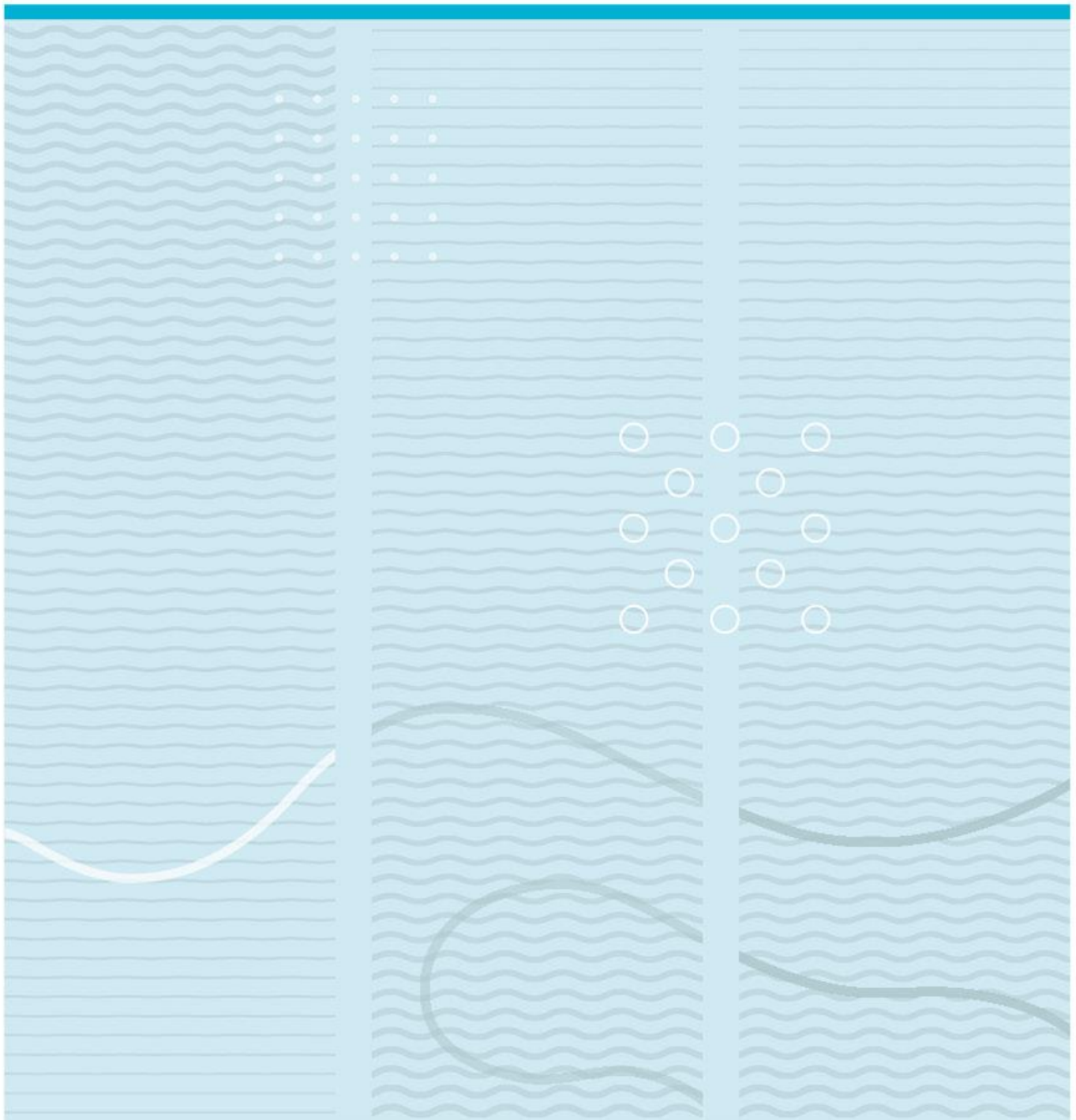


Ane Topnes & Heidi Sjulstad

Circular Economy in the Norwegian Building Sector

To what extent is circular economy adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy?



Foreword

This project marks the end of five years of higher education, the last two years with the master program Industrial management. It feels strange to hand in this study and knowing this could potentially be our last graded assignment ever. However, due to the enormous number of things we have learned during this study, we feel prepared to take the next step in to the official business world.

Studying circular economy have been challenging. From research we got the impression of uncertainties of what it entails, which was also a common factor in our findings, and we have yet to comprehend what it actually means to us. We have learned that a correct answer may not always be black and white, and realized that researchers struggles of defining such a broad concept is understandable. Yet we feel that we have a pretty good interpretation of what circular economy includes, and we hope others will do the same in the future, as this concept is still evolving.

We have gained insightful information of how a building industry works, which responsibility they have and how they have a strong will in order to take this responsibility seriously. We also felt this willingness enabled us to get this much information from our informants. In order for circular economy to become more dominant in the Norwegian building sector, we hope our study can benefit the informants, and give something back for their contributions.

There are many that have contributed to making this study a study we can be proud of. We want to thank our informants for the kindness and interest in our study. We are especially thankful for the way they opened their arms and took us in, as well as their will to share their experiences with us. We want to thank our advisor for his availability, guidance, as well as positive and constructive feedback. We also have to thank Espen Sjulstad, who gave us insightful words and helped us reaching the right people for this study.

We also want to thank our family and friends which have provided support, and a safe haven when things have been frustrating.

Kongsberg / 01.06.20

Ane Topnes & Heidi Sjulstad

Summary

With a rapidly growing population, the world requires more access to natural resources, housing, and jobs. Natural resources have been extracted and used at a high pace over the years, and access to these resources have become more limited as years pass. If humans continue the use of virgin materials at the pace they do today, the world will not be able to regenerate enough of its resources to keep up with the demand. Hence, we argued there is a need for a more sustainable way of keeping these resources in check. We found circular economy to be a countermeasure to this, as circular economy aims to utilize resources and materials more efficiently. A product in circular economy is designed to last longer and to not generate waste. By designing the product to be utilized beyond its original life cycle, one can use materials and components over again, either with the same purpose or a new purpose. A result of this would create less waste and less use of virgin materials, and a greater focus on reusing what we already have available.

We found the building sector to be fitting context for our study. Aside from the benefits the sector provides, such as jobs, housing and major contribution to the global economy, it also comes with a series of negative impacts on the world. These impacts are often related to climate and environmental challenges. As circular economy has gained more attention over the years, especially with the increased focus on sustainability, we found it interesting to see how circular economy was adapted in the building sector. The Norwegian Government reported that Norway should be a leading nation for circular economy. We also discovered that there was a low grade of implementation of circular economy in the Norwegian building sector and wanted to understand why.

Hence this study seeks to develop a deeper understanding of the phenomenon of circular economy in the Norwegian building sector. This study aims to answer; *“To what extent is circular economy being adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy?”*

By developing an understanding of why the situation is as it is, we can provide the sector with an overview of what need to be addressed in order to move further with implementation of circular economy. This study could be helpful for the building sector finding a common ground, both with circular economy and potential barriers they need to address in order to evolve and become more sustainable. As the building sector is in a more or less dominant position, successful implementation of circular economy could serve as a great inspiration for other industries.

From our theoretical framework, we discovered that circular economy was a term with vast and many definitions, as well as many surrounding concepts. On the area of implementation, the extent of research was somewhat insufficient, especially for the Norwegian building sector. The existing research were mainly focused on theoretical aspects, and there was a lack of examples on successful practical implementations. Some barriers were identified for the building sector in general in regard to implementation of circular economy. Barriers for implementation of circular economy in Norwegian building sector were an area much less researched.

When we conducted our study, we gained a lot of insightful information to supplement our theoretical findings. We found that the focus on sustainability has increased in the Norwegian building sector, mostly due to the push from EU. The focus was somewhat varied, in central areas and bigger firms the focus was clearly higher. It was clear that the wheels have started to turn in order to shift towards a more circular economy in the Norwegian building sector. We were able to gather insight on specific measures towards this transition. What we realized was that there was a great focus on reuse, which is only a small part of what circular economy actually entails. We found that circular economy requires one to see the bigger picture, also from a long-term perspective. We still feel that the building sector has a long way to go, although the initiatives are there. Yet we also believe this to be a result of the unclarity of what circular economy entails.

Currently the building sector is still in the process of trial and error, and some pilot projects have taken place. The current measures implemented is an enabler for shifting the way of thinking, and an important step in order to reflect on how things could be done differently. We found that measures ideally should be considered from an earlier stage, where design plays an essential part, and that this will result in a more long-term view, where you also could have a more holistic approach.

The main barriers we found which needs to be addressed in order to increase further implementation were divided in to five areas. These barriers were; 1. Cultural, such as knowledge and the need for supply chain collaboration. 2. Economical, such as the costs of implementation. 3. Sectoral, mainly related to reuse, where challenges regarded existing buildings, lack of efficient processes for quality assurance and testing, and time. 4. Regulatory, mainly providing challenges for reuse. 5. Market barriers in regard to lack of demand from customers and the need for a market platform in order to perform more reuse.

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Glossary

To make this study easy and understandable to read, we have used some abbreviations as described in this glossary.

BREEAM Building Research Establishment Environment Assessment Method

CE Circular Economy

NGO Non-governmental organizations

TEK Regulations on technical requirements for building works, a standard for Norwegian building products

1 Introduction

In this chapter we will describe the background and motivation for studying this phenomenon in the given context. Background and motivation are then followed by a presentation of our research question and our objectives of this study. Lastly, we will provide a disposition explaining the structure of the study we have conducted.

1.1 Background and motivation

With a rapidly growing population, the world requires more access to natural resources, housing, and jobs. Natural resources have been extracted and used at a high pace over the years, and access to these resources have become more limited as years pass. If humans continue the use of virgin materials at the pace they do today, the world will not be able to regenerate enough of its resources to keep up with the demand. The World Overshoot Day, the day where we exceed the limit of resources that can be extracted each year, comes earlier and earlier (Global Footprint Network, 2019). In 2019, this day was July 29th. In Norway, it was as early as April 18th (Global Footprint Network, 2019). Hence, we argue there is a need for a more sustainable way of keeping these resources in check.

The standard theory of economy today follows a linear model, the so-called “linear economy” (Andersen, 2007). The concept is based upon the fact that consumers buy, use and dispose of products. Whilst businesses with access to low-cost labor, energy and virgin materials can produce at low cost and high profits. Economic theory today assume that firms only aim to increase their profit (Boye, 2019, p. 35). Businesses are growing larger and larger due to economies of scale and consumers ability to purchase. Consumers desire to buy new things, make this economic model successful for businesses around the world. In this economic model, products lose value over its lifetime. The result of this is that it creates the predicament that the user should dispose of it and buy a new model later on.

Compared to linear economy, circular economy, from now on called CE, aims to utilize resources and materials more efficiently. It is widely promoted as a concept today by the EU and by several other national governments e.g. China, Japan, UK, France, the Netherlands, Canada, Sweden, and Finland (Korhonen, Honkasalo & Seppälä, 2018a). A product in CE is designed to last longer and to not generate waste. By designing the product to be utilized beyond its original life cycle, one can use materials and components over again, either with the same purpose or a new purpose. A result of this would create less waste and less use of virgin materials, and a greater focus on reusing what we already have available.

For businesses this could be done by leasing out their products to consumers or other businesses. When the product is at the end of its original life cycle, it could be disassembled and reused or upgraded to extend the cycle. An effect of this long term could be that the business cut costs by re-applying already processed materials and components, rather than procuring virgin materials. Consequently, this could decrease the rapid use and dispose rate consumers have today. In this economy, the consumer becomes a user rather than a consumer (Rowen, 2018).

As the use of natural resources is exceeding its limit compared to its natural renewal rate, it could indicate uncertainty around future access to primary resources. It may also be political regulations or conflicts making the access to certain resources difficult. As a reaction to this, industries such as the building sector, have had to think of better ways to distribute and handle their value stream inputs. An example of this is establishing access to secondary resources to gain more independency. It is therefore assumed that CE is a way of gaining competitive advantage seen from a long-term perspective (Boye, 2019).

CE is often recommended as an approach to economic growth that coincides with sustainable environmental and economic development (Korhonen et al., 2018a). Research has shown that by applying a CE approach within e.g. the European Union, it could reduce CO₂ emissions by 48% and create a net economic benefit of €1.8 trillion until 2030 (EMF, 2015). This goes to show the possible benefits of applying CE on a general basis. Even though circular business models are not financially sustainable today, they are predicted by Boye (2019) to be in the future.

Throughout this study we have come across the fact that the building sector is a potential context to explore further in regard to CE. Aside from the benefits the sector provides, such as jobs, housing and major contribution to the global economy, it also comes with a series of negative impacts on the world. These impacts are often related to climate and environmental challenges. The construction sector has been found to account for about 40-50% of the virgin material use in the world, and for 50% of landfill waste (Santamouris, 2016). As CE has gained more attention over the years, especially with the increased focus on sustainability, we found it interesting to see how CE was adapted in the building sector.

As Voltaire said; With great power comes great responsibility. As the building sector creates both opportunities and grave consequences, such as high CO₂ emission and waste. Actors in the industry have picked up on this and tried to come up with solutions and preventative measures to reduce emission and waste. One of the ideas has been adopting a more circular way of doing

business. The countries that until now that have had most success in this approach is the Netherlands (Van Buren, Demmers, Van der Heijden, & Witlox, 2016).

The Norwegian building sector accounts for 25% of all waste disposed in Norway (Statistisk Sentralbyrå, 2019). At the same time, they are also one of the industries requiring most resources such as energy and materials. However, the sector also has great potential for circular implementations (Boye, 2019). The Government reported in 2019 that they want Norway to be a leading nation in circular economy (Regjeringen, 2019). This is one of the main motivations behind the reason why we chose to look at the building sector specifically when doing a study of CE.

1.2 Research question and objectives

The previous section addressed the topic of CE, and the expedient context. For this study we seek to develop a deeper understanding of the phenomenon of circular economy in the building sector. We also discovered that there was a low grade of implementation of CE in the Norwegian building sector, and we want to understand why.

Through our preliminary studies we realized the term CE were not as straight forward as it may seem, there are vast and many definitions, which make it a challenge to really comprehend what it actually entails. We asked ourselves if this could be a reason for the lack of implementation. The fact that existing studies elaborate on all the benefits CE has to offer, we wonder if it is too good to be true. If this were plausible, one would think it would have been adapted on a far larger scale already. As the Norwegian Government claim Norway will become a leading nation in CE, we wonder why we have not heard more about it or seen more practical examples of implementation.

Hence, this study aims to research the extent CE is implemented in the Norwegian Building sector, and why more measures are not implemented today. By developing an understanding of why the situation is as it is, we can provide the sector with an overview of what need to be addressed in order to move further with implementation of CE. This study could be helpful for the building sector finding a common ground, both with CE and potential barriers they need to address in order to evolve and become more sustainable. This could again contribute to a better understanding of how to reduce the use of virgin materials and the amount of waste. As the building sector is in a more or less dominant position, successful implementation of CE could serve as a great inspiration for other industries.

Our research question is as following:

“To what extent is circular economy being adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy?”

In table 1, we have provided a summary of how we decided upon the research question. The process in question will be further elaborated in chapter 4.

Topic/Research area	Circular economy
Phenomena	Circular economy in the building sector
Problem	Low grade of implementation of CE in the building sector in Norway
Purpose	Research the extent CE is adapted in the Norwegian building sector, and determine what barriers are in the way for further adaption
Question	To what extent is circular economy adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy

Table 1: Process of determining research question

1.3 Disposition

In the following chapter, 2, we will give the reader a deeper explanation of the building sector, how they operate, which actors are involved, and which processes are included across their value chain. This will make our analysis and discussion more relatable for the reader. Chapter 3 will consist of existing research related to our research question. As we have mentioned, we did not find the current research sufficient, we therefore had to gather more data on the topic. The process of gathering this data is presented in chapter 4, including choices made in order to execute this study in the best manner. In chapter 5, we will present our findings combined with an analysis of the achieved data. To be able to use this data in order to answer our research question, we provide a discussion in chapter 6, linking the gathered data to our theoretical framework. In chapter 7 we will provide our conclusion and propose what could be further researched.

1 Building sector

To support the statements in our introduction chapter we will first present an overview of the building sector in relation to environmental impacts. Then we will present how they operate, which actors are involved, and which processes are included across their value chain. This will give the reader a better comprehension on how the dynamics are within the context and why it is of relevance to the study.

2.1 Overview of the building sector

The building sector is part of the construction industry, which is of major importance in the global economy (Santamouris, 2016, p. 61). In 2013, it was reported that 13% of the GDP came from the construction industry. The industry was the second source of employment worldwide in 2015, representing not only jobs with a direct link to the sector, but also in other industries e.g. manufacturing, wholesale and retail trade, transportation, warehousing, finance and insurance and real estate (Santamouris, 2016, p. 62).

Aside from the benefits the sector provides, it also comes with a series of negative impacts on the world, especially in regard to climate and environmental challenges. Regarding energy consumption, World Business Council on Sustainable Development reports in 2009 that the construction sector accounts for 50% of the world's demand (cited in Santamouris, 2016). Of the virgin material use, Hultgren reported in 2011 that 40-50% of the global annual material use was by the construction sector (cited in Santamouris, 2016).

When it comes to pollution, they also account for a serious amount. They account for 50% of landfill waste, 40% of the emission of greenhouse gases and emits 70% of the pollution of halocarbon. To add to this, they are also responsible for 20-24% of air pollutants and 40% of the pollution of drinking water in 2012, according to the United Nations Environment Program (cited in Santamouris, 2016, p. 62).

2.2 The Norwegian building sector

The environmental impact from the construction industry is also noticeable in Norway. In figure 1, on the following page, we show the amount of generated waste in the Norwegian building sector. In this figure we see that glass, electronic waste, plastic, discarded vehicles and paper and cardboard has had the lowest amount of generated waste ranging from lowest 2 tons to highest 27 tons. Hazardous waste has had an increase from 32 tons in 2015 to 149 tons in 2017. Mixed waste has decreased slightly. As other materials are not specified, we consider concrete and brick as the

type of material generating the most waste, at its highest in 2017 with 874 tons (Statistisk Sentralbyrå, 2019).

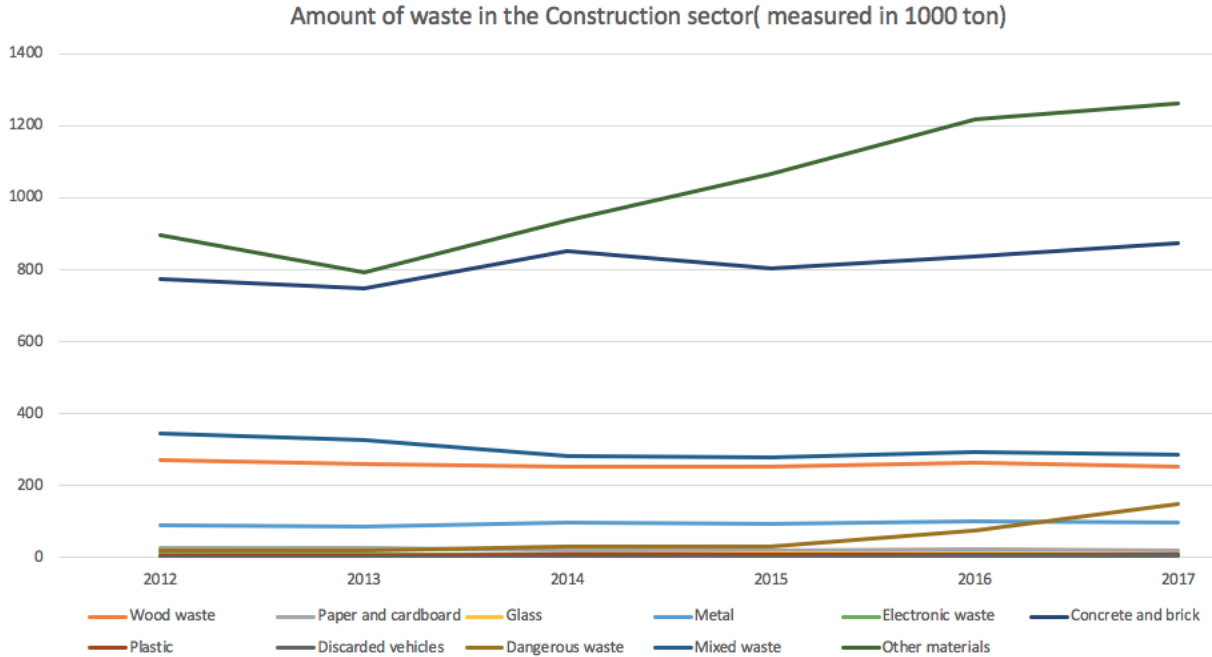


FIGURE 1: GRAPHIC ILLUSTRATION OF GENERATED WASTE IN THE NORWEGIAN CONSTRUCTION SECTOR

The generated amount of waste could be sorted into the following areas; 1. New buildings (35 %), 2. Rehabilitation (25 %) and 3. Demolition (40 %). Both new buildings and demolition has had a steady increase of generated waste. Demolition has had the largest increase at 6,2 % from 2016 to 2017 (Statistisk Sentralbyrå, 2019). Of the generated waste, 34% is recycled, 29% is used in energy recovery and 36% is disposed to landfill (Statistisk Sentralbyrå, 2019).

2.3 How they operate

We have chosen to divide the building sector into three areas, *new buildings, rehabilitation, and demolition*. Buildings may also vary from houses, commercial buildings such as offices, or governmental buildings. Our focus was intended to be on new buildings, due to the pro-active perspective, yet we came to realize most of the gathered data were in regard to rehabilitation projects.

Eikeland (2001) provided an overview of the three main types of processes in a building project, seen in Figure 2. This is based on a building project as a whole, and the value creation in order to satisfy customer requirements. The processes linked directly to development and production of the building are considered core processes. Administrative processes are needed in order to

facilitate for the core processes, and to manage and control all areas as a whole. Governmental processes are a prerequisite and necessary in order to approve the project (Eikeland, 2001, p.25).

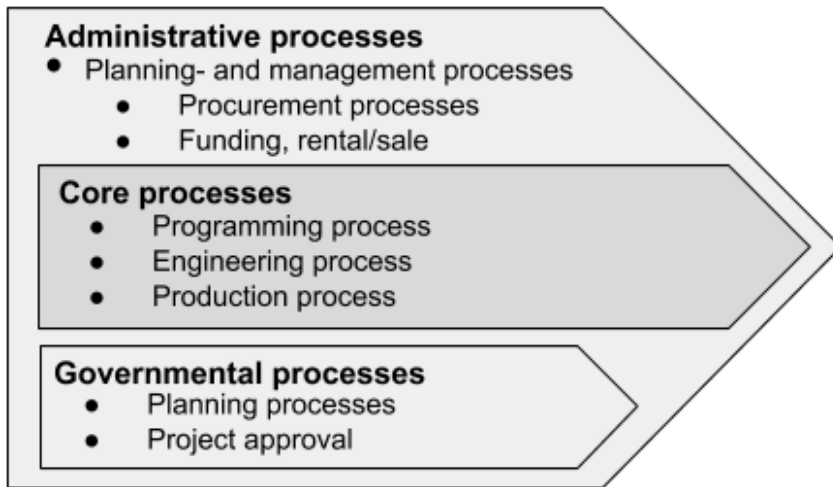


Figure 2: Adapted illustration of types of processes in a building project (Eikeland, 2001, p.25)

The next figure, 3, is a general illustration of the phases within a building project. By dividing the project into phases, one will get better overview and control, especially for the critical stages. Each phase will build a foundation for the next, and a new phase often comes with new actors and economical commitments (Eikeland, 2001, p. 34).

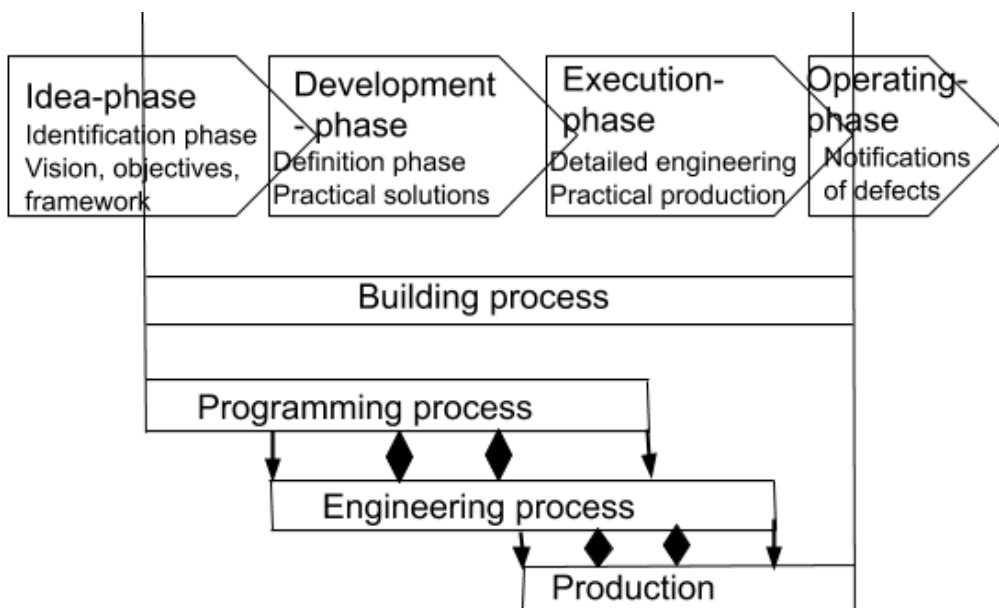


Figure 3: An adapted illustration of the phases of a building project (Eikeland, 2001, p.36)

2.4 Actors and supply chain

The building sector is very big and has several actors. These actors all play a big part in the construction of new and rehabilitated buildings all around Norway. The actors are *construction client, general contractor, producer, architect, waste firm, and authorities* and are all included in the building sector's supply chain.

Construction client is financially responsible for the building and in setting requirements for the buildings they want to develop, whilst **general contractors** are responsible for constructing the building within set requirements and cost. **Producers or suppliers** are responsible for producing the materials and products that are used inside the building and as part of the structure of the building. **Architects** are the ones responsible for sketching the building's infrastructure and designing it based upon construction clients wants (Byggenæringens Landsforening, 2019)

Waste firm is often at the end of the supply chain in most industries, as they are responsible for disposing and or recycling the waste that comes from the construction area. Lastly, we have the **authorities or government**, which are responsible for setting laws and regulation in the building process and making sure that actors within the sector follow them. These laws and regulation cover everything from planning the building, the technical requirements of materials used to the health of the workers at the building site (Byggenæringens Landsforening, 2019).

3 Theoretical framework

In the following chapter we will provide insight into existing literature on the phenomena and form a conceptual and theoretical understanding of what CE entails. Further we will address existing knowledge on implementation of CE in the building sector in general and in Norway. Lastly, we will address existing knowledge on current barriers for implementation of CE.

When developing this theoretical framework, we found it very challenging finding scientific research on the matter of implementation and barriers in the given context. We tried using keywords such as “circular economy the concept”, “circular economy in the building sector”, “circular economy in the construction sector”, “circular economy in the built environment”, “implementation of circular economy”, and “barriers for implementation of circular economy”, in scientific search engines such as Google Scholar and Oria. We experienced that there was very few hits that were relevant to our scope. This forced us to search further by looking into our sources references to provide us with the knowledge we needed. This might imply that there is a lack of knowledge and research on the matter of CE in the given context.

3.1 Circular economy

Today there is no one agreement of what the concept of CE entails, it is rather a mix of different approaches that try to describe the concept. The development of CE as a concept and its practice today has almost exclusively been done by practitioners e.g. business consultants- and foundations, policymakers and so on (Korhonen et al., 2018a). This demonstrates that there is still a lot to be explored on CE within the scientific community. Research today propose that CE has its footing within several other concepts, and that it is essentially still under development and finding its own.

3.1.1 Defining circular economy

Circular economy is a concept which have gained much popularity over recent years as a means to solve the current production and consumption model that is linear. With the increasing pressure on our natural resources and climate due to human activity, CE has been introduced as a possible savior for diminishing the pressure on the Earth. More than a concept, it is seen as an economic business model that will lead to sustainable development (Ghisellini, Cialani and Ulgiati (2016).

Though the term CE has been around for a long time, it has gotten significant traction within sustainable economics thinking over the last 13 years (Skene, 2018). CE has both a linguistic and a descriptive meaning. Linguistically it poses as an antonym to linear economy. The linear model is the current economic system we have today, where we extract-produce-use-dump material and

energy flows (Korhonen et al, 2018a). Linear economy has become an antonym to CE in many ways because of the use of it as a way of promoting CE (Murray, Skene, & Haynes, 2017).

It is hard to find one precise definition on what CE is. Kirchherr, Reike, & Hekkert (2017) implies that the reason behind this is due to its popularity by many different stakeholders. When a concept becomes popularized, the concept's meaning tends to diffuse, and it becomes blurry. This is something that is criticized by many (Ghisellini et al., 2016, Blomsma & Brennan, 2017; Kirchherr et al., 2017; Murray et al., 2017).

When trying to find a definition on CE we found that Ellen MacArthur Foundation's on CE was frequently used. This is one of the NGO's who has helped popularize the push toward CE by businesses today (Bocken et al., 2016). Their definition is:

“an economy that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times.” (EMF, 2015, p.46)

When reviewing publications, we also found other definitions for CE:

“a regenerative system in which resource input, waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops; this can be achieved through long-lasting design, maintenance, repair, reuse, re-manufacturing, refurbishing, recycling, and upcycling” (Rowen, 2018, p.125).

“Circular economy is an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations”

(Kirchherr et al., 2017, p.224)

These are some of the many definitions we came across in publications, which goes to show how hard it can be to pinpoint what CE entails. Though there are many definitions, they do have common traits and wording. “System” is commonly used word to describe CE, where some describe it as just an economic one. All the definitions have the same trait in the way it describes CE as a system. Another common factor is utilization of resources and optimizing its value, circulating, and extending its intended life. The way to approach this is however varied in the different definitions, although they all have characteristics of regeneration and restoration.

3.1.2 The Concept

CE is a concept where you aim to increase value throughout every step of the products life cycle. Korhonen et al. (2018a) critiques the fact that scientific research on CE as a concept is still unexplored. Though there is a lack of scientific findings on CE as a concept alone, we can find a number of concepts that act as pillars to CE as a concept. Most agree that sustainable development, industrial ecology, cradle-to-cradle, and performance economy (sharing economy), acts as the main conceptual pillars of CE (CIRAIG, 2015; Korhonen et al., 2018a; EMF, 2015). Besides these concepts, there are also several principles commonly found as an approach to CE such as eco-efficiency and eco-effectiveness, and the 3R principles. In the following section we will describe what these underlying concepts and principles within CE entail to create a better understanding of CE.

Sustainable development

Sustainability is defined as a situation where human activity is executed in a way that preserves the earth's ecosystem (Geissdoerfer, Savaget, Bocken, & Hultink., 2017). The Brundtland Commission provided the most commonly known definition of sustainability back in 1987, which then coined the term "sustainable development" (Kirchherr et al., 2017). The definition was "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (**Brundtland, 1987**). Thereafter, sustainable development has been a much spoken of term and a guiding principle for creating environmental quality, economic prosperity, and social equity (Kirchherr et al., 2017). Many see CE as an approach or a means that will lead the world in achieving sustainable development (CIRAIG, 2015; EMF, 2015; Ghisellini et al., 2016; Korhonen, Nuur, Feldmann, & Birkie 2017b; Murray et al., 2017).

Industrial Ecology

A great number of researchers find the relationship between industrial ecology and circular economy the strongest, and the notion is that CE has its roots from it (Blomsma & Brennan, 2017; Boye, 2019; CIRAIG, 2015; EMF, 2015; Korhonen et al, 2018a; Loiseau, Saikku, Antikainen, Droste, Hansjürgens, Pitkänen, & Thomsen, 2016; Murray et al, 2017; Skene, 2018; Ranta, Aarikka-Stenroos, Ritala, & Mäkinen, **2018**).

Industrial ecology is a research field in ecological economics that focus on integrating sustainability into environmental and economic systems (Loiseau et al, 2016). It is a theory that was first developed in the 1970s by environmental academics and is recognized as the most recent and largest sustainable economics movement (Murray et al., 2017). Much like CE, its focus is optimizing energy and materials, and minimize waste through a closed loop of materials and

energy use (Loiseau et al., 2016). It is a study of material- and energy flow in industrial systems with a focus on creation and maintenance of a closed loop industrial ecosystem (Boye, 2019; CIRAIG, 2015). Industrial ecology aims to measure and document material flow in these processes in order to understand how these processes affect the environment, how we handle waste and finally, how it affects our resource reservoir (Boye, 2019). By doing this, the concept seeks to optimize energy and materials, pollution and waste reduction through industrial by-products or waste into inputs, where the ultimate goal would be that it enables industrial systems to mimic natural ecosystems (CIRAIG, 2015, p.vi).

Cradle-to-Cradle

Cradle-to-cradle (C2C) is a biomimetic design philosophy proposed by McDonough and Braungart in 2002 (CIRAIG, 2015). Principles of cradle to cradle involve the use of fewer materials, less energy and minimization of waste in production (Tyman, 2011). The design philosophy considers all materials that are part of industrial and commercial processes as nutrients, categorizing them as either technical or biological (EMF, 2015).

Inspired by nature's biological metabolism and its ability to use very little input in regard to creation and its closed cycles, C2C envisages turning waste into fuel for the production process (Tyman, 2011). Much like industrial ecology, energy and material efficiency is key for a C2C design, and the design is based on "waste equals food" as means to achieve zero-waste products that have the ability to be indefinitely recycled (Tyman, 2011).

Performance Economy

Performance economy focuses on the performance or the function of goods and services. It is also called "functional economy" and is regarded as one of the main conceptual pillars behind CE (CIRAIG, 2015). This is a concept based on selling items as services instead of products (Boye, 2019). This is also a business model that enables businesses to decouple growth from their resource consumption (CIRAIG, 2015). Performance economy may also be associated with sharing economy. Sharing economy can be defined as an emergent ecosystem where you instead of purchasing or owning products, you rent or lease underutilized assets in exchange for money (Toivola, 2018). In other words, they are quite similar. The main goals of performance economy as described by CIRAIG (2015) is: increase in wealth creation, increase of jobs, and reduction of resource consumption (p.7).

Green Economy

Green economy is a concept that has emerged in recent years as an initiative by the UN, EU and OECD (CIRAIG, 2015). It is a strategic priority for governments and intergovernmental

organizations, where the concept is to improve human's well-being and social equity, and in the process reduce environmental risks and ecological scarcities. CIRAIG (2015) argues that green economy overlaps CE due to how both concepts leverages economic activities to attain sustainability (p.60). One could say that the biggest difference between the two concepts is at what level the concepts are carried out, where green economy is carried by international organizations, whilst CE is mostly carried out by private actors (Korhonen et al., 2018a).

Life cycle Thinking, Eco-Design and Cleaner Production

Life Cycle Thinking is closely tied with Life Cycle Management. The main goal of this concept is to reduce environmental impacts through eco-efficient methodology where one looks at each step of product-, process or service's life cycle. By looking at the steps of these life cycles, the notion is to either design or redesign these with less embedded impacts (CIRAIG, 2015).

Eco-design is the idea that the upstream design phase of product has a direct influence on all the downstream steps within a product's life cycle. The main feature of eco-design is "designing out waste" (CIRAIG, 2015, p.60). The principles of eco-design is to anticipate as well as minimize the negative environmental impacts throughout a product's life cycle (YouMatter, 2019)

Cleaner production is a preventative approach toward reducing unfortunate environmental, health, and safety impacts that products might have. Within this approach, one seeks to take preventative action throughout the product's life cycle, from raw material to the disposable waste (de Oliveira Santos, Alves, de Melo, & de Medeiros, 2019).

3Rs Principles

The 3R framework is the most prominent framework used by researchers and practitioners (Murray et al, 2017; Ranta et al., 2018), and it even acts as core principles in the 2008 Circular Economy Promotion Law of the People's Republic of China (PRC, 2008). The first R, reduce, implies applying minimal inputs of energy, raw materials and waste in processes (Ranta et al., 2018). The second R, reuse, implies that one shall reuse products, components and materials that are not waste for the same purpose over again. Resulting in the use of fewer resources, less energy and less labor compared to what is required when producing the product from scratch (Ranta et al., 2018, p.71). The last R, recycling, has been a significant part of sustainable practice for many years and is therefore a fundamental part of CE (Murray et al., 2017). Recycling refers to the recovery operation of waste materials by reprocessing it. The recovery operation is essentially waste materials being reprocessed into either products, materials or substances for its original purpose or other purposes (Ranta et al., 2018, p.71).

Many have later extended the R's principles. The European Union used a fourth R, recover, as a part of their R framework in regard to their official policy for CE, however it is found by Kircher et al (2017) that only a few actually apply this framework when defining CE. In the 6R framework, Sihvonen & Ritola (2015), argues that by adding repurpose and refurbish to the 4R framework, one could widen the scope of product development in CE to create products that can be used for other purposes than originally conceived (p. 643).

The Waste Hierarchy

The waste hierarchy is a set of priorities for efficient use of resources in the most environmentally friendly way possible (Korse, 2019). It is a fundamental understanding that serves as a backbone for the concepts elaborated above, some more apparent than others. The idea is that the highest level of the hierarchy is the most environmentally friendly measure, and the lowest level is the least. From another perspective, the lowest level of the hierarchy also provides the least desirable consequence for the environment.

What the different levels entail is explained below:

- Prevention/Reduction of waste: Design a product using less materials, design them for lasting longer or for re-use. Use less hazardous materials.
- Reuse: Check, clean, repair, refurbish products or components for reuse.
- Recycle: Recycle components of the product when this is possible.
- Energy Recovery: Products or components that cannot be recycled could perhaps be used in energy production, such as digestion, incineration, gasification etc.
- Disposal: Landfill and incineration with no energy recovery.

(Department for Environment, Food and Rural Affairs, 2011)



FIGURE 4: THE WASTE HIERARCHY (DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS, 2011)

3.2 Implementation

Most efforts toward implementing CE is based upon laws, legislative proposals, or policies today. These initiatives show that the main actors in trying to push further implementation of CE today are governments, NGOs and consultancy firms (Kalmykova, Sadagopan and Rosado, 2018). Even though this might be the case, Kalmykova et al (2018) found that implementation of CE is

currently split in two directions; in a systematic economy-wide implementation (national, local etc.), and in a group of sectors, products, materials and substances implementation (p.197). Countries like the Netherlands and China have set ambitions and policies on economy-wide level that covers macro-, meso- and micro scales within the countries (Kalmykova et al., 2018).

3.2.1 Implementation in building and construction sector

So far, our understanding is that most implementation across the globe in regard to CE is the promotion of it using legislation and policies. Our impression is that there are many proposed ways of becoming circular, but very few examples of it being performed. When researching implementation within the construction sector, we found that implementation within this context was also very driven by policies, especially by the Ellen MacArthur Foundation, The EU commission and the government in The Netherlands (EC, 2020; EMF, 2016; Kalmykova et al., 2018). As for evidence of these policies being upheld and implemented, we struggled to find any.

When searching and reading about implementation of CE in the building sector, we would often find identified challenges in regard to implementing CE rather enablers and proven examples (Adams, Osmani, Thorpe, & Thornback, 2017a; Hart, Adams, Giesekam, Tingley & Pomponi, 2019). As for these challenges or barriers, enablers would often be in relation to the barriers as a means to solve them. We will review these challenges and barriers in the next chapter **3.3 Barriers**. In this section we will present findings on how the political and strategic canvas is today in this given context, enablers for implementation of CE, aspects to consider, and lastly what we found of practical implementations.

Policies

There have been efforts done by the EU commission the last 15 years or so in promoting CE (Kalmykova et al., 2018). Back in 2015, the EU proposed an Action Plan with the Dutch Government, as a part of promoting CE (EC, 2015). This year this plan was duly updated, where they expressed that they would launch a new Strategy for a Sustainable Built Environment by 2021. The Action Plan 2020 proposed that this new strategy would have a greater focus on bringing forward relevant policies that cover “climate, energy and resource efficiency, management of construction and demolition waste, accessibility, digitalization and skills” (EC, 2020, p.14). And that the strategy would promote circular principles by:

- *Addressing sustainability performance of construction products (in the context of “Construction Product Regulation”), whereby also possibly introducing recycled content requirements for specific construction products (considering safety and its functionality)*

- *Promoting measures that improve durability and adaptability of built assets that are in line with circular economy principles;*
- *Developing digital logbooks for buildings;*
- *Using Levels (a voluntary reporting framework to improve the sustainability of buildings) to integrate life cycle assessment in public procurement as well as the EU sustainable finance framework. As an effort to come up with appropriate carbon reduction targets and potential carbon storage;*
- *Potentially revising material recovery targets set in EU legislation for construction and demolition waste including its material-specific fractions;*
- *Promoting initiatives to reduce soil sealing, rehabilitate abandoned or contaminated brownfields and increase the safe, sustainable and circular use of excavated soils.*

(EC, 2020, p.14)

The Netherlands have been a pivotal actor in regard to promoting and implementing CE, as mentioned in the section above. The government of The Netherlands have set policy requirements to the construction sector in regard to use of virgin raw materials. By 2023, 30 % of materials used in the construction process of buildings shall not be virgin raw materials. By 2030, they have set a requirement of 50 %, and by 2050 they require 100% use of non-virgin raw materials (Høiby & Sand, 2018).

Enablers

Enablers can be seen as acts that needs to be performed to enable and promote better conditions for CE implementation both across the sector and as a means to handle specific challenges that certain actors might have.

Leadership

Leadership and management are identified as an enabler for implementing CE, whether it is within the building sector or any other sector (Acharya, Boyd & Finch, 2018; Hart et al., 2019; Leisling et al., 2018; Ünal, Urbinati, Chiaroni & Manzini, 2019). Ünal et al (2019) exclaims that commitment from management plays a big part in whether organizations can successfully adopt CE. In regard to stakeholders within the supply chain, Acharya et al (2019) implied that policymakers, investors, and construction clients have to lead as they have the greatest influence on decision-making.

Supply Chain collaboration

Supply Chain collaboration is regarded as a key enabler for implementation of CE in the building sector (Adams et al., 2017a; Adams, Osmani, Thorpe & Hobbs, 2017b; Acharya et al., 2018;

Decker, Manshoven, Peters, Ribeiro & Weerdt, 2017; Leising, Quist & Bocken, 2018; Ünal et al., 2019). In a study conducted by Leising et al (2018) they emphasized the need for construction clients to start new collaboration processes with supply chain partners, to enable transition toward CE across the sector. Adams et al (2017b) implied that construction clients play a key role, as leaders, to enable conditions for both collaboration and innovation across the supply chain. Decker et al (2017) pointed out that there needs to be involvement from key stakeholders during all the important decision moments such as design and end-of-life treatment of buildings and its components. Both Decker et al (2017) and Leising et al (2018) pointed out that the standard contractual agreements have to be revised in a way where the focus is a collective aim rather than detailed specifications and requirements.

Design tools and strategies

Design tools and strategies is seen as an important enabler for implementation of CE (Decker et al., 2017; Hossain, 2018; Hart et al., 2019). Hossain (2018) implies that by using tools such as Life Cycle Assessment (LCA) and Material Flow Analysis (MFA) and other design tools during the design phase, it will enable implementation of CE. These methods identify material flows during the different stages of the building's life cycle and its environmental impacts (Hossain, 2018). Hart et al (2018) also bring up examples of design tools and strategies that can help enable CE in the building sector. BIM, BAMB, material databases, building passports, information and metrics, and Design for Disassembly, are some of the examples brought forth. Information and metrics as a means to provide information on circularity was highly ranked by many actors, especially designers, contractors, and manufacturers in the survey that Adams et al (2017a) performed. Respondents in this survey also emphasized the need standard for "design for demolition" was important as this could provide guidance and tools that should be used. Which is also supported by findings by Hart et al (2019).

Policy support

Support through policy was another element identified to enable implementation of CE in the building sector (Adams et al., 2017a; Acharya et al., 2018; Hart et al., 2019). Adams et al (2017a) found in their survey that many highlighted green public procurement requirements as an enabler for further implementation. This was especially important by the researchers and consultants, and designers, that participated in the survey. Adams et al (2017a) also found that a form of producer responsibility for construction product was seen as an important enabler, although this would have to be adaptive due to different approaches a building project might have. Not only policy but legislation was also seen as a driver, where the need for requirements set by the public sector was seen as enabler e.g. requirement to use design tools (Adams et al., 2017b).

Structure and support

Structure and support refer to the need for various structures in the building sector that need to be put in place to support CE. Recovery of materials and products have several enablers, where financial incentives for use of secondary materials and take-back schemes for these types of materials is identified as an enabler (Adams et al., 2017a; Hart et al., 2019). Another enabler found is having a marketplace for these materials and products, as a means to achieve widespread use (Acharya et al., 2018). This was also emphasized in Adams et al (2017a) study where respondents said addressing the market volatility for secondary materials is seen as an enabler, and the ability to rely on certain secondary materials on the market. Other infrastructures like storage facilities for materials, upcycling of materials facilities was seen as an enabler for development of a reverse logistic infrastructure (Hart et al., 2019).

Business

Business enablers involve financial and other business-related enablers. Good business cases are found to be an enabler for further implementation (Adams et al., 2017a; Adams et al., 2017b; Acharya et al., 2018; Hart et al., 2019). This was especially evident in Adams et al (2017a) survey, where all respondents ranked it as the most significant enabler, as this could help clarify and exemplify how CE affects one economically, practically, and marketwise. Another enabler was the need for a decision-making framework that could be used across a building's life cycle. In regard to the economic side of business, the clients and designers in the survey ranked having the ability to measure the value of a product or material over its lifetime as significant (Adams et al., 2017a).

Aspects

Although it was not necessarily easy to find measures specifically related to the building sector, we found aspects that needs to be addressed for implementation of CE. Adams et al (2017a) applied key CE aspects to the stages of a building's life cycle as a means to address this. Using these key aspects, we were able to describe measures and considerations that should be made in each stage. Some of these measures or aspects was also recognized in other works.

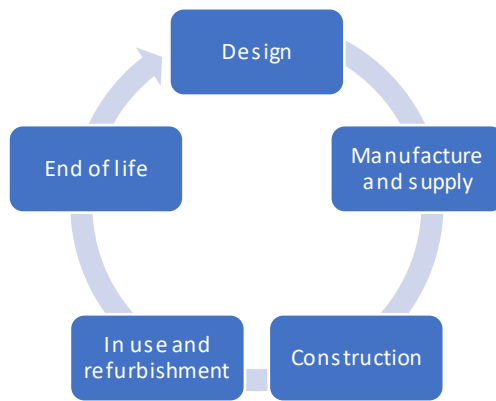


Figure 5: Life cycle of a building

Design phase: In the design phase, Adams et al (2017a) say that the design phases involves several aspects. Although Adams et al (2017a) listed many design elements, there is a correlation between the many measures proposed, therefore we have tried to present them together and show the context in how they are connected. Design for Disassembly (DfD) is a key design phase to make a building circular (Adams et al., 2017a; Debacker, Manshoven, Peters, Ribeiro & De Weerdt, 2017; Ünal et al., 2019). It requires designing the building with the end-of-life perspective in mind. As a means to achieve this one must design the building for adaptability and flexibility through design for standardization and modularity. This is a measure that will minimize waste during construction and deconstruction of the building (Acharya et al., 2018). A supplement to DfD found in a report from the Ellen MacArthur Foundation, is designing buildings for maintenance. By designing for maintenance, buildings will have the ability to be maintained, repaired, and reused during its operational use and at end-of-use (Acharya et al., 2018). Designing out waste, as well as specifying reclaimed materials and recycled materials are also measures identified by Adams et al (2017a). These measures can be seen in correlation with the design aspects that Ünai et al (2019) identified in their article: Design for Recycling (DfR), Design for Remanufacturing and Reuse (DfRe), and Design for Environment (DfE). Whereby designing out waste is interconnected with all three design practices. Whilst the measures on specifying reclaimed materials and recycled materials is measures more centered on the use of what is already available of materials.

Manufacture and supply: Within this stage, measures are based on the principle of reuse and eco-design. Eco-design principles should be applied, which essentially means designing waste out. The use of less materials and less hazardous materials are also proposed as measures (Adams et al, 2017a; Acharya et al., 2018). This involves optimizing material use and avoid choosing toxic materials. In this life cycle stage, design is also an important factor where design for product disassembly and design for product standardization are measures that should be executing during this phase. These practices correlate with the design measures that are proposed in the Design

phase. By designing accordingly, this will inevitably increase the lifespan of products and material. One can assume that most of these measures are related to new buildings as it includes designing products and materials for end-of-life. Whilst other measures proposed can be related to both new buildings and existing buildings, as it involves having a take-back scheme and reverse logistics as a means to create continuous material cycles (Adams et al, 2017a; Acharya et al., 2018). Take-back schemes involves manufacturers collecting materials and products at the end of its life, or after end of use. By creating a take-back scheme, manufacturers will be pushed to design its products/materials in a way where they can take it back and reuse again. By doing this process you will have reverse logistics, where it goes from the end-user back to the producer or manufacturer.

In use and refurbishment: In this stage, which is the operational phase of the building, Adams et al (2017a) recognize aspects such as minimal maintenance, easy repair and upgrades, as well as an adaptability and flexibility in the building. Overall, finding ways to minimize waste continuously in this stage is important.

Construction: In the construction phase, Adams et al (2017a) emphasizes the need to minimize waste, procure reused materials and procure recycled materials. These measures can be directly related to the 3R's principles and waste prevention. Another measure proposed during construction is off-site construction, which involves having components and elements made beforehand based on measurements, rather than having to perform adjustments on the building site.

End of life: During this phase, Adams et al (2017a) thinks measures such as deconstruction of the building and selective demolition is needed. Through this, one can take out components and products for reuse at a later point. Performing closed-loop recycling and open-loop recycling will enable waste prevention at the end of the building's life.

Practical

As for practical implementation we only found a few through a study conducted by Leising et al (2018). This case study involved three building projects in the Netherlands that was known for having adapted some circularity through CE principles. The cases they reviewed differed in the nature of the type of building project, where one was a new building project, the other a rehabilitation project, and last one a demolition project.

In the new building project, they applied a cradle to cradle approach throughout the project, by using a so-called “resource passport” for their materials and products. This was introduced as a measure to support end-of-use options for the building. A resource passport can be defined as a material document which include all information of the materials and allows tracking of materials and their residual value throughout the lifecycle of a building (Leising et al., 2018). Besides the resource passports, they also used C2C certified materials throughout the building. C2C certified materials are materials that are designed with disassembly options of components and that scan for toxicity of products throughout their supply chain (McDonough and Braungart, 2002). Examples of C2C certified materials they used was LED light system, solar panels, and office equipment (Leising et al., 2018). Another concept they applied was performance economy. By adapting a performance economy approach, they paid for the service instead of having ownership of the products. Examples of this was instead of buying lamps and buying an elevator, they paid for the service of light and vertical transportation. To optimize material efficiency, they also reduced spatial needs for users of the building. Lastly, they also used renewable substitutes as an energy source for the building.

In regard to the renovation project, they had a clear vision and goal from the start to have 80% circularity of the materials and a net positive building (Leising et al., 2018). To reach this goal they applied reuse and a C2C approach. Examples of this was reuse of materials to the degree possible, reuse of structural components such as steel, and use of resource passports to support a take-back scheme.

The last project, a demolition project, had a strong focus on closing the loop at the end of the lifetime of the building, rather than realizing circularity during the building’s entire lifetime (Leising et al., 2018). This in essence meant that the demolishing process was to be conducted in the most sustainable way with the focus of creating value by waste. A part of this process was to separate demolition waste into 20 different streams so that the waste could be reused afterwards. One can say by doing this they applied circular principles such as recycling and reuse using waste management.

A common factor that applied to all the projects was that they were all BREEAM certified. Where the demolition project was the first BREEAM certified project of its kind in the Netherlands (BREEAM, 2013). BREEAM is an international certification scheme that assess the sustainability performance of individual buildings (BRE Group, 2019). Assessments and certifications take place in several stages of the building’s environmental life cycle, where the end goal is to receive a rating. The rating is based on the performance of the project and its stakeholders against

BREEAM standard and its benchmarks. This scheme provides stakeholders with sustainable solutions in regard to the type of building project.

An interesting practice that was mentioned in this study was that two of the projects, the new building- and rehabilitation project, both adapted a multidisciplinary collaboration model called the “construction team model”. According to Leisling et al (2018) this is a common model applied in the building industry in Netherlands, where stakeholders work collectively on the preparation of a building project.

3.2.2 Implementation in the Norwegian building sector

Implementation of circular economy in the Norwegian building sector is a field lacking sufficient research. While searching in academic search engines, both in Norwegian and English, relevant data were close to none. The only available data were two master thesis, and one article. Thereby, we had to expand our search to using Google in general. We could divide this chapter into three sections, *government, non-governmental organizations and practical implementation*.

Government

The Norwegian Environment Agency claim CE to be key in order to lower emissions and reaching UN’s sustainability goals (Miljødirektoratet, n.d). The Government reported in 2019 that they want Norway to be a leading nation in circular economy. Developing such economy should utilize resources better (Miljødirektoratet, n.d). While completing this study, the national strategy for CE were presented. As this was published after we were done collecting data, we did not include in the theoretical framework. Yet this is of high relevance for further implementation of CE in the Norwegian building sector, hence it will be addressed further in the “future research” section of chapter 7.

In the political platform suggested by the government, they want to collaborate with the construction sector to facilitate fossil-free construction sites by 2025, demand 30% green public procurement where applicable, and apply more specific requirements on environment and emission where this is better suited (Regjeringen, 2019). The requirement for degree of waste separation is now 60%. In the sector today, the best contractors have a separation rate of 80 to 90 %. However, waste separation does not necessarily reflect the degree of waste recycling. Currently, the degree of waste recycling is about 42%, and the Government is to present a demand of 70% at the end of 2020 (COWI, 2019).

Non-Governmental organizations

As sustainability and CE has gained more focus over the years, non-governmental organizations shown initiatives for addressing CE in the Norwegian building sector. The Federation of Norwegian Construction Industries (BNL), COWI, Future in our hands, Norwegian Green Building Council, SINTEF, Avfall Norge, Future Built and Circular Norway is among these. The initiatives are e.g. reports, analyzes and proposed measures, the most relevant for our study is shown below.

The Norwegian Green Building Council created a “Roadmap towards 2050” to serve as a recommendation for choices building clients can make both short- and long-term, in order to ensure the building sector contribute to a sustainable society (Grønn Byggallianse & Norsk Eiendom). They shared the following 10 immediate measures:

1. *Environmentally-certify the organization.*
2. *Remove fossil fuel heating, including for peak loads.*
3. *Only purchase building products that do not contain substances that are hazardous to health and the environment.*
4. *Introduce an environmental-management system, for example, a BREEAM-In-Use review, to the entire portfolio and establish a plan for continuous improvement of the buildings.*
5. *Conduct a study of what roof surfaces can and should be used for, such as stormwater management, energy production, recreational area, or beekeeping.*
6. *Reward innovative solutions and discuss risk management, for example through allocating a separate item in the budget for risk associated with testing new solutions.*
7. *Require the architect to draw up a plan for how the materials can be dismantled and reused during reconstruction or demolition work and strive to identify solutions and materials that generate the least amount of waste.*
8. *Commission an energy budget for the estimated actual energy consumption (in addition to the calculation requirements in the regulations on technical requirements for building works) and documentation of which measures have been implemented to reduce the anticipated actual energy consumption in running the building.*
9. *Request and prioritize building products that produce low greenhouse gas emissions (documented through an Environmental Product Declaration).*
10. *Request fossil-fuel-free construction sites.*

(Grønn Byggallianse & Norsk Eiendom, 2016)

The Federation of Norwegian Construction Industries developed an analysis of roles, proposed circular measures, and accompanying activities. Regarding CE in the building sector, we were able to get a perception of which stakeholders they deem as essential in performing circular

measures. This is based on chapter 2.4 regarding the building sectors actors. The adapted figure is illustrated below.

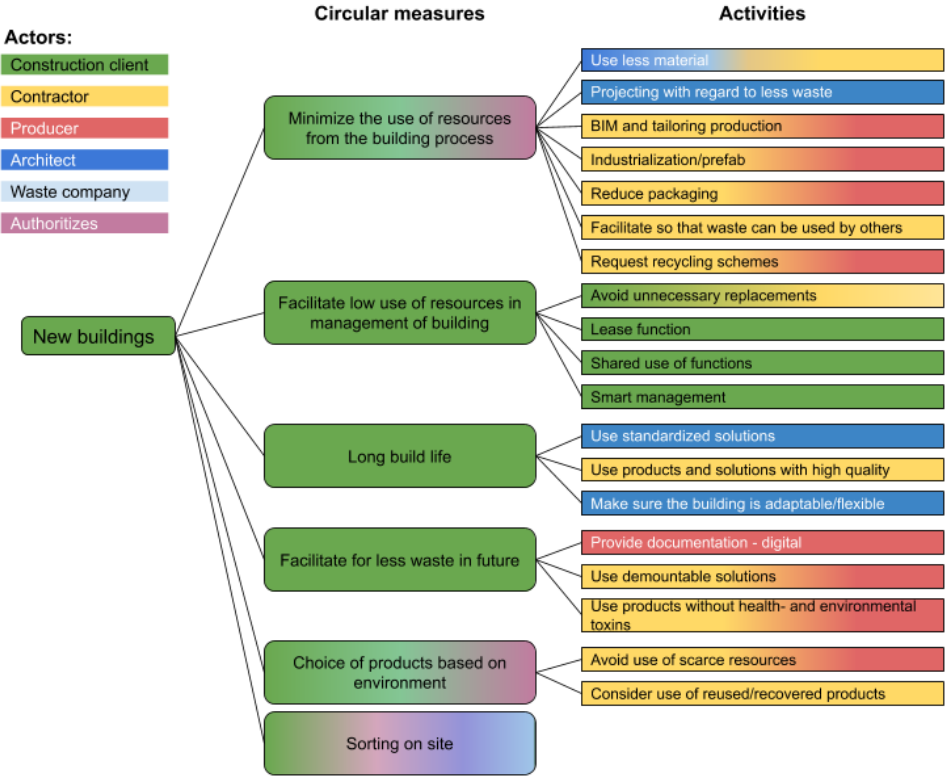


FIGURE 6: EFFECTIVE USE OF RESOURCES AND ACTORS’ ROLES. ADAPTED FROM BYGGENÆRINGENS LANDSFORENING (2019)

Within this report, BNL also provided a waste hierarchy adjusted in order to fit the Norwegian building sector. If we compare this to the “original” waste hierarchy in section, 3.1.3, we mostly see similarities. The main difference within this hierarchy is the top level. Here they have divided “prevention” into “waste prevention” and “reduced material use/ resource effectiveness”. Although one might reflect over the fact that these “new” areas are already accounted for in the “original” waste hierarchy, they emphasized the importance of making this an overall goal. They claimed the waste hierarchy combined with focus on the use of resources would equal circular economy (Byggenæringens Landsforening, 2019). When we are moving forward with our study, this is the hierarchy which will be used.

Practical implementation

In 2018, a number of actors in the Norwegian construction sector started a program called “Byggflokken” (RENAS, 2018). The focus of this program was to identify the challenges within the value chain of the construction sector today, and to come up with innovative ways to solve them. Byggflokken is driven by Æra Strategic Innovation and includes 26 actors collaborating to

solve these challenges (RENAS, 2018). The building sector in Norway also encourages the government to include a demand of 20% circularity in tender processes (Boye, 2019).

In order to provide examples on practical implementation we need to address what a circular building is. FutureBuilt (2019) defines a circular building as a building which facilitate resource utilization at the highest possible level and exists of at least 50% reused or reusable materials and components (p. 3). The definition is accompanied with criteria divided in 5 topics; *Environmental based decisions whether to rehabilitate or demolish a building, resource utilization when demolishing buildings, reuse of materials, reusability, and change of skills*. Each criterion includes an objective, strategies, and measures for given objective and requirements for achieving set objective and documentation. The five criteria are presented below:

- *Environmental based decisions whether to rehabilitate or demolish a building* address the considerations which has to be made when deciding what to do with a building when it is at the end of its original lifecycle. Advantages and disadvantages should be accounted for with the two alternatives and the new lifecycle should be seen as a whole.
- *Resource utilization when demolishing buildings* relate to the objective of keeping materials intact and as high in the waste hierarchy as possible. The potential of reuse, within internal or external project should also be addressed.
- *Reuse of materials* have the potential of heavily reducing the CO₂ emissions, extraction of raw materials and waste. Reusable materials could be found in internal rehabilitation projects, external or from a third-party. The material should have sufficient technical quality and documentation should be sufficient.
- *Reusability* is one of the most complex criteria. Building to be reused in the future could follow several strategies such as robust choice of materials, DfD using flexible connections, available information or producer agreements that include take-back schemes or leasing. The strategies might vary in regard to which type of material which will be prepared for reuse.
- *Change of skills* discuss the possibility to change a buildings function and purpose without major structural changes. Generalization, flexibility, and elasticity is among the strategies for this criterion.

(FutureBuilt, 2019)

When it comes to practical examples of implementation, one of the most known examples are the office-building in Kristian August gate 13 in Oslo, this is an ongoing project where they focus on circular principles. It is a rehabilitation project, and one of the circular measures in this project is to reuse building parts from the original building, such as the support system. They also reuse

building parts from external projects, such as steel, hole cover elements and facade elements. At the same time, they aim to have an emission-free building process, and 100% waste separation at the construction site, and a maximum of 20 kg waste per square meter (FutureBuilt, 2019).

Kristian August gate 23 is another example. This project aim to have 50% of materials and building parts, either reused or made to be re-usable in the future. This project focused heavily on mapping consequences for the environment in terms of deciding which parts would be demolished and which parts would be reused (FutureBuilt, 2019).

3.3 Barriers

We found a lack of sufficient research on barriers linked directly to the Norwegian building sector. Hence, we found it necessary to look at barriers addressed by other countries in order to see if they are also evident in the Norwegian building sector. We will first address general barriers for implementing CE, then address barriers directly linked to the building sector, and lastly specific for the Norwegian building sector. At the end of this chapter we will provide a summary which connects them all together.

Even though there has been a lot of traction and initiatives around adopting and implementing a CE approach within governments and firms, there are still barriers that can be found to this day that need to be broken down to enable the full potential and implementation of CE (Ranta et al., 2018; Ritzén & Sandström, 2017; Kirchherr, Piscicelli, Bour, Kostense-Smit, Muller, Huibrechtse-Truijens, & Hekkert, 2018). Some of the challenges that CE is having is cope with is resource scarcity, environmental impact and simultaneously increasing economic benefits (Ritzén et al., 2017). This in turn, reflects on the complexity of trying to transform any institution towards a circular economy.

Ritzén et al (2017) conducted a case study of two large manufacturing firms to explore what barriers could be found within these firms regarding its transition to a CE. The most dominant barriers that was found was related to (1) attitude and knowledge, (2) integration between functions, (3) supply chain structure, (4) values and finance, and lastly, (5) technology. Within attitude and knowledge, they identified barriers based upon the common consensus that CE is not an established model in the industry. This was proven in their study as most respondents, except for respondents working specifically with sustainability, found the concept unfamiliar and lacked an understanding of the meaning of CE. With a lack of knowledge around the concept it becomes a great organizational barrier for implementation of CE and change within the organization, as employees will not be able to see the benefits nor the practicality of implementing it.

Structural barriers were also identified within the two firms regarding integration between functions. These barriers come as a result from lack of communication and guidelines within the firms as to whom is responsible for initiating a change towards CE, as well as the notion that “sustainability issues” is to be directly handled by a specific department (Ritzén et al., 2017). Lastly, they also found evidence supporting previous literature that there are financial and technological barriers that do affect the transition to CE. The study found that the firms emphasized on the barriers surrounding the quality of recycled materials (technological barrier) and the lack of business cases illustrating possible revenues (financial), as well as barriers of responsibilities and dependencies connected to their supply chain (Ritzén et al., p.10, 2017). These barriers are mainly concentrated around what CE is, rather than the actual transition toward CE.

Ranta et al (2018) found that an institutional barrier to CE is that there is a cultural-cognitive (attitude and knowledge) view that if the product is made sustainable it must offer poorer prices or performance. This goes to show that there may be a negative relation to the word sustainable within institutions, and that they may relate the use of sustainable ways to lower quality.

3.3.1 In the building sector in general

Barriers can be seen as challenges that hinder progression, or in this case hinders the whole sector or individual actors within a supply chain to perform CE. Without handling or diminishing these barriers, implementation of CE in the building sector will not be successful. In regard to research, there are several barriers that define why the building sector have not come further in implementing CE. These barriers are often interconnected or dependent on different parties, such as lack of action by governmental bodies. Below we will describe the barriers we found.

Cultural barriers

These barriers are often focused on the human and social aspect, which include behavior, attitudes, and management across organizations. Notably, the lack of interest, knowledge and engagement throughout the value chain and supply chain is a barrier (Adams et al., 2017b; Hart et al., 2019; Henrotay, Debacker & Steinlage, 2017). This includes the end-user. In a report by EMF and Arup, this notion was supported where they found that familiarity with CE and its principles, as well as the lack of knowledge on how to apply CE in the built environment was insufficient (Acharya et al., 2018). This is also supported by findings in the survey by Adams et al (2017a), where respondents ranked themselves as largely aware of CE, but that respondents said it was lacking within their own organization and even less industrywide. Another barrier that Hart et al (2019) identified was the lack of collaboration between firms, where competitive nature

was most likely the reason. This can also be due to the fact that the sector is very fragmented, and that decision-makers have different objectives which do not align (Adams et al., 2017a; Acharya et al., 2019). Adams et al (2019a) also found that there was a lack of a holistic approach within the sector, which could be related to the fragmented industry as well as the competitiveness among actors.

Lack of collaboration between functions within organization was also seen as a barrier (Hart et al., 2019). Where functions are not necessarily aligned and work together, which makes it hard for firms to fully commit to implementing CE. In regard to the value chain, Adams et al (2017b) found that the acceptance of reused or recycled products was a barrier, which may be related to human attitude in regard to using something that is used beforehand and that it may lack quality.

Regulatory

Regulatory barriers are often concerned with policy, legislation, and regulations. A lack of consistent regulatory framework and policy support is found as a barrier in regard to implementation of CE in the built environment (Acharya et al., 2019; Hart et al., 2019). Adams et al (2017b) pointed out that it is desired by construction clients to make new policies and legislation that enables competitive conditions against the current linear economic model, which implies that current policies and legislations are barriers. Many existing policies and instruments today are developed from a linear standpoint, which creates a barrier for CE as it does not consider the reality of how it can affect construction of circular buildings (Henrotay et al., 2017). Specific barriers related to legislations and policies was found in the survey by Adams et al (2017a), where they found that policies today are too focused on landfill diversion which directly affects their ability to apply reuse. Another barrier is ambiguous end-of-waste regulations which was seen as a big barrier for implementing CE (Adams et al., 2017a; Acharya et al., 2019).

Economical

Economical barriers are related to the financial issues related to implementing CE. A big economic barrier is the short-term view many in the sector have, especially those who invest. Like many businesses it is about short-term profits, and applying CE requires a long-term view with longer collaborations and financial paybacks (Hart et al., 2019). As long as businesses, specifically construction clients and developer, have a short-term perspective on investments, this will be a barrier for implementing CE. Poor business cases or lack of business cases is seen as a great barrier as to why more have not tried implementing CE in the building sector (Adams et al., 2017a; Hart et al., 2019). This as a consequence creates another barrier, an unclear financial case. When one does not know how or what economic consequences performing CE will have, it will

naturally become a barrier as it is unclear. Low prices for virgin raw materials and subsequently the low end-of-life value is seen as another big barrier (Hart et al., 2019). The fact that it is so cheap to buy new materials and products today in comparison to conducting processes for reuse and recycle, it may disincentives the transition to CE. Another economic barrier is the high short-term investment costs (Hart et al., 2019). This may be related to costs related to research and development that need to be done implement CE (Hart et al., 2019; Ünal et al., 2019).

Sectoral

Sectoral barriers are barriers related to activities in the supply chain. In the survey performed by Adams et al (2017a), they found several barriers related to activities in the supply chain. One of the most significant barriers found was lack of incentive to design for end-of-life for construction products. Lack of end-of-life considerations for the whole building's life cycle is seen as a barrier as well as the complexity of the building, which are connected. Another barrier that was found was the lack of market mechanisms for recovery of materials (Adams et al., 2017a). In regard to recovery of materials, there were also some technical issues identified. The lack of long-term warranties of materials, lack of certification and quality assurance of both reclaimed products and recycled materials (Adams et al., 2017b; Debacker et al., 2017). As well as challenges in regard to trying to reuse structural materials such as concrete and other composite products (Hart et al., 2019). Lastly, a notable barrier by Hart et al (2019) is the insufficient use of design and collaboration tools. This also included development of such tools, as well as the use of information and metrics which are often combined with such tools (Adams et al., 2017a; Adams et al., 2017b; Hart et al., 2019, Debacker et al., 2017).

3.3.2 In the Norwegian building sector

As we see from the implementation chapter, we get the understanding that there is a general lack of implementation of CE in the Norwegian building sector. One may wonder why that is, therefore, we have presented the most common barriers we could find in this section.

COWI did a study on CE in the Nordic construction sector in 2018 (Høibye & Sand, 2018). While conducting their study, they found some barriers. These were in regard to cooperation, existing buildings, economy and laws and regulations. First, we will address the cooperation challenge. They explain that there is a lack of cooperation across the value chain in regard to CE, this also includes partnerships and better cooperation is especially needed in the early phase of a building project (Høibye & Sand, 2018).

Secondly, economy was found as a barrier. In their study they address the lack of economics of scale (Høibye & Sand, 2018). The fact that there also exist transactional barriers, which provides

a risk is also mentioned. Many products are cheaper to buy “new” instead of reused, which calls for a need for economic incentives in order to create a better balance regarding reused products (COWI, 2019).

Third, they address the challenges with existing buildings. First of all, many of the existing buildings have been built a long time ago, this may indicate that they were not built with reuse in mind. Also, existing buildings may contain hazardous materials which will not be sufficient to use according to new laws and regulations (COWI, 2019). The fact that these buildings have existed for so long creates uncertainties regarding the material quality, and they might also lack quality assurance documentation if they are to be reused, as well as CE-labelling (Høiby & Sand, 2018). The process of dismantling a building for reuse is also a complex task, and with a common lack of time, strict budget, and limited space this is highly challenging. Even the process of recycling in a demolition process is challenging (COWI, 2019).

Lastly, laws and regulations are a major part of their study. As we saw from the perspective of existing buildings these are often linked to laws and regulations. Laws in relation to waste often lack flexibility, and a lot of materials from demolished buildings are to be treated as waste. The laws in regard to certification and documentation is also a barrier, especially when it comes to reuse. Goals and requirements for energy efficiency is also hard to operate by if the building materials are to be reused, and the current TEK is found to be fuzzy when it comes to reuse of materials (COWI, 2019).

3.3.3 Summary of barriers

From the general barriers implementation of CE is facing, we found the following barriers: (1) attitude and knowledge, (2) integration between functions, (3) supply chain structure, (4) values and finance, and lastly, (5) technology.

Linked to the building sector directly the barriers are structured a bit differently yet surrounding the same aspects. Aspects linked to attitude and knowledge, as well as integration between functions are here presented as cultural barriers. Supply chain structure and technology is linked to sectoral barriers. Lastly, values and finance are linked to economic barriers. Aside from this, they also included regulatory barriers.

In the Norwegian building sector, we could draw lines from the barriers connected to cooperation and existing buildings to the sectoral barriers. Laws and regulations are connected to regulatory barriers, and economy is also here mentioned to be a barrier.

In order to use this as a framework for our analysis and discussion, we have chosen to use the general barriers linked to the building sector as a framework, and include the surrounding aspects from the other authors in cultural, sectoral, economic and regulatory barriers.

4 Methodology

The theoretical framework contributes to a greater understanding of the phenomena we are researching, and it acts as a necessary building block for establishing a good research plan. The planning of the study entails choosing a research strategy works best with our research question and help determine whether the study is feasible to conduct within the given timeframe. The purpose of this chapter is to provide a thorough description of our methodological choices and our research process based on the structure of our problem. This entails that we break down the problem we have which will provide further directions when choosing research strategy, research design and data collection methods. Finally, we discuss the quality of our research by discussing its reliability and validity and describe research ethics.

To summarize our methodological choices, we have made the following table:

Nature of the research question	Explorative/Explanatory
Research approach	Qualitative
Context	Building sector in Norway
Research method	Case Study
Data/Information	Primary data – interviews Secondary data – Articles/reports/books/PowerPoint
Data analysis	Transcribing, coding

Table 2: Summary of our methodological choices

In this table we describe in short, the conclusions we came to in regard to our methodological choices. The left describes the methodological choices, whilst the right side shows which choices we concluded with. A methodological choice that was left out of this summary was scientific ideals. We did not include this aspect as this was not essential for the rest of our methodological choices.

4.1 Breakdown of problem and research question

Already in chapter 1.2 we started to look at our problem statement by trying to define our research question. By breaking it up into different components, we were able to come up with a research question as shown previously in table 1.

We have our phenomena, the chosen context, our problem, and our research question. We may have all of these, but it does not necessarily help us determine what form of studies this is and what form of approach we should take. Therefore, we need to break down our research question even further. The research question is as following: *“To what extent is circular economy being adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy?”*

The first part of our research question tries to explain the situation today in the given context. The context of the study is set to the building sector in Norway. There are two aspects to this part of the question, the situation today and why the situation is as it is today. This in part makes it explanatory research, as we try to identify the extent and nature of cause-and-effect relationships of this phenomenon in the given context.

The second part of our research question explores how the phenomenon can be adapted further and what barriers need to be addressed. This requires a more exploratory approach to the research as we want to identify possible barriers in regard to applying CE in the Norwegian building sector. As established our problem is “low grade implementation of CE in the Norwegian building sector”. We do have some knowledge based on our theoretical framework, yet it remains to establish if this also applies to our chosen context. That is why it is essential to explore this further to establish insight and understanding as to why and how this is a problem.

Taking both aspects into account, we believe that we have a combination of an explanatory and exploratory study. Having said that, we also believe that we have an abductive approach. The reasoning behind this is due the fact that there is a lack of empirical studies on this phenomenon in the chosen context, which we can use to come up with theory to explain it (inductive). We also do not have a vast amount of theory due to the novelty of the phenomenon to test against empirical data we collect (deductive). Therefore, it is reasonable that we have an abductive approach, which essentially is an interaction between the two described above.

Now that we have established the nature of our research question, explanatory and exploratory, and what approach our study has, we can look further into how we can come closer to finding answers in our study.

4.2 Research strategy

To answer our research question, we need to determine what research strategy will help us get these answers. There are two approaches, either through a qualitative approach or quantitative

approach, or a combination of the two. Qualitative research is defined as “a social research that is aimed at investigating the way in which people make sense of their ideas and experiences” (Savin-Baden & Major, 2013, p.11). Whilst quantitative research is defined as a form of research that explains phenomena by the collection and analysis of numerical data (Aliaga & Gunderson, 2002). These two strategies are very different in how they are used, and it is therefore important to discuss each of them against our problem when determining what research strategy is appropriate.

As the first part of our research question aims to find out the extent CE is adapted in the Norwegian building sector, we discussed whether a quantitative research strategy would be best. “What extent” as a question is closely related to the observer’s belief of the degree CE is implemented from their perspective. This would support a quantitative strategy as we are “discovering facts” about the social phenomena in a context, which in this case is the building sector. However, as discovered in our theoretical framework, knowledge around CE in the building sector has been found limited and therefore a fixed and measurable reality is not evident. On the one side it would enable us to confirm whether CE is implemented in the Norwegian building sector and get an impression of the level of implementation using fixed measures. But on the other side it does not necessarily tell us to what extent. There is a distinction between degree and extent in the way that degree can easily be measured using fixed factors, whilst extent asks for a more descriptive answer and is subjective to the person in question. As CE is a novel concept and the extent cannot be found out using a fixed measure at this point of time, it seems reasonable to lean toward a more open approach such as qualitative research proposes.

The second part of our research question looks to what barriers needs to be addressed for the sector to implement more circular measures or in a larger scale. From what we have seen in our theoretical framework there are measures today that are proposed, so the rationale behind this part of the research question is to figure out why firms is not using these proposed measures to date. These questions can be answered using an open approach i.e. qualitative research, as it enables us to understand how people within the sector experience CE in action today and what factors might be standing in their way of implementing these measures.

Our research question sets the precedent for which research strategy is the most fitting. As our research question is of an exploratory nature where we assume a dynamic reality, it naturally leans us toward a qualitative research strategy. We already know for a fact that this concept is very novel in the building sector in Norway, and that it is in general a concept that have not been implemented to a large degree in any other country as well. This poses a lot of open questions, which in hand requires us to have flexibility in our research strategy. Quantitative research is the

very opposite of flexible, and it requires a strict structure through questions and a set of answers that are pre-defined, which we do not have today (Jacobsen, 2005). A qualitative research strategy will also enable us to dive deeper into informants understanding of the CE as a concept and insight into what knowledge and experience they have with the phenomena. There is a need for further understanding in how CE can be implemented in the Norwegian building sector or in the building sector globally, and with a qualitative research approach we will hopefully be able to discover “what” these issues are.

4.3 Research Design

Now that we have decided upon a research strategy, qualitative research, the next step is to decide what research design will enable us to get the answers we are looking for in this study. Research design can be seen as the blueprint of our research where the design is the “logical sequence that connects the empirical data to a study’s initial research questions and, ultimately, to its conclusion” (Yin, 2009, p.26). The research design is not only a work plan for our research, but also helps us avoid situations where the evidence does not address our initial research questions (Yin, 2009, p.27).

There are various research methods and finding the best suited approach for our research question is critical in order to provide a meaningful and reliable study. There are five major research methods that Yin (2009) discuss in his book and the methods are: experiment, survey, archival analysis, history, and case study. Here he makes distinctions between the five methods based on three conditions. The three conditions are: (1) Form of research questions, (2) Requires control of behavioral events, (3) Focuses on contemporary events (Yin, 2009). With our research we do not require control of behavioral events, which eliminates experiment as a method. Our study will also focus on contemporary events and not historical events. This eliminates both history and archival analysis. After this there are only two methods left: survey and case study. To determine which method to use we must look to evaluate the condition first condition “form of research question”. Our research question focuses mainly on “what questions” in an exploratory sense, but we find elements of “how questions” related to our research question. As knowledge within this field of study and its practices in the Norwegian building sector is still very novel we will have to pose questions about how the situation is currently, how they conduct themselves, and how they experience the sector regarding sustainability and circular economy.

We also have a strong focus on “why” questions within our research question. For us to develop an understanding of what measures need to be implemented in the sector, we need to ask “why” the situation is as it is today, and why the sector has not progressed further. Yin (2009) claims

that “how” and “why” questions are very explanatory and is likely to lead to case studies as preferred research method. In contrast a survey would be more fitting if our research goal were to “describe the prevalence of a phenomenon or when it is to be predictive about outcomes” (Yin, 2009, p.9). This is not the case for our research; hence it seems reasonable to go for case study, rather than a survey.

4.3.1 Case Studies

A case study can be defined as “a research strategy which focuses on understanding the dynamics present within one single setting” (Eisenhardt, 1989, p.543), or “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context” (Yin, 2009, p.18). Case studies are known for collecting rich information from either a small number of units or a case through detailed and extensive data collection (Johannessen, Tufte & Christoffersen, 2016). Dubois and Gadde (2002) believe that the interaction between a phenomenon and its context is best understood through in-depth case studies (p.554). This statement further supports our decision in using case studies as preferred research design.

Yin (2009) presents two dimensions to case studies; single- and multiple-case studies. This is shown in figure 7. Within the two dimension you have two types of designs for case studies, which gives us a total of four types of case study design to choose between. Within single-case designs we have single-case holistic design (top-left) and single-case embedded design (bottom left). Within multiple-case designs we have multiple-case holistic design (top right) and multiple-case embedded design (bottom right).

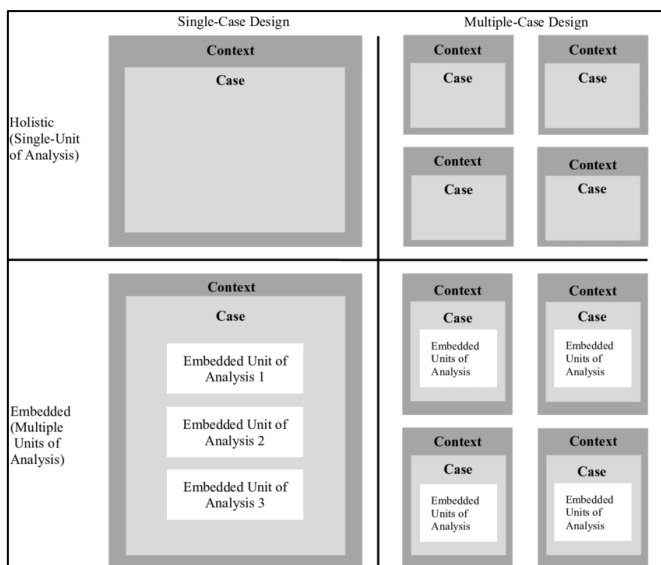


Figure 7: Basic types of design for case studies (Yin, 2009, p.46)

When choosing a case study design, we needed to determine whether it is a single-case or multiple case-design. Yin (2009) acknowledges five rationales for choosing a single-case design; critical case, unique case, representative or typical case, revelatory case, and longitudinal case.

Based on our theoretical framework, we think that this case is both of representative and revelatory nature. It is a representative case as we want to capture the circumstances and conditions of how CE is practiced in the building sector by

studying representative firms and their employee’s experiences of how they practice today. It is also of a revelatory nature, as this phenomenon has not been investigated within the given context, i.e. the Norwegian building sector. Our theoretical framework shows it is studied to some extent on a global scale, but within our chosen context there is lack of evidence of how it is practiced today. Based on these rationales, we believe that a single-case study is the most reasonable approach.

Secondly, the question is whether this single-case study is holistic or an embedded case study. As our context is the building sector in Norway, we need more than one unit-of-analysis. To be able to conduct a study within the context we are required to have multiple units-of-analysis that come from different organizations as means to establish our findings at an “industry” level, rather individual. In conclusion, our case study design will be a single embedded case study.

After deciding our research design and determining our selection, which we explain in the following section, we were able to present our research design in the following figure 8. The research design includes 8 units-of-analysis. How we came about 8 units-of-analysis is explained in the following section **4.4 Sample description**.

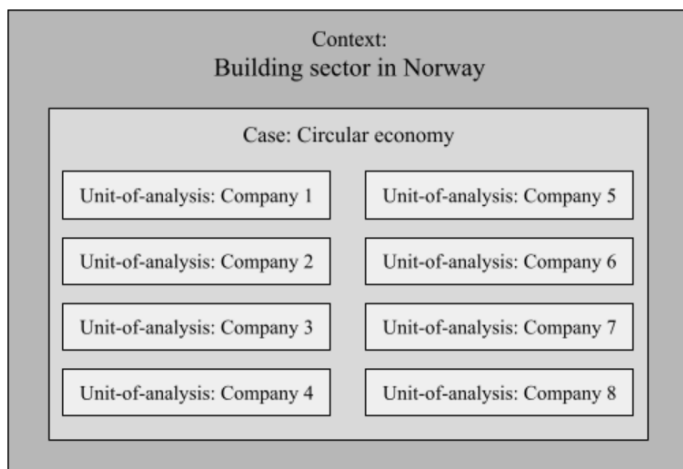


Figure 8: Research design of our study

4.4 Sample description

When deciding who should be the source of our data in this study, we first had to discuss the three factors *time*, *population* and *accessibility*. In the next section we will discuss these three factors in an effort to determine the sample of this study, and we will also discuss the sampling methods we ended up using to determine our selection.

As Savin-Baden et al (2013) says there are three factors one must consider when deciding upon whether to sample. Time is a factor which takes into consideration the need for time when conducting qualitative research, as this requires not only time to interview, but also the time to travel, set up, debrief, reflect and transcribe (Savin-Baden, 2013). Even after all this there is data analysis and data interpretation, which also takes up several hours. Taking this into consideration, we found that to be able to complete the work within the given timeframe we had to keep our sample limited to 8 firms with a maximum of 2 participants from each firm. Initially we thought about sampling up to 6 firms, as this was what we thought we could get access to. However, when we started reaching out through email, we received positive feedback which brought our sampling up to 8 firms. Up to 16 participants requires a large amount of time, however, we believe that this is just within the maximum level of data we can collect and analysis within the given time frame. To stay within the time frame, we decided to finish our interviews within the two first weeks of February 2020, which would give us enough time to transcribe and conduct analysis thereafter.

Secondly, we have the accessibility factor. Accessibility considers whether it is possible to gain access to information, especially access to the participants (Savin-Baden et al., 2013, p. 313). Both of us have close relations that work within the building sector, which gave us access to contacts and several firms. Although we had accessibility through our network it did not necessarily mean that it would give us automatic access to participants. As with the time factor, we initially thought sampling 6 firms would be hard to complete. This was due to the novelty of this phenomena, however after sending out initial requests, we found the response overwhelming.

The building sector has a large population and many actors, which makes it hard to conduct a qualitative research study on the whole population. When it comes to the population factor, we found it necessary to establish which population within the building sector in Norway can represent the sector in our study. Due to this we found it necessary to go deeper into the selection process by looking into different methods for participant sampling, whilst also applying a stakeholder analysis to support our final sample. This was done by first combining **2 Building sector** and **3 Theoretical framework**, and then applying this in a stakeholder analysis shown in table 6.

There are two main approaches for sampling in qualitative research; theoretical sampling and purposeful sampling (Savin-Baden et al., 2013). Out of the two sampling methods, we found purposeful sampling as the preferred method as our research is not grounded theory. This is underpinned by the fact that our sample selection is conceptually driven by our theoretical framework. Within purposeful sampling there are many sampling strategies e.g. homogeneous

sampling, theoretical or conceptual sampling, intense-case sampling etc. (Savin-Baden et al., 2013). These are some of the many different strategies that have been developed over time.

For our study we found theoretical or conceptual sampling as the most logical sampling strategy. The rationale behind this choice is that this strategy selects persons that are known to experience the concept, to be attempting to implement the concept i.e. the type of persons we are looking for. This sampling strategy is in direct relevance to our research question as we want to establish what the persons within a sector know about a concept, circular economy, and what measures are being taken to implement it today, as well as challenges regarding implementation. Savin-Baden et al (2013) propose that it is very common to combine strategies together, and for our study we see it as fit to combine it with convenience sampling in the form of network sampling.

The reason for combining conceptual sampling with convenience sampling (network sampling) is that our concept is often related to different roles within an organization. Therefore, it is hard for us to determine whom is the appropriate fit for our research. By having network sampling, we will be more compromised in the way that we as researchers do not choose participants, however, we believe that by using this sampling method we will be put in direct contact with persons that have experience of the concept and will be able to provide us necessary information. Within these organizations there are various of people with different roles that *can use this power*, and we deem it necessary to investigate not only one person per organization but up to two people. We find this essential as each person may have different perspectives on the phenomena within their organization and the sector, and what factors are affecting the organization's implementation of CE.

Using these two sampling strategies, we first must establish which sample we are to use, as well as persons within this sample. As established from chapter 2 **Building sector**, there are many actors in the building process. It is our mission to establish which actor enforces environmental or circular economic requirements regarding new buildings. The actors are construction client, general contractor, producer, architect, waste firm, and authorities.

Figure 6, found in section **3.2.2 Implementation in the Norwegian building sector**, show that construction clients are categorized as the stakeholder with the most impact. This is shown by how all circular measures within the category "new buildings" include a high concentration of green (the color representing construction client). The fact that all measures in the figure are highly concentrated by the construction client goes to show that actions toward implementing more CE in new buildings starts by them. Looking to the activities to enable these circular measures, we can see that responsibilities are more diversified between the stakeholders here.

This goes to show that though all stakeholders do not have the same degree of impact within the sector, they still play a vital part through their contribution. If the smaller impact stakeholders do not contribute through these specific activities, the implementation of CE will most likely be harder to execute.

Our stakeholder analysis focuses on the different stakeholders and their impact, degree of impact, and lastly, the circular effects these actors have, based on previous research and figure 6. The “Impact” section of the stakeholder analysis reflects and evaluate the roles of these stakeholders and what processes within the building sector they touch. “Degree of impact” is the level of impact we assume they have on the process of implementing CE in the building sector. The scale is as follows; low, low-medium, medium, medium-high, and high. High is the greatest impact and low is the smallest impact. Whilst the last category is “circular effects” which reflects what effects the different stakeholder have. Using the key (color code) from figure 6, it can help us determine both the stakeholder’s impact and what circular effect they have in the implementation process of CE. This in hand will help us determine which stakeholder(s) we should choose as our sample in this study.

Stakeholder	Impact	Degree of impact	Circular effects
Construction Client	Decision-makers regarding building specifics, investors, building process (holistically)	High	Drivers for change. Can facilitate circular measure from top-down in value chain.
General contractor	Builds, choose suppliers, procurement,	Medium-High	Drivers for change down the value chain
Producer / Suppliers	Create innovative and new technological solutions, decision-makers regarding use of resource	Low	New innovative solutions of materials and other resources
Architect	Decision-maker in flexibility of the building, as well as its esthetic looks.	Low-Medium	New innovative solutions regarding building’s structure and flexibility. Use design
Waste firm	Innovation and solutions of waste. Define how the value	Low-Medium	Advise and help throughout the value chain

	chain process and use its waste		
Authorities / Government	Can both engage and stop any building process. Define the playing rules within the sector.	High	Enable and/or prevent change.

Table 3: Stakeholder Analysis

In our stakeholder analysis, *table 6*, we found that though authorities/government are a high-impact stakeholder for circular economy in the building sector, they have expressed and chosen not to put forth stricter policies and regulations for the time being, which in hand pushes the responsibility onto the market and the other stakeholders. This is the impression we got in our initial research when we conducted preliminary research. From our theoretical framework, we see that all stakeholders in the building process is of importance for the overall implementation of circular economic elements and business model, however after conducting a stakeholder analysis (*table 3*) we have established that construction clients are the stakeholders who essentially have the last word as well as influence on whether the building is built using a circular economic approach.

Based on our stakeholder analysis we assume that by selecting construction clients as our sample, which in this case is unit-of-analysis, we will achieve greater insight into how the sector practice CE today, and why more have not been implemented to this day. Based on *figure 6* and *table 3*, they conclusively have the highest impact and power within the building process and can be recognized as the main influencer within the sector regarding changes. Therefore, we would like to collect information from construction client firms, both public and private, as these firms are central in deciding what environmental requirements the buildings must have.

4.4.1 Selection

Now that we have determined case, context and sample for this study, it is time to determine who will be our unit-of-analysis. We have established 8 units-of-analysis based on the sample description and sampling methods described in the section above. As mentioned earlier, we had contacts within the sector who gave us a preliminary list of construction clients from central and non-central areas in Norway. Using this list of firms, we reached out with emails which included some general information about us and the study, and whether they would want to participate in it. In our preliminary email we made a note of that we would like up to two participants that have a role or have some form responsibility concerning setting or applying environmental measures in their building projects. We also made it clear that even if the recommended participants from

the firm do not necessarily have a great deal of knowledge of the concept, this would not make their contribution invalid but rather provide us with greater knowledge of the concept in the set context. Using network sampling we were able to get 1 participant from three of the construction clients, 2 participants from four construction clients, and from one construction client we had a total of 3 participants. This gave us total of 8 unit-of-analysis and 14 participants.

In this section, we will describe the selected different construction clients to some degree. The reason we are not disclosing the construction client’s names and the participants names as there are not many construction clients in Norway, and we do not want the collected data to reflect poorly on any of the participants or units-of-analysis. In the table below, *table 4*, we have created an overview of our units-of-analysis and our participants. We have chosen not to include roles in relation to the unit-of-analysis due anonymity. The roles of informants generally included project managers, environmental advisors, directors and general managers.

Units-of-analysis	Participant(s)	Location	Public or Private	Type of building projects
Firm 1	<i>Person 1</i>	Central	Private	Offices and urban development
Firm 2	<i>Person 1</i>	Central	Private	Offices and housing
Firm 3	<i>Person 1</i> <i>Person 2</i>	Central	Private	Offices
Firm 4	<i>Person 1</i> <i>Person 2</i>	Central	Public	Multipurpose buildings e.g. schools, museums
Firm 5	<i>Person 1</i> <i>Person 2</i>	Central	Private	Offices and urban development
Firm 6	<i>Person 1</i> <i>Person 2</i> <i>Person 3</i>	Less central	Private	Housing
Firm 7	<i>Person 1</i>	Less central	Private	Housing
Firm 8	<i>Person 1</i> <i>Person 2</i>	Central	Private	Offices

Table 4: Overview of selection

4.5 Data collection

In qualitative research there are many different methods to choose between for collecting data. It can be done through interviews, fieldwork, focus group interviews, observations, or documents (Savin-Baden, 2013). Choosing the method that will enable us to collect this rich data will be

discussed in the following section and a further description of the method we chose and how we executed it.

4.5.1 In-depth interview

For our data collection we have chosen to conduct interviews. Our purpose is to gather relevant in-depth answers and have informants tell their story in a more conversational manner. We strive to uncover facts, gain complex in-depth information and to develop an understanding and interpretation of the situation (Savin-Baden, 2013). Some of the main benefits with this way of collecting data is that we get a lot of information in a short amount of time. We are also able to sort questions into topics and obtain impressions from multiple perspectives. This form of information-gathering is also responsive, and we have the opportunity to ask follow-up questions. However, there are some limitations. The flow of information can become overwhelming and we can lose focus on what we are after. The subject could remember wrong or answer dishonest. Informants could also answer what they believe we want to hear. Lastly, the process of transcribing the interviews can be very time consuming.

When conducting interviews, one can choose between four types of interview forms: structured, semi-structured, unstructured, and informal. The choice is often very dependent on the level of understanding the researcher has on the topic. Structured interviews are often most appropriate when the researcher has a well-developed understanding of the topic one is researching as it requires a very strict protocol where most questions are closed and standardized (Savin-Baden, 2013). By conducting a structured interview, you are not allowed to ask follow-up questions. Semi-structured interviews are appropriate when the researcher has less understanding of the topic and want to use the interview in a more flexible manner, where one is allowed to stray from the guide (Savin-Baden, 2013). It is often more open-ended than the structured interview, so it allows for interviewees to express their perspectives on the topic at hand, and allows researchers comparable data (Savin-Baden, 2013). As for unstructured interviews, the researcher often has a great understanding of the topic and requires no structured interview protocol, but rather a goal and plan. This requires the researcher to generate questions based on the context and that responses are broad. This is often applied when the researcher has a great understanding of the topic and the setting, and a clear agenda (Savin-Baden, 2013). Lastly, informal interviews are when researchers talk to people in the field without a protocol and without recording it. One relies on their own memory which makes it hard to record the data.

When deciding upon which interview type, we had to evaluate what we know based on our research on the topic. From our theoretical framework it is established that CE is a concept which is hard to define, and that there is a lack of practical implementation in the building sector both

globally and in Norway. This essentially means that we have to have open-ended questions to be able to get an impression of what is implemented in the building sector in Norway. We also have to be able to follow-up on questions as we want to have the ability to explore their perspectives further. Due to time we will only be able to perform one interview per interviewee, hence it is essential to choose a type that enables us to collect the necessary data on the day of the interview. Based on these reasons, we have chosen to conduct a semi-structured interview.

4.5.2 Interview Guide

Preparing a good interview guide is crucial in order to gather relevant and useful data. We divided the questions into sections starting with initial questions as a means to establish general information on the informant, then in-depth questions based on topics related to our theoretical framework with follow-up questions. The questions we prepared focused on the following:

- Introduction and knowledge on CE
- Sustainability and possible measure within firm
- Processes to handle waste, and current focus within the waste hierarchy
- Motivation for implementing CE
- The building sector and its focus on sustainability and CE
- Competitors
- Laws and regulations affect implementation of CE
- Current CE measures the firm has implemented
- Enablers for CE implementations
- Current maturity level of the market for CE
- What are the current barriers for implementing CE
- Further measures to implement CE
- Possibility for further implementation of CE in the future for firm and sector

The interview guide was divided into the five topics, where questions were centered on their impression and perception of CE and the implementation on an organizational level and sector level, including impressions of what the current barriers are within both organizational and within the sector.

Pilot interview

Before we conducted our interviews, we performed a pilot interview with a project manager in the building sector. By performing a pilot interview, we were able to test whether our questions performed in the way we intended, the duration of the interview, and whether the structure was

appropriate. The feedback we received was positive, although we did have to do some small adjustments to make sure some questions was not repetitive.

4.5.3 Preparations

Before the interviews were conducted, we had to carry out some preparations. As the interviews were to include personal data in the form of what role they had, we saw it necessary to apply for permission for this. We sent in an application for treatment of personal data to NSD, where we had to set up a consent form and an information sheet for our informants. This information sheet and consent form was provided to our informants at the beginning of the interviews, where we had to ask them for their signature on the consent form for the treatment of personal data and audio recording. The approval of the application from NSD, the information sheet, and a copy of the consent form can be found in appendix 1, 2 and 3.

We have already described earlier in **4.4.1 Selection** how we went about establishing contact with our informants. Using email, we had an introductory text prepared and sent to list of firms we had. It was important for us that our email requests were well prepared as this would be our first, and possibly only impression with the firms in question. Therefore, it had to be interesting, professional, short yet informative. Based on the number of firms we reached out to, we received mostly positive and quick feedback.

We provided practical information and focused on following their time schedule and offered to conduct the interviews at their locations. By doing this they were in a «safe and familiar location». We provided them information on which topics we were going to talk about. However, they were not provided with the interview guide before the interview. The reason behind this decision was that we wanted the informants to be as honest as possible. If the informants were to get the questions up front, they could prepare and maybe learn some things up front about things they did not know before. This could give an untrue reflection of the actual situation.

4.6 Data preparations and analysis

Following the end of interviews, it was time to prepare the data for analysis. As part of our data preparations we transcribed our data from audio format and then proceeded to use Nvivo as a tool for examining data. How we went about this is described below.

4.6.1 Transcribing

To conduct a good data analysis, it is essential to prepare the data first through transcription before proceeding to use an analytical software where we code our data before analysis. The first part of data analysis is to characterize the data (Savin-Baden, 2013). We as researchers must

choose how we would like to go about characterizing the data. Essentially it is whether we would like to transcribe “verbatim”, which means “to express in exactly the same words originally used” (Savin-Baden, 2013, p.419). Or whether, we chose to condense some of the data by excluding nonlinguistic observations or verbal tics that often occur during an interview.

McLellan, MacQueen & Neidig (2003) believe that one should transcribe the audiotape in its entirety and provide a verbatim account of the interviews. This means also including elisions, mispronunciations, slang, grammatical errors, nonverbal sounds and background noises. We chose to follow the proposed protocol by McLellan et al (2003) as strongly as possible, however deviating somewhat with the fact that instead of trying to express speech elisions such as “uhm” and “ehh”, we consistently chose to use punctuations in this case. This also applied to when participants would pause and think during their statements. We also chose to exclude slang or dialect when transcribing to make our text clearer to interpret during data analysis.

We divided the transcriptions up in two, where one would start with the first interview conduct, whilst the other would start at the end with the last interview. To assist us during the transcription phase, which is a very time-consuming process, we bought a subscription to the transcription tool called Transcribe. Transcribe is a software online that let us use features that would e.g. let us slow down the pace of the interview, rewind two seconds back automatically, and use abbreviations to save time. By using this program, we saved time by avoiding stopping the recording at every second as it would do it for us and auto-loop.

4.6.2 Coding

As a next step to our data preparation and analysis we started to examine our data. An essential part of our examination of the data was to code the data. Coding is labelling and categorizing the data using labels that describes or have a strong relevance to the data. Codes tend to be based upon themes, topics, ideas and more (Savin-Baden, 2013). Qualitative studies can often be overwhelming as you collect a great amount of information, however by using codes, it allows greater control of the data by sorting the data accordingly. In hand, this gives the researcher a greater overview over the data and can interpret patterns and relationships within the data.

To aid our coding, we chose to use NVivo as our analytical tool to systematically process our transcriptions. In contrast we could do it by hand using highlighter, however this appeared to be more manual and time-consuming. Using Nvivo we were able to not only code, but also classify our case “construction clients” and give them a set of attributes that could be used during our analysis. The attributes we used was based on our “general” section in the interview guide: location, experience, roles, and type of building projects.

To start off our coding we used the themes from our interview guide, which was based on our theoretical framework. This meant our initial codes were categorized into themes and concepts such as circular economy, barriers, implementation, and sustainability. We also included general information as a category to code information that could not be placed under the main themes and concepts but could be relevant in analysis. Under the four main categories, we also included under-categories to condense the data further. Coding was done a total of 27 times as we coded separately. The reason we chose to code separately was to create investigator triangulation, and as a quality measure to make sure that neither one of us missed out on coding what may be important for our data analysis. This in hand increased the study's internal validity.

4.6.3 Data analysis

After coding, we started our data analysis by merging our coding together into one document and deleted what had been coded twice. Though this was time consuming, we found it helpful to see what each other had thought in the process of coding. For starters we tried to organize and analyze based on our theoretical framework but found that our theoretical framework and our data could not be categorized accordingly to each other. When analyzing the data, we found it necessary to remove speech elisions as well as double words and words that did not add information. The purpose of this was to make the quotes more comprehensible and easier to read. When we had executed this and analyzed our findings, we sent the chosen quotes out to the corresponding informants.

4.7 Data quality assurance

Quality assurance is critical in order to provide a useful and good study. There exist many quality criteria within qualitative research. Even though most of these criteria are building around the same aspects, different researches have their own interpretations on what is important and why. Yin (2014), Gibbert (2008), and Eisenhardt (1989) sets of quality criteria are among the most used, and they address these criteria in different phases of the research process. They focus on different aspects on validity, while also discussing reliability. They also focus on quality criteria specifically in case-studies. Yin (2014) and Gibbert (2008) focus on the design-phase, while Eisenhardt (1989) focus on theory-building. Yin (2014) and Gibbert (2008) emphasizes the importance of construct validity, internal validity, external validity and reliability while Eisenhardt focus primarily on validity, reliability and triangulation. Due to the approach of our study and research question, we have chosen to use Yin and Gibbert's set of quality criteria. These will be elaborated in the following sections (Yin, 2014; Gibbert et al., 2008).

4.7.1 Construct validity

Construct validity is defined as “*Construct validity refers to the extent to which a study investigates what it claims to investigate*” (Gibbert et al., 2008 p. 1466), and “*it is about identifying correct operational measures for the concepts being studied*” (Yin, 2014 p. 40). For us this was especially important in the process of building the theoretical framework, regarding the fact that CE is a less common term. We had to use multiple sources of evidence (Yin, 2014). We used media, research articles, political notes and talked to “experts” within the field along with our interviews. We also had informants review our findings, in order to ensure that our gathered data reflect the reality.

We also had to make sure that we understood our informant’s interpretation of the term. Thus, we included questions to uncover this in our interview guide. We also asked what each firm have seen from other firms (open-ended, no firm in particular) in regard to implementation of CE, to see if implementation was visible for others.

Creating a chain of evidence is also important in order to ensure construct validity (Yin, 2014). Through the process of collecting data, we worked in a systematic way to store audio recordings, transcriptions, and other data. We used a shared and safe platform(database) and used change-trackers when editing. By using change-trackers we could easily find out when, by whom, and how changes were made. This made it easier when we had to go back and reflect on how and why we address or interpret something. This also assisted us when writing assumptions and conclusions (Gibbert et al. 2008).

Gibbert et al. (2008) also emphasize the importance of establishing how our data was achieved, and how they were analyzed, which thereby have been included in this section. We chose to keep quotes from the informants in their original language, in order to not change their message in translation. This also give the reader visibility of how we have extracted and made assumptions based on these quotes.

4.7.2 Internal validity

Internal validity refers to the extent in which causal relationships exist between variables and results (Gibbert et al, 2008). As we are to establish to what extent CE is implemented within the Norwegian building sector, and also establish what barriers that needs to be addressed in order to move further, we seek to find links between the barriers we find and the current extent of implementation.

This form of validity is mainly ensured in the phase of data analysis. First, we used key words from our theoretical framework in order to code our findings, in that way we could find patterns and match them to our theory. While coding we also did this separately, in order to ensure we found the same link. As the current research were somewhat insufficient, we also had to address other explanations, and in general build possible explanations during the course of our analysis. For the barriers chapter we also used theory triangulation, as research in the current context were insufficient. Hence, we addressed this part from overall perspective, in the general building sector and the Norwegian building sector in the theoretical framework (Gibbert et al. 2008).

4.7.3 External validity

External validity is about whether you can transfer your results to other settings. «*External validity*» or «*generalizability*» is grounded in the intuitive belief that theories must be shown to account for phenomena not only in the setting in which they are studied, but also in other settings”(Gibbert et al, 2008 p. 1468). It is about defining the domain to which a study’s findings can be generalized (Yin, 2014). Ensuring external validity can be done in different ways and depends on which type of study you are performing. For a multiple-case study you could use replication logic and do a comparative analysis. For our case, a single-case study, we used already known theories to build upon our findings (Yin, 2014). Explanations with details on our context is important in order to ensure external validity (Gibbert et al, 2008). We have done this in chapter **2 Building sector**, as we provide a description of the context along with why this context is appropriate for our research question. We also provided rationale for our case-study selection in this chapter (Gibbert et al, 2008).

4.7.4 Reliability

Reliability is about whether you can execute this study again with the same method and get the same results. Yin (2014) address the importance of how one should be able to repeat the study, by demonstrating the data collection process, and still get the same results. Gibbert et al. (2008) also emphasize that one should not have random errors, which enable researchers to arrive at the same insights if they construct the study along the same steps again.

This chapter, **4 Methodology**, is a good description of how our study has been conducted and are in many ways a reflection of our case study protocol. As elaborated in section **4.7.1** we stored all our data on a database. Labeled with enough information for us to understand, but still keeping the anonymity of the informants intact. Being structured and thorough opens for replication.

Details on when, how, and in what order, to which degree of depth is also visible throughout this chapter combined with our database. This increase the level of transparency (Gibbert et al., 2008)

Another way of ensuring reliability is to use informants actual name, however, due to the purpose of this study, and the type of questions we asked, and the level of analysis, we have decided to keep the firms and informants anonymous.

4.8 Research ethics

In a study it is important that the researchers show good research ethics and the same ethical guidelines apply to qualitative studies as any other study. When conducting scientific research, it is important that scientists set some criteria on their ability to reflect over their own practice (Ringdal, 2013). These criteria should be set in the “spirit of science” norms, such as communalism, universalism, disinterestedness, skepticism, and originality (Ringdal, 2013, p.452). In principal this means that our research should be shared and open to everyone. Second, that our research can be considered by established criteria that are independent of our age, sex, nationality, and our affiliation. Third, we should stay impartial throughout our research by avoiding bias. Fourth, we should be skeptical of others work when building on our own research, and lastly, our scientific work should be new and increase new knowledge.

Besides following the norms, we also have laws to consider in research ethics. Within social science, a researcher must protect the privacy of the people that choose to take part in the research. This is done through setting demands within the research process that secures participants their freedom and their right to protect their privacy. This demand is upheld by laws on personal information. The law says that any and all research- or student projects that include some form of personal information or data must be registered to Norsk Samfunnsvitenskapelig Datatjeneste, also called NSD (Ringdal, 2013). As part of our research process, we registered our project to NSD in early January. Our application to the NSD was approved on the 17th of January 2020, and the approval documentation can be found in appendix 1.

We informed the informants that sensitive information given in interviews would be censored or omitted, and the informants would be anonymized in the study. We chose to anonymize the firms as there are only a small number of construction clients in central areas of Norway, and because we wanted to enable our informants to speak openly and freely without thinking it could cause any repercussions i.e. protect their privacy.

Another part of research ethics is to also consider how our research effects the environment. We conducted our interviews at the informants' workplaces, which required us to take the train and travel locally by buss, trams or underground. Our carbon footprint was reasonably low when we travelled to execute the interviews, as we made use of public transport when we set out to travel from Kongsberg to the business locations. Another precaution we made to maintain a good environmental footprint, is that we tried to conduct as many interviews in the same day. This, and staying within the region of where the interviews were to take place minimized our use of transport.

5 Findings and Analysis

In this chapter we will present and conduct an analysis of our findings. The analysis will be further used in the next chapter together with the theory presented in the theoretical framework and our research question. The research question we want to answer in this thesis is:

“To what extent is circular economy adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy?”

Throughout this chapter we will categorize and select quotes from our findings to help us answer our research question presented above. We have chosen to present our findings and analysis under 3 sections: the concept, implementation, and barriers. Within these sections we will have underlying topics that are based on our findings. Using these underlying topics, we will present quotes from our informants and analyze these in relevance to our research question.

We have assigned each of the firms with a random alphabetical letter from A to H in order to preserve the firm’s and informant’s anonymity, whilst also being able to differentiate between the firms when we present our findings. This also includes numbers between 1 to 3 to differentiate between each informant in the firm.

5.1 The concept

The understanding of CE is a central part of our study. By analyzing factors such as how our informants were introduced to the concept, how they define CE, their knowledge on the concept, and their perception of sustainability, we will be able to describe and get an impression of the extent CE is adapted within the Norwegian building sector.

5.1.1 Introduction to CE

Questioning our informants about how they were introduced to CE was an essential part in trying to build a picture of how they as individuals within the sector and how the firms they represent are taking on the concept.

When we asked how our informants were introduced to CE, we received a broad specter of answers. From being introduced through their network, reading about it online or in the media, or not recalling how. A common factor the informants spoke of was that the focus on environment and sustainability had increased rapidly in recent years, which has led to increased awareness on CE. The use of the word CE had especially been used over the last the couple of years according to some informants. **H2** explain the increased focus as shown below:

«...det har vært snakk om det i mange år, men jeg synes det er først i de siste to årene, som det egentlig har begynt å skje noe rundt det. Det har vært fokus på det på Statsbygg, med Byggflokken, og vi har jo en satsing på miljø og bærekraft her lokalt. Men jeg vil si de siste årene egentlig, og mer og mer...» - H2

A1 reflected on the fact that the “school of thought” on the concept of CE has existed for a long time but have only recently gained more focus. Another informant felt they got thrown into it and was not aware of the extent in which they were forced to adjust routines, in order to work in a more circular manner. Only a couple of informants recalled being introduced to CE from corporate management, which was significant compared to other answers.

The term was addressed as a buzzword within the building community. Organizations such as The Federation of Norwegian Construction Industries (BNL), Byggflokken, The Confederation of Norwegian Enterprise (NHO), Norwegian Green Building Council and EU have contributed to create awareness on CE. We got the impression that informants with roles linked directly to environment and sustainability were introduced earlier to the term due to personal interest. Examples of both findings are shown below:

«Jeg tror egentlig det kom inn i den prosessen som Grønn Byggallianse og Norsk Eiendom jobbet med, eller gjennom Katharina Bramslev som gikk på dette studie for grønn vekst på BI, og som følge av EUs arbeid med det sirkulære direktivet. Det var nok egentlig min første kontakt med begrepet i 2016.» - H1

«... Så det er jo litt gjennom foreningene vi er i, om det da er boligprodusentene, NHO, Byggebransjens landsforening, Byggmesterforbundet.. Det er i de foreningene som de, så har de noen som er veldig på, som har det som en fanesak, og da blir jo vi dratt inn enkelte fora ...» - E1

We could divide these findings in to two main areas, through non-governmental organizations and through management. Those who had personal interests and/or had roles directly linked to the environment were the ones that were introduced the earliest. Most got introduced through non-governmental organizations, which may imply that these organizations have been key in order to increase awareness on CE. Some also mentioned being introduced through corporate management, which could imply that CE is possibly a part of their strategy.

5.1.2 Defining CE

We asked our informants what they knew about CE as a part of establishing the level of knowledge within our informants. By analyzing what they know and define CE as, it can help build upon the foundation around what extent CE is adapted within the sector.

A common factor we found in our findings was that the informants did not describe what CE was when directly asked about it. More than half avoided giving precise answer as to what circular economy entailed, and rather spoke around it. One may see this as a digression, as many started explaining how they worked with CE, or said they know a lot without elaborating further. We asked the following question: *What do you know about circular economy?* One example is shown below:

«Jeg er vel den i bedriften som har satt meg mest inn i det, men det er jo sånn jeg tenker på bransjemessig så er det jo en kompetanse utfordring. Alle er jo i ferd med å lære seg dette her, og du skjønner prinsippet på at man skal lukke alle strømmen på en måte.» - A1

As **A1** exclaim, this might reflect how novel the concept is in this industry or may reflect uncertainty around what the concept entails. The impression we got from most of our informants was that they were a bit unsure about whether their description of what CE entailed was correct or not. Some were very honest about the fact that they should probably know more about CE. The few informants that directly tried to answer our question used words like “reuse” and “recovery” when describing what circular economy entails.

«Du, jeg kan nok altfor lite om ordet sirkulær økonomi. Det jeg tror sirkulær økonomi handler om det er vel ... jeg tror det handler om det er jo å gjenbruke ting, rett og slett. Også at du istedenfor å skrote ting gir det nytt liv på en eller annen måte, og bruker det på nytt igjen i en eller annen sammenheng ...» - F1

A point informant **F2** made was that CE entailed building in a way that makes it easier to use again in the future, which is one aspect that many did not mention. As for reuse, informant **F1** expressed confusion as to what is implied by reuse and drew lines to lack of clarity in the guidelines and measures proposed by Norwegian Property and The Norwegian Green Building Council. This may imply that information that is available for them may be a bit unclear or lacks considerations on the level of practical competence.

One informant, **B2**, said that their knowledge was quite good based upon their direct experience in working with applying CE within their building projects. Two informants were more precise

in defining CE and described it in a more holistic way, and included the importance of waste being a resource, closing the material loop and resource utilization, as seen below:

«... Jeg skjønner jo hva det går ut på, det er jo at avfall er en ressurs og at man skal skape minst mulig avfall, når du river og for eksempel bygg, at du tar vare på de gode materialene i det bygget du river så det kan bli bruk i andre bygg da, som senere, altså at det går i et mest mulig evig omløp så vi ikke får noe avfall til slutt, tenke vugge til grav å helst ikke grav. Vugge til gjenfødelse.» - D3

«I bred forstand handler det om å få alt avfall til å gå i sirkel i økonomien, og være en ressurs istedenfor avfallet blir tatt ut av økonomien gjennom deponering av avfall. Jeg tenker at essensen av sirkulær økonomi er at alle ressurser skal sirkulere i økonomien og at det er ingenting som går rettlinjet gjennom og blir avfall uten å bli utnyttet.» - G1

In general, most of the informants from the bigger firms were more confident in their knowledge on CE, compared to the smaller firms. An exception from the smaller firms, were **D3** which was able to answer us quite precisely. This person worked directly with BREEAM certifications of the firms' building projects, which may explain why this informant was able to explain CE to us so easily.

An aspect that was brought up by some informants was that it was hard to define what CE meant to either their firm, or even the building sector in general. Informant **G2** spoke of how they had invested a lot of resources in trying to translate what CE is for them and the sector, however they had no luck as no one could tell them. Informant **A1** also spoke about how they found it challenging to define what CE is for them as a firm and how to break the concept down. This may support the notion that there is uncertainty around what the concept entails especially in regard to defining it within the Norwegian building sector.

When analyzing our findings, we found it somewhat surprising that several of the informants expressed that they knew a lot about CE but did not necessarily explain how or why. For us to determine whether they know what CE is, it was important for us that they tried to explain it to some degree. Without this explanation, we can assume that either they know what they exclaim they do, or it could imply that they find it hard to explain. As for the ones that did explain what CE meant for them, several spoke of the reusing materials or products in contrast to letting it become waste. The fact that reuse was such a common word used in explaining CE may imply that this is what they have interpreted as the main aspect of it, or that this is something that has been presented to them through some of the NGO's mentioned in the section before. The fact that

one of the informants brought up the “10 immediate measures” proposed by the collaboration of The Norwegian Green Building Council and Norwegian Property, may support the last point.

Based on our findings, it implies that most do have knowledge of CE although it is hard to determine to what extent based on the responses we received. Although this was rather an individual question and not in regard to the firm, it does help us make up an impression of what CE mean for people in the sector.

5.1.3 Sustainability

Our impression is that sustainability and CE fits like hand in glove, and for that reason we found it necessary to address this concept in our interviews. We also assumed that our informants may not recognize what elements are included in the term CE, which also were reflected in the previous section. This assumption was somewhat supported by the fact that we experienced that many shared several circular elements when we used the term sustainability in our questions.

When we asked what our informants’ interpretation of sustainability was, the most common answer was to have a balance between environmental, financial, and social aspects. Building their buildings to last as long as possible was also emphasized as important in regard to sustainability. One example is shown below:

«... du må ha med deg alle de tre pilarene, det sosiale, økonomi og miljø. Når vi har definert det for oss så handler det om klima, sirkulær økonomi, ressurseffektivitet, nabolag, altså folk. Det er ikke bærekraft om man ikke får med seg den sosiale dimensjonen.» -A1

Some reflected on seeing the bigger picture, use less non-renewable and virgin resources, reduce CO₂ emissions, to take care of what we have and reuse as much as possible. Two informants also addressed the fact that focusing on environmental aspects may be better for the world yet being less economically sustainable for their firm. Another informant also reflected on how the Western-European countries are obsessed with “new and trending” which is often not sustainable. As **B2** exclaim below, some also saw CE as a tool for acting in a more sustainable manner.

«...man må jo begynne et sted, og ressursene blir jo redusert betraktelig på verdensbasis. Man må begynne å ta grep for å ikke bruke opp alle reservene vi har. Og der mener vi at en sirkulær økonomi er en god måte å imøtekomme det på..» - B2

Sustainable measures

We asked about sustainable measures within the firm. They mentioned focus on local reuse, keeping register of what they have available within the firm and their properties, using BREEAM, exploring needs in the market in terms of social measures, climate and environmental accounts to reduce emissions, both in the building process and the operative phase after. **B1** emphasized that both sustainability and CE has been a focus at all levels in their firm and within their building projects, such as suppliers, routines, development, and construction. A significant point made by **E1**, was that they saw the sustainable way of building as a win-win for both customers, in regard to lower price during the use of the building, as well as for the environment. One example is shown below:

«... Vi må sørge for at selve prosjektet, i prosjektfasen, gir minst mulig miljøfotavtrykk, og at det tilrettelegger for minst mulig avtrykk i driftsfasen.» - H1

Informants from one of the smaller firms said they did not really focus on sustainable development as a main area, however when we asked other firms of examples in the industry on sustainable measures, this firm were mentioned using geothermal heating solutions, both in regards to environmental and financial aspects for the end user. We may reflect over the fact that this specific project was a BREEAM-certified project built for their municipality.

Industry and sustainability

We included a question where they reflected on how the industry in general acted in terms of sustainability. All agreed that the focus has increased rapidly as mentioned in “Introduction to CE”. Many mentioned had been evident in the last five, especially two years. One informant stated that this is something the whole industry is working on.

However, there was a difference between central and less central firms. Less central firms addressed the fact that the market was on standby. Thereof, being able to sell was more important than being environmentally sustainable, in order for the firm to survive. They did not see the demand for more sustainable buildings. These firms were also working with housing instead of commercial buildings. Firms in more central areas experienced a high focus on sustainability, and what had earlier been only talk, now were taken into action and specific projects were brought up as examples. Yet most of them state that even though the focus on sustainability has increased and measures are being taken, they still have a long way to go, and measures must be taken on a bigger scale.

BREEAM was mentioned by many, and it has become somewhat of a standard for the industry:

«... BREEAM har gått fra å være ganske avskrekkende til å bli nesten standard i alle nybygg. Om man ikke har bygget et BREEAM-bygg, så kan man få spørsmål om hvorfor vi ikke gjort det. - C1

«Ser at det kommer veldig mange BREEAM prosjekter, og det er jo med på å gjøre at mange bedrifter kanskje legger litt om, at de gode rutinene som etableres gjennom BREEAM vil de dra inn i andre prosjekter også.» - D3

Another informant said governmental buildings have had a bigger focus on sustainability. Focus on waste management were also mentioned to be one of the things they have been focusing on for long time. Some felt the industry has become more open, and willing to share and learn from each other. On the other hand, one informant expressed that other actors in the sector, such as contractors, have not been as positive as they are used to doing things a certain way.

One of the informants sums up the industry and its focus in a chronological manner as shown here:

«De siste fem årene har det skjedd fryktelig mye. Det begynte en utvikling når energimerkeordningen kom i 2009-10. Det ble veldig økt bevissthet, og det er mange innvendinger mot energisertifikatenes kvalitet og innretning, men det gjorde at alle byggherrer måtte ha et fokus på energistandard... ...Så fikk vi BREEAM sertifisering, som ivaretar bredden i miljøaspekter og bærekrafts aspekter på en god måte... ...Da fikk man en god kvalitetsreferanse på hva det er å bygge bærekraftig, som har vært et opplæringsmoment for hele bransjen... ...Og da er det en del av bransjen, spesielt de store aktørene, og spesielt de Oslo-nære aktørene som nå jobber med bærekraft på en veldig god og systematisk måte. Så er det selvfølgelig en del av bransjen som ikke er der, og en del av bransjen som er mer kortsiktig enn vi er. Noe som kanskje gjør det litt populistisk. Men det har skjedd veldig mye, og nå begynner det å bli så mange som jobber helt konsekvent med å BREEAME byggene sine. Da blir automatisk både klima og mange miljøaspekter ivaretatt på en god måte. Likevel er ikke sirkulærøkonomien godt nok integrert enda, men det kommer i nye revisjoner av denne ordningen ...» - H1

H1 also explain that greenhouse gas emissions have gained increased focus, which could be an enabler for CE, as reuse of materials generates less emission. Energy use has also had a higher focus, and health- and environmentally friendly materials, which has prior been a difficult area. However, due to the BREEAM certification this has been easier to cope with.

One informant, **E1**, reflected on the difference in focus on sustainability to the football league table. Some are in the sixth division and some are in the Premier League. **E1** explained that the competitive conditions are different, and some smaller firms are not at all aware of what CE and sustainability means, yet the bigger firms are more aware.

A1 explained that the whole industry is shifting towards a more sustainable development, especially the bigger firms. The informant said that a lot has happened within this area the last two years than it has for the past twenty. To **A1**'s impression, everyone is talking about it and objectives are starting to take form in order to become climate neutral. There are more BREEAM certified projects, yet it remains to see if all objectives are set into practice.

To summarize this topic we see that environmental, financial, and social aspects are central, as well as building to last and seeing sustainability in a bigger picture. A couple mentioned that CE was a great tool to work in a more sustainable manner. Less central firms addressed the fact that the market was on standby and that they did not see the demand for more sustainable buildings, especially for housing. Central firms experienced a high focus on sustainability, and what had earlier been only talk, now were taken into action and specific projects were used as examples. Yet they still have a long way to go, and measures must be taken on a bigger scale. BREEAM was mentioned by many, and it has become somewhat of a standard for the industry. Focus on waste management were also mentioned to be one of the things they have been focusing on for long time. Greenhouse gas emissions have gained increased focus, which could be an enabler for CE, as reuse of materials generates less emission. Energy use has also had a higher focus, and health- and environmentally friendly materials.

5.2 Implementation

Circular measures were something we asked all our informants about as a part of determining the extent CE was adapted within their firms and the sector in general. Throughout this section we investigate measures within their firm, measures they have across their projects, measures their competitors have, and an impression of the measures within the industry. By analyzing these findings, we can determine the extent CE is implemented.

5.2.1 Strategy

When we asked our informants what CE measures they had within their firm, several of the informants would speak of their organization's strategy and explained how CE was incorporated in it. There was a difference to what lengths CE was implemented strategically, as this was not necessarily something we asked them specifically about, but rather something the informants shared when explaining what they have implemented.

Informant **B1** exclaimed that they as an organization were heavily invested in implementing CE, and that the high focus on environment within the firm made it natural for them to take it on:

«for oss faller det veldig naturlig, for det har vært med oss så lenge, dette med mer fokus på miljø. Så om strategier på toppen skifter litt retning, så er det fortsatt helt naturlig ettersom vi hatt det med oss i så mange år. Det sitter i ryggraden, i DNAet til firmaet, det med miljøet. Den ligger så høyt og er med oss, og det er ting vi skal gjøre og må utvikle oss på. Vi må fornye oss der også.» -

B1

The informant also exemplified how they as a firm try to challenge the usual building processes through their building projects and try to do what no others have done before them on a big scale. Although the informant implied that they were heavily invested across the organization, the person did recognize that there was further work to do, reflecting upon their project execution model and addressing CE from an early phase in the building's life cycle and throughout their building projects.

Another firm, **Firm G**, had a very thorough environmental strategy with clear ambitions for the whole firm, and further into their various business areas. The informant, **G1**, said that all their areas of business had objectives in regard to environment, CE, and the local environment. The person also pointed out how they work systematically with creating an awareness toward environment and sustainability within the whole firm and across functions:

*«Vi har gjort mye for å sørge for at strategien skal være gjennomgående, og at alle roller tar ansvar for miljø, ikke bare fagekspertene. Vi synes vi har kommet ganske langt, men det er fortsatt noe vi må jobbe kontinuerlig med for å holde bevisstheten oppe. Det er ivaretatt i systemene våre at det skal følges, men man trenger hele tiden påminnelser med informasjon, opplæring og kompetanse. Vi har nettopp hatt en internkampanje, hvor vi har hatt tre kurs som har gått ut til alle på epost. Disse omhandler miljøstyring i virksomheten, og viser samtidig hvem som har ansvar for hvilke deler av miljøansvaret i bedriften.» - **G1***

The impression we got from several firms was that they were currently setting new strategies that would involve CE in a greater manner than before. This may be due to the fact that CE has recently gotten more focus in the building sector. Informant **C1** spoke of how they still have to become better in regard to implementing CE, but that the focus on CE was evident in their sustainability strategy. The informant also pointed out that they were currently working on setting a new environmental strategy, and that CE would be of even higher focus through this.

Another informant, **F1**, spoke of how they have recently put forward a new environmental strategy for the whole firm. Setting higher BREEAM ratings on all new building projects was one of their objectives in this new strategy. Other strategic measures the informant pointed out was that they had decided to adapt UN's Sustainability goals and Norwegian Green Building Council and Norwegian Property's "ten straightforward measures" as a step to become more circular and sustainable. Apart from the overall strategy, the informant said they had different approaches depending on whether it was project specific goals or a tenant adaption:

«Når det gjelder i prosjektspesifikke målene når vi utvikler prosjekter, så er det gjerne prosjektansvarlig som kommer med forslag til mål, som deretter vedtas i ledergruppa. Når vi skal gjennomføre et en leietakertilpasning, så ønsker vi også å ha et miljøfokus også her, for eksempel ved at vi i størst mulig grad skal tilstrebe å bruke miljøvennlige produkter.» -F1

An informant from another firm, **H2**, also pointed that they have set specified BREEAM certifications strategically. Where their total rehabilitation projects were to be built in regard to BREEAM certification Very Good, and new building projects were going to be BREEAM excellent certified.

As pointed out in **5.1.3 Sustainability**, the focus on sustainability is currently very high in the building sector. With such a high focus on sustainability, it did not come as a surprise that many had regarded CE as part of the firms' strategy. The impression we got from the answers was that there was a clear difference between some of the firms. It came across that both **Firm B** and **Firm G** had a very strong focus on CE from the top-down within their organizations. From our findings, they both gave the impression that CE is something they are working very much on trying to realize through setting objectives and awareness in their firms.

With regard to other findings, it was clear that many of the firms have strategically positioned themselves to take on CE in a greater capacity, although we did get an impression that it is currently in the early stages and finding its footing. It seems that although firms have a strategic goal of becoming circular, measures and objectives regarding CE is based on the type of project they do and is set specifically in that project. This could imply that CE is still in an early phase of being implemented.

Lastly, BREEAM was also brought up as part of the strategy for some, which we interpret as a way for many to perform more sustainable during the building process. Having objectives to reach a certain BREEAM certification, may be a driver for many to become more sustainable, but also an enabler for circular thinking throughout the building process.

5.2.2 Waste hierarchy

As many answers could be connected to the waste hierarchy, we chose to focus on the questions specifically related to the hierarchy for this section. We asked them where in the hierarchy they focused today. The answers varied from describing the focus of the industry in general or their specific firm. As this question was asked mainly to get an overview of their focus area, we have provided the answers for this section in tables.

We discovered that there were different interpretations of the term “energy recovery”, these are marked with asterixis in the following tables. These informants referred to the term, as energy-saving and -efficiency.

The first table, 5, provides an overview of *the firms* focus area in the waste hierarchy. An interesting observation were that focus areas varied among informants within the same firm. We reflect over fact that their roles were of different occupation, which could cause skewness. **Firm G** was coherent and had measures for all areas. **B2** worked directly with a project of a circular nature yet did not reflect on the focus areas within the firm. Does the informant think we already know their focus due to their belief of it being obvious, or is the informant not aware of their focus? This informant did although reflect over the industry’s focus which could also indicate a misunderstanding of our question.

	A1	B1	B2	C1	D1	D2	D3	E1	F1	F2	G1	G2	H1	H2
Reduction		High focus		High focus			Some focus	High focus	High focus	High focus	High focus	High focus	Medium focus	
Prevention		High focus		High focus	Some focus	Some focus		Medium focus			High focus	High focus	High focus	
Re-use		High focus		High focus				Some focus		Some focus	High focus	High focus	Some focus	High focus
Recycle	High focus	High focus			Some focus			High focus	High focus	High focus	High focus	High focus	High focus	High focus
Energy Recovery	High focus				Medium focus*		Some focus			High focus*	High focus*	High focus		
Disposal					Some focus									

■ High focus
■ Medium focus
■ Some focus
 * different interpretation of the term

TABLE 5 FOCUS IN WASTE HIERARCHY - FIRM

For those who reflected on the focus of the industry in general, close to all mentioned “recycle” and “energy recovery”. Some also mentioned an increased focus on re-use. These informants were from firms located in central parts of Norway. These findings are presented in table 6.

	A1	B1	B2	C1	D1	D2	D3	E1	F1	F2	G1	G2	H1	H2
Reduction														
Prevention														
Re-use					High focus					High focus				
Recycle	High focus		High focus		High focus									High focus
Energy Recovery	High focus		High focus*											High focus
Disposal														High focus

■ High focus
■ Medium focus
■ Some focus
 * different interpretation of the term

TABLE 6 FOCUS IN THE WASTE HIERARCHY - INDUSTRY

5.2.3 Waste management

Waste is a natural consequence of building new buildings and removing old buildings, and with the amount of waste the building sector produce we found it interesting to find out how the different firms handle waste and what requirements they set for their contractors.

Degree of waste separation

All of the firms have a waste separation degree they set for building projects. Waste separation is an activity that require the workers on the building project to separate as much waste as possible accordingly for recycling. The higher degree of waste separation you have the less waste is sent to the landfill and the more can be recycled. This is often set by the construction client and executed by the contractors on the project.

The bigger firms all had a high degree of waste separation requirement, averaging at about 90 % separation per project. When we asked our informants how they felt this requirement was upheld by contractors on projects the responses were somewhat varied, but most were satisfied:

«Vi oppnår høy sorteringsgrad på avfall fra byggeprosjekter fordi entreprenørene er veldig flinke og fordi at det er veldig gode ordninger på mottak.» - F1

«Stort sett så blir det opprettholdt. Vi har ett prosjekt hvor de ikke har oppnådd høy nok sorteringsgrad, og da tenker vi å ta et oppfølgingsmøte for å høre hva årsaken til dette er.» - C1

Whilst the smaller firms did not have such a high average. One of the smaller firms said that apart from BREEAM certified buildings where they have over 90% separation degree, they do not set a higher degree requirement for waste beyond the one set by law at 60% presented in TEK 17. The second small firm had a bit higher with a 75% separation degree requirement.

Our impression from the interviews is that most contractors out there already practice a high degree of waste separation, and that having a high degree of separation is sort of the norm in the building sector now. Though there was some difference between the smaller and bigger firms, the impression was that the degree of waste separation will become absolute in the near future.

Amount of waste

Another measure for handling waste that some firms had was a requirement for maximum amount of waste per square meter. This was a measure that seemed very novel within most of the firms, where only three firms seemed to practice this measure at their building projects. None of the smaller firms practiced this measure.

“Og maks 25 kg per kvadratmeter, nybygg. Det det klarer vi ikke i dag, det viser seg. Men vi prøver i hvert fall å påvirke der vi kan.» - A1

«..krav til lave avfallsmengder, under 18kg per kvadrat, som er ganske lavt. Det er ikke uvanlig med 25 heller... 18 kg? Det er vårt krav nå på det prosjektet vi har nå. Man må jobbe med leverandørene, for å sørge for at de enten emballerer mindre, eller at de tar emballasjen tilbake, og da skaper man et insitament til at de velger emballaseløsninger som er tilrettelagt for gjenbruk og ombruk.» - H1

A surprise for us was that one of the firms who had implemented several circular measures said that they had not looked into setting such a requirement yet. This was claimed to be because they mostly rehabilitated their buildings, where the amount of waste is fixed whether they like it or not.

The two last big firms did not have a requirement for waste amount at this time, however informant C1 said that this is something they are looking into and will introduce in the near future. *«Etterhvert skal vi også begynne med å stille krav om mengde per kvadrat- for at det ikke skal bli mer avfall enn nødvendig. Vi har også miljøoppfølgingssystem på avfall, sånn at vi i driftsfasen også ser hvor mye avfall vi genererer både i kilo og sorteringsgrad» - C1*

Even though three firms did practice setting this requirement in their building projects, all of them spoke of challenges with upholding the requirement that they had set. Where lack of systems and knowledge was the reason behind it:

«... men vi er nødt til å begynne å jobbe med volum og mengde... Der er ikke bransjen så gode enda. Mange av entreprenørene jobber med det, så de prøver å komme ned på mengde.. ... men vi ser det er vanskelig.. Der er det potensiale for forbedring.» - A1

This might reflect that there is still much to be learnt within the supply chain in regard to handling requirements set by the construction client.

From this topic, we realized our informants in general had a high average of waste separation and we assume this is meant as an enabler for increased material recycling which is often done by the waste-firms. Most also reflected over the fact that they are better than the requirements set in TEK. As one of the informants nicely put it, waste management is something the Norwegian building sector has been good at for a long time, hence it is not surprising that firms could implement such high requirements on waste separation. Although they were good at waste

separation, there were only three firms which have requirements to reduce the amount of waste. We assume that this could be ideal to create more awareness around the amount of waste, which again could open for ideas on how to prevent waste earlier in the building phase. Some claim it is difficult to set requirements for amount of waste as many are working with rehabilitation projects which make the amount set from the beginning. Yet challenges with upholding requirements of amount of waste could also be linked to knowledge and processes within the supply chain.

5.2.4 Circular measures

Firms

To help us determine the extent CE is adapted in the building sector, we asked our informants what circular measures they had within their firms today. This was first and foremost to establish what they interpret as a measure in relation to circular economy, but also to find out what measures are present in the sector today and what these measures tell us in regard to our research question. As the firms had very different circular measures within their firm, we found it necessary to break this section up and present measures from each firm as a means to analyze it better. Though the idea of the measures was often the same, the processes and the extent was very different from one firm to another.

Informant **A1** said that they try to go by the “sharing is caring” thinking in their building projects and organization. Sharing space, energy and cars were some of the measures they had, where area efficiency was the focal point. One of their examples was specifically around only having one cantina to share per building, rather than having a cantina per tenant which would make the space a waste in regard to use. Besides sharing mentality and area efficiency in their projects, they also had reuse of inventory i.e. desks and chairs as a circular measure. Our impression was that the level of reuse was only internally within the organization and across their buildings.

*«... Det er ofte sånn at det er noen pulter til overs her, også er det noen stoler til overs der, og lamper og aggregater etc. Så vi prøver å holde oversikt over hva vi har som er brukbart.. ..inventar etc., og som er enkelt å flytte mellom byggene. Vi prøver å gjøre det, det går litt mellom de ulike byggene vi har og vi gitt bort ting til leietakere.. Vi prøver å ikke kaste ting.. det blir ikke volum av det, men det har noe med at man bygger en kultur..» - **A1***

We found it interesting that the informant pointed out that these small activities within the firm such as reusing inventory in their buildings was part of building up a culture of reusing things rather than throwing away.

As mentioned in the section above regarding the waste hierarchy, informant **A1** expressed that their firm was no better than everyone else in the sector, which was energy recovery and material recycling, according to them. When we asked the informant what other circular measures they had besides the ones presented under waste management, their response implied that their main focus correlated with what had been said before. Though the informant did not say that they directly had any reuse beyond reusing inventory internally, the answers we received did imply that this is something they are assessing in every project with the collaboration between them and demolishing- and waste firms:

«..vi har med oss rive-entreprenørene og avfallsselskapene, nettopp for å se på hva er det her? Hva er det som finnes her av volum, mengde og materialer? Er det noe vi kan bruke om igjen i prosjektet, kan vi bruke noe av den knuste betongen til bærelag under de nye byggene f.eks.? Hva kan vi gjøre? Hvor høyt kan vi dra materialgjenvinningen her, slik at det ikke havner på deponi?»

- A1

The informant also addressed that they are looking into solutions with design for disassembly in new projects through collaboration with manufacturers.

In firm **B**, reuse was the focal point of their circular measures. Informant **B1** expressed that they have reuse throughout their organization both in regard to inventory and structural components. The informant also implied that they perform reuse outside their organization as well, and that this was something they would like others to perform as a means to create CE on a larger scale within the sector:

“Vi har et behov her. Her kaster vi noe, kan vi bruke det til noe? Også på tvers internt, men også litt ut i bransjen for å se hvordan andre gjør det og hvordan kan vi kan gjøre dette på kryss og tvers av de store aktørene. For å få sirkulær økonomi til å fungere i stor skala så må flere av de store eiendomsaktørene på banen, vi kan ha en sirkulær økonomi internt i bedriften, men skal vi få det store hele bildet og virkelig påvirke og gjøre noe for miljøet så er vi nødt for å gjøre det i stor skala. Vi må gjøre det på kryss og tvers av de store selskapene» - B1

Informant **B1** also spoke of how they are currently developing a tool to enable the process to perform more reuse such as a database, as the process is very manual for them today.

Informant **B2** is currently working on a project that is of a circular nature. Some of the explicit measures they have within this project was that for the building extension they collected and used 80% of steel structures from other buildings. To enable dismantling of the building at a later point, they are welding less and using more bolt connections. Within the internal structure of the

building they are actively identifying products that can be easily dismantled and remounted, either now or later. The informant also implied that new products that had the ability to be reused were currently being introduced to the market.

«Vi har sett på produkter inni bygget som for eksempel delevegger, glassvegger, hvor man ser på nye produkter som lett kan demonteres og monteres ... nå ser vi mer på produkter som vi kan demontere, lagre ett sted også kan vi montere det hvis vi ønsker det. Det kommer nye produkter på markedet nå som er mer tilrettelagt for gjenbruk og den sirkulære biten. Det er veldig interessant.» – B2

Informant **B1** pointed out that they actively go out both nationally and internationally to share their knowledge on the matter, which can be seen as a circular measure.

«Vi går aktivt ut, ikke bare i Norge, men på kryss og tvers i hele verden, spesielt Europa, for å få med oss hva som skjer. Vi jobber veldig bredt mot bransjen generelt, i forhold til å informere og dele hva vi jobber med og hvordan vi har tolket å gjøre ting.» - B1

Even though reuse of existing materials, inventory and components seemed to be the essence of their reuse measures, the measures proposed through their ongoing project showed that they are also creating a demand for a new line of products that are designed to be reused, which is another perspective in relation to reuse.

Firm **C** was another firm where their main focus was reuse as a means to implement CE. Informant **C1** implied that the focus was especially strong in regard to tenant adaptations, where they as a measure have firms come in and assess whether they can reuse all inventory. Reuse of existing inventory seemed to be the extent of reuse they focused mainly on within the organization. This notion was supported by another example that the informant spoke of:

*“I *prosjektnavn* skal vi ombruke mest mulig av det som er der, internt. Og det som vi ikke får brukt, vil noen eksterne aktører komme og hente, slik at det kan ombrukes andre steder.» - C1*

As for future projects, informant **C1** implied that they are currently planning a new-building project that is to be designed for reusability i.e. the ability to dismantle it, where the thought is to create a recyclable building. As to how they were planning on executing this was not elaborated on further. In comparison to **Firm B**, the informant also said they are working on a tool as a means to perform more reuse:

*«Vi er i dialog med *selskap* for å få en oversikt over alt vi har av overskuddsmaterialerNår f.eks. noen leietakere flytter ut og de har masse pulter eller andre ting, de ikke trenger videre, så kan vi ha en database og registrere det. Da kan kanskje noen andre bygg bruke det*

eller noen andre prosjekt internt i selskapet. Vi må ha et system på alt så vi ikke bare kjøper, bruker og kaster.» - C1

Firm **D** gave us the impression that they had not implemented any circular measures at this moment:

«Jaja, men per i dag så er det ikke implementert veldig mye ...» - D1

As to why this might be the case will be presented and analyzed in the barriers section of this chapter.

Firm **E** implied that they have measures to reduce the amount of materials, where they would avoid wastage by conserving the residual materials and deliver them back to producers or use in future projects. Informant **E1** also said they would often try to choose environmentally friendly products in their buildings.

Firm **F** had a concrete measure in regard to reducing material use, where they would often demand use of BIM by contractors in their projects. As many other firms, they also said that they try to use as many environmentally friendly products as possible in their building projects and pointed out that they have energy reuse through solar panels and other energy saving measures. Besides these measures, informant **F2** spoke of how they do try to reuse as much as possible in their building projects, especially technical installations within the buildings.

Informant **F1** spoke of how they try to perform greenhouse gas analysis for every project to evaluate and determine what actions are appropriate to take in regard to the effect it will have on the environment. The actions the informant spoke of was whether they should rehabilitate the building or demolish it and build a new one, and what effects these actions would have in the long run on the environment. This is an interesting point and observation by the informant as to whether the current focus within the building sector in Norway is narrowed in on materials rather than looking at the big picture. And as for firms focusing on reusing and rehabilitating buildings – is this necessarily the blueprint for CE in the building sector?

Next up we have **Firm G**, who described their firm as having a very strong environmental focus through their strategy. Informant **G1** described the firm as having specific measures related to each level of the waste hierarchy, both strategically and in building projects. They demand recycled content in several of the products that are delivered to their buildings to preserve material recycling. As part of their strategy, they require at least three products with a minimum requirement of recycled raw materials for each building project.

Another example of recycling measures they had was specifically to steel work. They require a minimum weighted average of 70% recycled content in steel, and they also require that reinforcement steel they use is made up of a 100% recycled steel.

Informant **G1** also implied that they have a goal to have certain amounts of reuse in new building projects as many other firms. One way they have performed reuse was to take down hole covers in one of their projects and go through due process to get it re-certified and quality checked, before sending it to another construction client to be used in another building project. Another example was using glass walls from a renovation they did and put it in another one of their building projects as a means to uphold the environmental requirements set for that specific building.

They also have certain goals in regard to reducing their CO₂ emissions, and the informant implied that CE was used as a means to achieve these goals. In regard to these goals, informant **G1** spoke of how they are calculating and documenting emission reduction, and utilizing a program that enables them to calculate the buildings' climate footprint throughout its life cycle:

“I alle prosjekter beregner og dokumenterer vi utslippsreduksjon, og følger en norsk standard som omhandler klimagassberegninger for byggeprosjekter. Vi bruker en programvare, hvor vi nå har utviklet en egen beregning som en modul som ivaretar tidlig fase kravstilling. Det gir oss mulighet til å regne på hele byggets klimafotavtrykk inkludert alle bygningsdeler, bygningsteknikker, elektro, osv.» - G1

Informant **G2** spoke of how they try to challenge the infrastructures within the sector as a means to enable more reuse of structural components e.g. hole covers, and implied that the firm have a concrete measure in regard to enhancing competence on CE within the firm. As well as they are trying to push the market by demanding products and services that enhances CE. These may not be seen as direct measures in themselves, however it does act as a means to become more circular.

The last firm, **Firm H**, had recently come up with a guide called “material document” as a means to help the firm in choosing products and solutions with CE in mind when planning for either furnishing or a rebuild for their tenants. The considerations were e.g. ability for future reuse and amount of recycled content. Informant **H1** implied that this guide was only formally set for new products, however they spoke how they are supplementing this guide with guidelines in how they are to first-and-foremost seek solutions where they do not need to buy new materials using e.g. reuse mapping. The informant also spoke of how they still have some work to do as they are still having to buy mainly new materials:

«Vi er fortsatt der at vi kommer til å måtte kjøpe mye nytt, og da skal vi ha tydelige kriterier for hva vi skal kjøpe, noe vi har konkretisert i materialdokumentet.» - **H1**

Another measure informant **H1** spoke of was how they facilitate as little as possible environmental footprint in both project phase and operational phase of their buildings by using indicators:

«Blant annet energi, vann, avfall og klima. Så vi har indikatorer for energiforbruk per kvm., vannforbruk per kvm., klimagassutslipp per kvm. osv. og det følger vi opp og setter målsettinger på, som man jobber med på bygg og driftsnivå.» - **H1**

In regard to environmental plans they set for their projects, they spoke of how they are currently working on tightening and setting new minimum requirements in place. Although they implied that this was not something they had done yet, informant **H1** spoke of how they are testing this in smaller projects currently to create a format for a future environmental plan.

In one of their on-going projects, **H1** spoke of how they try to use prefabricated products and send residual materials and packaging back to suppliers.

In regard to reuse, they were currently working on a development project where their goal is to reuse as much as possible by optimally keeping the structure of the existing building. If they would have to demolish parts of it, they also had goals to reuse as much as possible directly back into the project or eventually other projects. In general, they found performing reuse during the building phase challenging.

Informant **H2** also spoke of how they are currently developing a digital platform to create a marketplace for residual building materials and waste.

To summarize these measures, we have divided them in *internal*, *overall*, *specific project and future measures*. For *internal measures* most of what has been implemented were focused on reuse, especially in relation to inventory. One firm also specifically mentioned measures for knowledge enhancement.

Overall measures were the most dominant one, where the frequent measure also was reuse. Some worked on enabling a sharing culture, supply chain collaboration and sharing knowledge. Others focused on reducing the environmental footprint through choosing renewable energy sources, environmentally friendly products, conserving residual materials and focusing on having no waste. Some were also calculating and documenting CO₂ emissions, and others performed greenhouse gas analysis. Using indicators to facilitate lower environmental footprint during

building phase and operation phase were mentioned, and some were even utilizing a program for such measures. One firm had established a material document as a guide for choosing products and solutions. Another firm had measures that attends to the waste hierarchy. Some were in the process of developing a tool for reuse, such as a database and digital market platform.

Specific project measures ranged from having circular building projects to more specific requirements. Some had focus on reuse, and enabling for future reuse, other used BIM as a tool to reduce use of materials. Some also used ongoing projects in order to test minimum requirements for future environment plan, as well as conserving residual materials. Lastly some also talked about *measures to be implemented in the near future*. The main factor here was the focus on design and solutions which could be dismantled for future reuse.

Industry

As we seek to establish to what extent CE is implemented in the Norwegian building sector, we found it necessary to ask our informants if they were aware of any circular measures implemented by others within the industry. Since this is a qualitative study, we did not have the opportunity to ask hundreds of informants. Even though our informants were strategically selected, there could be some firms which had implemented circular elements which we did not reach or did not reply to our request of including them in our study. Also, this question worked as an overlap. If one firm elaborated on their circular measures, they probably would have been noticed by other firms. This strengthened the reliability of the measures presented in the section above regarding circular measures within the firms.

From the previous sections of this analysis, we understood there was an increased focus on sustainability and circular economy, especially in the last two years. **A1** explained that practical competence on CE is only in its starting phase. Others added to this statement and elaborated further by referring to the smaller or specific pilot projects as examples in the industry. Many are willing to try yet struggles to figure out how to do it. Both **A1** and **B1** emphasized that the industry is still in the piloting stage, and that it will not have an environmental effect until they do it on a bigger scale.

Reuse was a dominant principle among these “pilot projects”, but so far many expressed that it has not been implemented on a bigger scale. One of the informants say they need good examples such as these pilot projects in order to move forward.

As mentioned in **5.2.2 Waste Hierarchy**, recycling of materials is something they are good at. Yet when it comes to reducing waste, their impression was that several firms still have a long way to go. Where only some have started focusing on it.

D3 also emphasize that larger firms are more likely to work in a circular manner, as they have sufficient resources and opportunities. This was also reflected by other informants. It was indicated that central firms, have implemented more circular elements. One informant reflected that this might be due to different competitive conditions, and the ability these construction clients have to set certain requirements. **E1** also claim that it has been implemented on large buildings such as commercial buildings, yet there is a long way to go for housing.

Informant **G2** addressed the shift from a linear to a more circular economy, and that many may not be aware of how hard it will be to transition to it as it is a disruptive innovation. The informant also expressed that as this is a disruptive innovation it is natural that many barriers come up, as people do not necessarily want to change the way they do things today as this makes them money. The same informant also reflected over the trend in the market, where everyone wants new buildings rather than try to develop existing buildings in Norway.

On the other hand, **F1** claim this focus might be changing and that more have started focusing on rehabilitating existing buildings, rather than demolishing it and building a new one.

«.. og det blir også veldig mye mer rehabilitering fremover har jeg inntrykk av. Det er jo signalene fra politikere og byrådet at man nå skal man bevare mer. Det kan hende man frem til nå har revet for mye og bygd for mye nytt ...» - F1

F1 also reflected over the fact that the industry in general is too focused on materials and fail to see the bigger picture. This informant explains that there are some firms who have been using analysis in order to better evaluate what is best for the environment when determining whether to rehabilitate or build a brand-new building.

«Det er ikke feil å ha fokus på materialer, men man må se på helheten. Det er hvordan vi bygger og bruker byen og byggene som til syvende og sist genererer utslippene. Altså du må se både på materialer, energi, og transport samlet... Først da har du svaret egentlig ...» - F1

In central areas, some of the larger firms mentioned that they were in a CE focused community. Among this community some were also collaborating and trying to develop a digital platform for the industry. Some initiatives have been made to strengthen the knowledge. In general, we get the impression of “a lot of talk, and less practical implementation”. Some of the informants also

mentioned this, yet we mainly got this impression when conducting this analysis. When we tried to extract what is actually being done, we realized a lot of what has been said in these interviews were often stated as “we hope, we try, we want” instead of “we do”. However, we still got several specific answers as provided in this chapter.

International

A few of our informants mentioned how other countries had come further in implementing CE. Our informants drew parallels to Denmark and Netherlands, and the EU in general. We chose to include this to see if the presented cases we found in our theoretical framework were recognized by our informants, to see if they have used some of these as inspiration. Of the few examples that were mentioned, some addressed that the Netherlands has come furthest to utilize the business opportunities in regard to CE. BAMB were also mentioned. **B1** explained being on an event where representatives from countries in Europe held lectures and shared experiences, studies, and ideas. Yet it was mostly focused on theory, and lack of practical processes.

Informant **G2** talked about how the EU in general are implementing CE in a greater extent compared to Norway. According to the informant, the reason for this was that CE in Norway is very centered on the environmental aspect, and in EU they focus more on the economical perspective, i.e. employment and growth after a time of financial crisis and unemployment.

5.3 Barriers

Based on our research, we questioned our informants whether they found any barriers regarding implementing CE both in their own firm and within the sector. Our informants spoke of many barriers, and our findings show that most of the barriers were centered around economy, laws and regulation and market. In this following section we will analyze these barriers as well as other barriers based on what our informants said.

5.3.1 Economical

All the informants recognized economy as a predominate barrier as to why they are not further along in implementing CE within their firm and as a reason the sector itself has not come further.

Informant **A1** and **F1** both pointed out that today it is cheaper buying new products and components, rather than trying to reuse what they have, and that this was an economic barrier. Both informant **C1** and **F2** also pointed this out, but explained that this was due to costs related to reuse such as: temporary storage space, logistics, cost of labor, and lack of business models and new actors within the sector that can perform activities that makes reuse easier.

Informant **B1** was another informant that pointed out the high cost of being circular as a barrier. The informant said the reason for this was that there was still so much that still have not been tried, and they are currently in the phase where they have to perform “trial and error” as a means to figure out what works best. This in itself take up a lot of their time and resources. The second informant from **Firm B** also spoke of how economy was a barrier for them, especially in regard to performing reuse. This informant spoke more around the fact that it is more due to the impression of it being expensive and the lack of others performing reuse in the sector which is making it cost more:

«Det handler om økonomi, og per nå er det dyrere å bygge med ombruk. Hvis man får ombruksfokus i bransjen, så tror jeg man vil kunne redusere kostnadene på sikt. Men det er det å påvirke hele kretsløpet. Alt fra entreprenør, leietakere, du må få med deg hele kretsløpet» - B2

Informant **H1** said their main challenge was emphasizing to their investors and management that performing circular measures within their projects do not necessarily have a negative economic consequence. The informant pointed out that it is currently very hard to show what losses and gains you will get by implementing specific CE measures today, and that it was very easy to dismiss CE by saying it is hard to perform and too expensive. In contrast, the other informant from the same firm said that CE is currently costing too much, and that it needs to be rewarded in some form if firms are to implement more CE.

When it came to one of the smaller firms, **Firm D**, they spoke of how they do not have customers that are willing to pay for their homes being built in a more circular way. This combined with the assumed cost of performing circular measures seemed to be the fundamental reason behind their lack of CE implementation. As they did not have any experience being circular, we found it interesting as to why they assume being circular is expensive.

«Nei det er en del krav hvis vi skal resirkulere, hvis vi skal ha det ut av byggeplass og resirkulere og tilbake på byggeplass. Det er måten du river på, det er måten du bygger det opp på, det vil komme til å koste penger. Det vi helt sikkert koste penger.» - D1

Firm E, who was also one of the smaller firms we interviewed, said that financial aspect within the project is what stops them from pursuing a circular economic approach. Informant **E1** stated that competitive conditions would be unbalanced between them and their competitors. The point that informant **E1** made is that if they try to become circular, it will essentially make them less competitive as their prices would be above the level of other actors within the region. This point may be in relation with the current market in this region, which is said to be on standby.

In contrast to the angle that most informants spoke about on this barrier, informant **G2** proposed that the barrier was that one cannot earn money on being circular at this point in time.

«Det er ingen i utlandet som gjør dette for å være snille, de gjør det for å tjene penger. Og skal dette komme videre i Norge må det være mulig å tjene penger. For at det skal være mulig å tjene penger, må det a) være lov, i dag er det mye som ikke er lov, også må det b) være mulig å få det til.. uten at det blir altfor dyrt i forhold til andre ting.» - G2

Another point the informant made was that there is too much money in Norway, and that this may be one of the reasons as to why Norway and its building sector has not come further in implementing CE.

«Jeg har veldig troen på det å se litt på hva andre land gjør.. Jeg tror ikke Norge er først ut i løypa her. En av grunnene til at vi ikke er først ut i løypa er fordi vi har mye penger.. Og så tror jeg at det i Norge har blitt mye løftet frem som en miljøsak og for lite som en forretnings sak.» - G2

Does the informant refer to them and other actors within the sector as having too much money, or is the informant referring to their tenants having too much money? Or both? The notion that having too much money and by that standard not feeling the pressure of surviving is an interesting angle for this barrier. As well as the point that CE in Norway is being raised as an environmental issue, rather than an economical one.

We asked all our informants whether they thought implementing CE within their firms would have a positive economical long-term effect, and all responded that they believe so.

All informants mentioned economy as a barrier, many saw the cost of CE implementation to be a deciding factor. Even though economy were a common denominator there were many different perspectives on this as a barrier:

- 1) It is currently cheaper buying new rather than to reuse, this were addressed by most.
- 2) CE is currently costly, due to the lack of processes and methods which require “trial and error” processes and a long with the lack of others performing reuse making it more expensive. One might also argue this could be related to the lack of supply chain collaboration, and the complexity of reuse-processes regarding technical barriers which will be elaborated in one of the following sections.
- 3) We also found that there was a general belief that implementing CE as being more expensive, especially for investors and management. We reflect over if one does not know how or what economic consequences performing CE will have, it will naturally become a barrier.

4) As elaborated upon above, CE is currently costly, which again make the price tag of building higher. For some, especially in the housing market, this resulted in the fact that they became more expensive than others in the market, which made the competitive conditions a barrier. We may argue that for those who emphasized this, the market in their area were on standby.

5) CE has in general had a more environmental focus, rather than seeing it from an economic perspective. On the other hand, it was mentioned that Norway has too much money. This might be connected to cultural and market barriers and will be furthered addressed in following sections.

5.3.2 Market

Market was a recurring barrier amongst our informants. As to how market was a barrier for them was very varied, but we found that market as a barrier could be divided into two, demand and platform.

Demand

Several spoke of how the demand for a circular building is currently not present, except for a few tenants from the bigger firms. The informants spoke of two aspects regarding demand, first and foremost that there are few customers that want to pay for it, and secondly, their customers are wary of not having something new.

Our impression was that the bigger firms often face the problem of having tenants that speak of profiling themselves as an environmentally conscious firm, but then go back and ask for everything new due to expectations of employees. Another impression we got from our informants was that this was also because people have a perception that recycled or already used products/materials cannot be as good as new ones. They mentioned there were some exceptions, and some were positive, yet this was not typical. The process of getting tenants to be onboard with the CE perspective early in the planning phase required a lot of work, and for some projects the tenants are not present this early on.

«Vi som byggherre, og gjerne også entreprenørene som utførende kan være opptatt av gjenbruk, men vi opplever leietakerne, ikke alltid er så veldig opptatt av gjenbruk. Dessverre.» - F2

Informant **F1** suggested that they find it hard to deny or change tenants' minds when they want everything new as this can have repercussions on their income and the length of the deal.

«Som regel ønsker leietaker ny planløsning og omfattende tilpasninger, som krever at mye rives ut og erstattes med nye materialer. Det syntes ikke vi nødvendigvis er riktig ut fra et miljøperspektiv, men det det er veldig vanskelig å ikke rette seg etter kundens ønsker. Det er

også vanskelig å ikke oppgradere dersom dette medfører redusert lønnsomhet pga. lavere leie og korte leieperioder.» - F1

Other informants from the bigger firms in the central part of Norway also suggested it is hard to change their tenants mind in regard to not only having new products and materials in their buildings, and that it was even harder when they had already built in a circular manner and then having new tenants come in. A couple of the informants brought up examples of how tenants have no regard for the environment when it came to furnishing their given space. Tenants could have something new put in, like a carpet, and would then change their mind and have it ripped out and new ones put in because it was not part of their color scheme.

As a counterpoint to lack of demand, **B2** and **C1** suggested that there are some in the market that are interested and that circular buildings are getting somewhat traction. However, to this point there is only talk rather than doing by most customers. Young adults were a segment that was often spoken of as being interested in having more circular buildings or more environmentally friendly solutions.

Some informants suggested that it was not necessarily that customers were negative toward environmental or circular measures being performed in their buildings, but rather the fact that they do not want to pay for it. This was evident from informants from the bigger firms and the smaller firms, but it was especially a big barrier for the smaller firms. Informant **D1** spoke of the focus on sustainability within their market was very different in their geographical area compared to central areas of Norway, and that this may be a reason why the demand is higher in that area compared to theirs.

The informant from **Firm E** suggested that they have tried to present themselves and their homes as sustainable or circular, but they have had no luck in selling more homes.

«Nei vi har prøvd med de faktorene som vi synes var våre virkemidler, med hva vi kunne fremstille og hva som var veldig positivt. Men vi får ikke solgt mer boliger dessverre.» -E1

Marketplace

Seven out of eight firms said that not having a marketplace or platform for recovered building materials was hindering them from applying more reuse in their building projects. Many of the informants pointed to the digital market platform for used items called Finn.no and the hardware store Maxbo as an example of what they would like in regard to a market platform. Several said that today there are no good system for finding out what is available and where you can find it in

relation to used materials, and that this works as a barrier for them in implementing more CE within their firms.

«Det er flere barrierer, men jeg tror manglende plattformer à la Finn, må komme på plass. Hvor alle kan legge ut sine ting, som gjør det mye lettere å velge ombruk. En slags Maxbo men med ombruksmaterialer. Det er også andre ting som infrastrukturen rundt, det er lagring, tilgjengelige materialer og logistikk. Det er flere ting. Jo flere som gjør det, jo flere kanaler og valgmuligheter får man, slik at strukturen og infrastrukturen rundt det med sirkulær økonomi, vil gjøre det lettere.» – C1

Two informants, **A1** and **B1**, said that even if a marketplace would be available at some point, there would still be limitations by the current laws today that would effectively hinder selling and buying recovered building materials in an open market, referring to requirements around documentation, which will be further addressed in following chapters.

Informant **B1** expressed that a new marketplace or market actor would have to take responsibility in regard to the documentation and quality as well, referring to the issue informant **A1** and **B2** spoke of.

“Det er ingen som tar på seg ansvaret og går inn og henter produktene, skaffer dokumentasjon, kategoriserer og lagrer det, for å så kunne sende det ut igjen. Det er det vi savner i det prosjektet. At vi kan ringe til noen å si "du, har dere det og det.. ja det har vi, vi kan sende det i morgen", nå må vi inn og demontere alt selv.» - B2

The informants gave the impression that a marketplace for used building materials would go a long way for them to apply circular measures such as reuse of old building materials. One informant **F1** pointed out that this was one of their two biggest barriers to date, and that as long as systems like these are not in place every building project would just be a pilot.

“Jeg tror den største barrieren er ... markedet og regulatoriske barrierer. Det at det ikke finnes noe gode systemer for å håndtere det.» - F1

As a countermeasure toward this barrier, informant **B1** and **H2** implied that their firms individually are currently working with another firm in creating a digital platform for the whole sector to use as a marketplace for building materials, but that this is currently in an early phase.

As we see from analyzing this barrier, market barriers are mainly divided by demand and platform. In general, the demand for more sustainable and circular buildings were not substantially present among customers and end-users, especially in the housing-sector and less central areas. Some were positive, yet many got more skeptical when it came to the price of it. This might also have something to with the fact that many end-users were wary of not having something new. We could reflect on whether end-users perceive “new” to be more valuable and provide a higher status, combined with “reused” which could be seen as “old” and less valuable. Yet we also reflect over if they have sufficient knowledge about how these solutions are perceived as better for the environment. Some reflected upon the importance of having tenants on board early in a building project, yet this were somewhat difficult as they were not always present at such an early stage. It is easy to forget that the end-user is a part of the value chain, yet there might not be a point in designing and constructing sustainable or circular buildings if the customer is not aboard with the idea. In the end, customers are the ones which are going to use it and none the least pay for it.

On the other hand, there is a need for a marketplace or platform for recovered materials. This was to our understanding missing. However, we found that this was currently being addressed by some where they have started developing a digital platform. The lack of system, such as access to information of recovered or reusable materials, storage and logistics were mentioned. This could again be linked to technical barriers which will be further addressed in following sections.

5.3.3 Knowledge

It was established quite early on in our interviews that knowledge was a dominate barrier as to why the firms and the sector had not come further in implementing CE. Our informants understanding of the concept was very varied from not knowing at all, to knowing some aspects of it, and to showing good understanding of the concept.

We have already presented and analyzed the understanding of our informants earlier in this chapter under **section 5.1 The concept**. In that section we chose to only look at what they knew about CE and tried to withstand from presenting too much around the informants that showed a lack of knowledge as this can be directly related to this section. For starters in this section we will present the findings from the few informants that expressed that their knowledge or knowledge within their firm was low, and then we will present what the informants said in regard to the sectors knowledge on the matter.

Firms

In our interviews, competence and knowledge on CE was brought up as a barrier in regard to implementing CE. Some pointed out that their lack of knowledge on it was even a barrier, this was pointed out by informant **F1**. When we asked our informants about what possibilities they saw for further implementation in the future, knowledge and competence was two of a few factors they would often bring up as measures they need to address to get where they want to be.

Informant **B1** reflected that the lack of knowledge in the sector might be due to lack of awareness on the matter, and it was very dependent on how other firms approached the concept. The informant pressed that this is not a concept you can take on just partially within an organization, but you would have to do it full time.

“Jeg tror sånn hovedsakelig da at det går på mye uvitenhet. Man vet ikke helt hva som er ute og man blir opptatt og ting går fort. Man har så mye å gjøre at man ikke klarer å absorbere og gjøre det der ordentlig, og så må du sette av tid og ressurser» - B1

Six informants spoke of how knowledge and competence was a barrier within their firm. Four of these informants spoke of how they do have some knowledge as they are currently trying to become circular, but that there was a need for more knowledge and competence on the matter if they want to reach their wanted state. **Firm A, Firm F, Firm G, and Firm H**, all spoke of how they as a firm need to work continuously on increasing competence and knowledge on the matter in order for them to implement more CE in the future.

«Der er vi på lik linje med resten av byggenæringen. Vi må bygge kompetanse.» - G1

One informant **F1** pointed out that in regard to their firm it would take 2 to 5 years before they would have the competence needed in all levels within the firm. This informant also made a point that they maybe should know more of CE at this point than they actually do, which may imply why this informant said it would take so long for them to diminish this barrier.

The two firms who gave the impression that knowledge was probably their biggest barrier was the smaller firms.

«Nei, jeg tenker at det burde helt sikker vært bedre, både for meg selv og generelt. Så er det klart vi har for lite kunnskap om det ...» - D2

The informants from these firms expressed that they themselves did not have enough knowledge on the matter nor the rest of their organization. One of the informants solidified this stance by

saying that they personally have never heard anyone in the firm speak or mention CE before, which may reflect the extent of this barrier within that firm.

A few of our informants expressed that lack of information or availability of information on CE was a factor as to why they themselves did not know more. Whether this is really the case, or whether it is based upon them not engaging and searching for it was not elaborated on further.

Another factor that was often brought up in regard to the lack of knowledge was the lack of experience. Several informants pointed out that they need to reap experiences with doing circular measures as a way of learning about CE. One informant pointed out that everyone is doing their own thing and obtaining their own experiences through this. Hence, it is important to share experiences with each other across the sector, especially the good ones.

“...det er utfordrende og så har det per i dag ikke gått seg til hvordan ting skal gjøres. Hver enkelt nå sitter fra scratch, og jeg håper at noen på et eller annet tidspunkt begynner å samle det. Slik at de gode erfaringene blir delt. Det tror jeg er viktig, deling tror jeg er viktig.» - H2

The power of examples was brought up as a means to gain experience and provide knowledge within the sector. **Informant G2** said that good examples is what the building sector in Norway need for further implementation.

«... Eksempelets makt, det har vist seg på andre områder når vi har jobbet med miljø og byggenæringen i Norge. Det er veldig fint å se at ting går fremover. Ofte er det som har fått ting til å rulle, at noen har vist noen pilotprosjekter og vist at det går an. Så eksempelets makt har jeg troa på. Det vi kanskje mangler i Norge er noen skikkelig gode pilotprosjekter med en kunde som har etterspurt noe og noen leverandører som har vist at det går an.» - G2

The sector

When we asked our informants about how they felt the general knowledge on CE was within the Norwegian building sector some replied it was surprisingly good. This was especially evident in responses from informants from the bigger firms, although they seemed to speak about the construction clients in relation to the sector rather than the sector as a whole.

«Det er egentlig ganske bra, og så tror jeg de fleste sitter og vet ikke helt hva de skal gjøre med det her, du har ikke full informasjon, for du har ikke all informasjon, og så skulle jeg ønske at det var et eller annet sted noen som tok ansvar for at nå skal vi samle noe, nå skal vi gjøre noe sammen.» - H2

«på byggherresiden og på eiendomsbransjen, syntes jeg den er veldig bra, sånn generelt sett.» -

B1

The informants that seemed to speak of the whole sector spoke of how the sector had very varied knowledge. Informant **H1** said that their impression was that the firms who engaged in building greener and sustainable buildings would often have lots of knowledge on CE, however this could not be seen as representation of the whole sector in Norway.

Informant **C1** felt that the knowledge of CE within certain parts of the supply chain, specifically contractors, could be very varied and that there was still lots of work to do in general with regard to learning about the concept throughout the sector. This implication was also supported by another informant from another big firm, where they implied that knowledge on the concept and what it means would differ greatly between contractors, where the bigger contractors would often have more knowledge in contrast to all other contractors. This was further supported by informant **B1** who also implied it goes even further down the supply chain to under-contractors and so on.

“Men når du begynner å gå litt utover i kjeden mot underleverandører, de store entreprenørene og underleverandørene, der føler jeg ikke kunnskapen er god nok. Der har man litt å gå på. Veldig gode når det kommer til tradisjonell avfallssortering. Håndtering av avfall og den biten der er kjempebra, men bærekraft og sirkulær økonomi og hele den tankegangen. den er ikke så god ute i ende-leddene da. ... Så der er det trengs det mer opplæring, informasjon eller kommunikasjon.»

- B1

Informant **G1** said that there is still a lot to go on in regard to the level of knowledge of those that carry out the projects for them.

«I forhold til kunnskapsnivå er det nok en del å hente. Jeg har vært på mange inspeksjoner og gått gjennom alle miljøkravene i prosjekt med entreprenørene våre rundt omkring i hele landet. Så jeg har aldri opplevd det eller at det er noe stor uvilje at det har vært veldig konstruktivt og fint, men ganske.. stort spenn i kunnskapsnivå det er det.» - G1

Another informant gave us the impression that the whole building sector did not have satisfactory knowledge on the concept, and rather implied that most firms within the sector are in the start phase of building knowledge on the matter.

«Byggenæringen har laget et veikart fremover mot 2050, og har bidratt til å sørge for at sirkulær økonomi var en del av det bildet. Så næringen er nok interessert. De har så vidt satt det på dagsorden og nå er vi i den fasen der vi bygger kunnskap.» - G2

In contrast to what the informants from the bigger firms expressed on the building sector, informants from the smaller firms had the impression that there was still a great lack of knowledge on CE within the Norwegian building sector. This may pose the question as to whether the concept is widespread enough in Norway or whether it is just concentrated in some geographical areas.

«det er en del å gå på, det er mitt inntrykk ...» - D1

«Og da var det med folk som, de skulle snakke om dette her, og så var det jo hva byggebransjen kunne gjøre i forbindelse med sirkulær økonomi. Og så innledet de med å spørre om vi visste hva det var og det var ikke noe håndsopprekning, men det var et skjema vi skulle fylle ut. Og jeg tror.. ja vi var cirka 50-60 mann og jeg tror ikke det var mer enn 10 prosent engang.» - E1

To sum up this barrier, we gather that knowledge was perceived as a dominant barrier. Informants reflected of a variation in the level of awareness throughout the supply chain, especially contractors, however some claim the general knowledge on CE within the sector were good. They explained that there might be some that were unaware of CE, especially if you are to address the building sector as a whole. This was especially evident for smaller firms and less central businesses. Most had a common understanding of the need for more knowledge and competence, and the fact that this were something that needs to be addressed continuously, especially in order to strengthen this on all levels of the firm.

Some also reflected on the lack of information available, along with the lack of experience as they are only in the starting phase of implementing CE, following this they also emphasized the need for sharing of experiences and good examples.

5.3.4 Cultural

Normative barriers are related to human norms or standards i.e. how humans behave or their attitude in regard to change. Some of our informants spoke of facing barriers in regard to attitude and lack of awareness within the sector, and that there is a need for change of attitude and awareness to further implementation of CE in the sector.

A couple of informants spoke of how there was a need for awareness and a change in attitude in the building sector in general and within their organizations. Informant **D3** said that there is still a long way to go before we will see a change in attitude regarding the environment within the whole sector. The informant related this barrier up against the lack of processes, market possibilities and economics, and said that unless this is solved so they can perform CE measures

easier, the attitude within the sector will still be unchanged. Informant **H1** had a different view in comparison to **D3** and said that instead of always looking at all these barriers, it is important that one has an enabling attitude towards it as a means to progress in implementing CE.

Another informant spoke of another problem with attitudes both in the sector and within their organization. Informant **A1** spoke of how it is easier to do what you know and stay with it, and that without the awareness of possibilities, the demand, the pressure or the need to think differently from either customers or society, it will hinder the sector from progressing.

*«Det er jo alltid enklest å gjøre det du kan. ...hvis du ikke vet at det finnes noen mulighet for å gjøre det annerledes, eller hvis ingen spør etter andre løsninger, eller hvis du ikke ser noe behov for å gjøre det annerledes, så gjør du det heller ikke annerledes. Det må jo komme et press et eller annet sted. **Ja fra kundene?** Ja eller fra samfunnet, fra Greta Thunberg eller hva.. Det er en bevegelse. Ja, en bevissthet rundt bærekraft som er helt annerledes nå enn det var for.. fem, to, ti år siden..» - **A1***

Four informants spoke of how they all have faced challenges with contractors and other actors in the supply chain when inquiring them about the possibility of performing certain circular measures such as reuse. Informant **A1** spoke of a good collaboration between them and their contractors, however the informant pointed out that they face obstacles when they ask the possibility of performing or trying out something new, such as more circular solutions. The informant said that the contractors often decline without assessing it and refer to the fact that is not set in their contract. Speaking about this, the informant expressed that there is a need for a change in attitude within this part of the supply chain if they are to come further in trying to implement CE.

Both informants from **Firm B** also spoke of how they have to spend lots of energy on the fact that they meet resistance with contractors and suppliers when they ask for e.g. reuse of technical installations.

*«... å snu en hel bransje til å tenke annerledes, og tenkte de mulighetene det gir kontra det å skulle jobbe på en eller annen spesifisering, og gjøre som man har gjort det hele tiden. Men det er et paradoks, det er jo eiendomsbransjen som har drevet de til å tenke og gjøre det på den måten. Og så skal vi få de til å snu og gjøre ting annerledes, det er ikke gjort over natten. Det tar tid. Og der må hele bransjen også hjelpe til da, til sine leverandører igjen og tenke litt annerledes, tenke hvilke muligheter det gir.» - **B1***

Informant **B1** pointed out that it is paradox due to the fact that it is the construction clients that have made them think the way they currently do, and now they want them to think differently in how they work. Informant **B1** and **B2** both pointed out that it will take a lot of time until practices and the way of thinking is changed down the supply chain and this also applied to tenants, but it is something they as a firm are trying to influence by demanding circular measures in their building projects.

D3 also addressed the importance of management and how their attitude are crucial to become more sustainable. This informant also emphasized that it is not enough talking about it, it is the actual measures being taken which really counts. We reflect over the fact that this might be evident for smaller firms where the market is more on standby, together with the market- and economical barriers mentioned earlier.

“For jeg tror det med holdningsendring og det må helt opp i ledelsen i bedriftene og det er jo lett å si mange rare, fine ord, men det er faktisk handling som teller.» - D3

As we see from this section, cultural barriers ranged from lack of awareness, the need for change in attitude, especially due to lack of focus on potential processes, market possibilities and economics. Some also reflected over the fact that there is too much focus on barriers. The general attitude within the supply chain on the matter that it is easier to do what you are used to, especially for contractors who work on strict time schedules and budgets. We reflect over the fact that this might also be linked to the general lack of knowledge on CE, together with the lack of examples on successful attempts of actual implementation on a bigger scale.

5.3.5 Technical

When it came to technical barriers there were three areas with increased focus, all of them were related to reuse. These were *time, product-quality, and practical processes*.

Almost all reflected on the fact that reuse was challenging. Existing buildings that are built many years ago, may not be suited for reuse. Materials in such buildings may also contain elements not corresponding with the current TEK. Many reflected over the fact that the products used in buildings today has matured and are more environmentally friendly and includes less hazardous substances. This calls for a challenge when determining if they should rehabilitate or build a new building. We get the impression that there are no existing methods and processes for reuse which has been used with success. Hence, firms who focus on reuse are now in a process of “trial and error”, which also comes with risks. The other challenges regarding reuse are categorized and explained further in this chapter.

Product quality

Regarding product quality there were many elements mentioned. Firstly, they mentioned that they need a way of registering their products to keep control over what they have, and what could potentially be reused in the future. We got the impression that this existed to some extent in certain firms, yet for most informants this was missing.

How to ensure quality on re-used products was also presented as a challenge. We assume product quality will decrease over years of use, and to our understanding recovered products has to be treated and quality checked as a new product. This include providing re-certification and CE-labeling of the reused products as well. Informants emphasized the fact that processes for testing of quality and re-certification of existing products existed only to a small degree, and that this was a barrier for applying a higher degree of reuse within the sector. An example of how it was explained is shown below:

«... Hva er det man kan fire på for å muliggjøre ombruk uten å gå på akkord med kvaliteten? Det er mye å gå på når det gjelder å få en systematikk for å teste kvaliteten. Dette er noe av det vi ønsker å utforske gjennom et av prosjektene vi har, å lage en god prosess for å re-teste betong. Dette finnes det ikke noe standard prosedyre for i dag... Man bør optimalt ha det for alle materialtyper for å klare å ivareta kvaliteten på en god måte. Dette er noe bransjen må gjøre for å muliggjøre ombruk i et større omfang.» - G1

Due to the uncertainties around product quality of recovered products some claimed this to be a risk. They also raised questions regarding warranty and responsibility. Who should be responsible for the product quality, how will the warranty on recovered products be? Some also reflected over where they would store products that will be reused in the future. Are materials made to last for that long?

«Det er sjelden at du får garantier på gjenbrukte materialer. Hvis du ikke får en systemgaranti på et teknisk anlegg fordi du har gjenbrukt en del komponenter, så kvier du deg gjerne for å gjenbruke ettersom entreprenøren skal tilfredsstille et garantiansvar i forhold til byggekontrakten.» - F2

Practical processes

Many claimed the logistics behind reuse was a challenge. The actual process of dismantling buildings instead of demolishing buildings was new territory for everyone. Questions were raised on how extracted components can be used in new buildings and how one can practically execute it, especially when existing buildings are not built with reuse in mind. Some claimed these processes demanded a lot of manual work. Informant **G1** stated that they would need to

completely adjust the way they build today to succeed in dismantling buildings and reusing components. Such transition also requires a lot more effort throughout the whole sector, both national and international, as there are no good examples to follow today.

Informant **H1** reflected over the fact that there was a big difference in how theory explain the building process versus the actual process. Another informant also reflected on the fact that the planning phase is done too late. One informant claimed that constructing buildings suited for reuse require more preparations beforehand.

*«Jeg vil si generelt at norsk byggebransjes praksis, avviker fra det man lærer på skolen, om hvordan byggeprosjekter bør planlegges og gjennomføres prosessmessig... .. at man nærmest bygger mens man planlegger, istedenfor å planlegge ferdig og så bygge. Det er en kjempebarriere Sertifisering etter BREEAM, stiller også en del prosesskrav som gjør at man nærmer seg litt mer tilbake til skoleboka. Men ordinær praksis tilrettelegger ikke for dette. Krever tid i en prosess som man somregel aldri har noe tid i. Det er vel den viktigste barrieren tenker jeg.» - **H1***

Concrete were among the most challenging materials according to the informants. The informants from **Firm B** implied that they had tried reusing this and reflected over the fact that they might not do this again.

Time

Time was mentioned by many as a barrier, especially in regard to reuse. The building process today has a strict time-schedule. Dismantling instead of demolishing takes a lot more time, especially with a lack of efficient processes. Two examples are provided below:

*«...tid er viktig. I dag, når man setter i gang et byggeprosjekt er man ofte presset på tid, det samme gjelder riving av eksisterende bygg. Man tar en miljøkartlegging av bygget for å finne farlige stoffer som skal ut av kretsløpet, og så setter man i gang med å rive bygget. Jeg tror man må ha litt mer tid med tanke på en demonteringsfase ...» - **B2***

*«... det er forventning at prosjektet skal realiseres raskt til en satt kostnad. Eksempelvis har du riveprosessen, hvor bygget knuses med maskin på kort tid. Skal denne prosessen være sirkulær økonomisk må det istedenfor tas ned manuelt. Dette vil medføre at det vil ta lenger tid og koste mer penger, eksempelvis i form av et større innslag av manuell arbeidskraft» - **G1***

To summarize this chapter, we see that in general existing buildings were often not suited for reuse, either due to 1) content of hazardous substances, 2) materials not corresponding with

current TEK, 3) lack of documentation for materials or 4) the building was not built with reuse in mind. Uncertainty of product quality in combination with reuse were presented as a main barrier. This provided risks and raised questions about warranties and responsibility, as well as how to ensure quality. There was a lack of efficient processes for quality assurance and testing, and many also had concerns in regard to logistics and storage of recovered materials. The indication was also that such processes were time consuming and required increased manual work. There were also challenges regarding the fact that recovered products are treated the same way as new products, and this provided challenges of re-certification and CE-labelling. There is a need for a register of recovered and reusable materials, both internally and externally. Some also reflect on the need for adjusting the way the building process is executed, and the way it differs from how it should be done in theory, and that the planning phase need more focus.

5.3.6 Laws and regulations

Due to prior research we found it necessary to ask our informants whether they saw any barriers in regard to laws and regulations. As mentioned in the section above, documentation and product quality were mentioned as barriers, this is highly connected to laws and regulations.

In general, most informants argue that the laws and regulations contain great barriers. As mentioned, recovered materials should be treated as “new materials”, which means there are laws and regulations which has to be followed, and as these are mainly made for “new materials” this calls for a challenge.

Some also reflect about the fact that it is cheaper to send it to landfill instead of reusing it, due to the current laws. The fact that “old” materials are not necessarily corresponding with the current laws and regulations, also provides a challenge in terms of reuse. Even though certain “old” materials technically should correspond with current laws and regulations, however, as long as they do not have sufficient documentation this provides a challenge in terms of re-certification.

«... hvis du får tak i et produkt, det trenger ikke å være veldig gammelt, men hvis du mangler dokumentasjon på at produktet er CE-merket så er det veldig vanskelig å kunne resertifisere det. For CE-merking sier ingenting om kvaliteten til produktet, den sier jo bare at den har fulgt en viss standard ved produksjon... Så det er en baug, som er spesielt gjelder stål og betong» -B2

Some reflected on the dilemma between ensuring quality and reuse of recovered materials in regard to laws and regulations. The dilemma that was addressed was how to ensure quality while still being able to reuse it, and how to find a balanced approach within current laws and regulations.

«Det er en del begrensninger som går på kvalitetsmerking og kvalitetstesting av brukte byggevarer, noe som medvirker til å begrense mulighetene. Samtidig er vi avhengig av det finnes et godt regelverk som sikrer kvaliteten på det som oppføres. Det skal bli et godt bygg som skal stå godt, vare lenge og det skal ikke kunne falle sammen og skade noen. Det har vært en del utfordringer knyttet til ombruk rundt det som ligger i lovverket. Det er likevel vanskelig å fastslå hva som er det rette nivået, og hvordan dette eventuelt skal endres ettersom det er viktige kvaliteter som også må ivaretas.» - G1

One informant explains that regulations on technical requirements for building works (TEK), were supposed to be updated every second year, yet they have a tendency of not being updated continuously. At the same time, others reflect over the fact that the sector only sees this as a minimum, and always strive to, and most often do better.

«...vi bygger etter noe som heter teknisk forskrift, og planen er at den skulle revideres hvert andre år, det var krav i fra myndighetene. Og så kom den da i 2010, så skulle det være revidering hvert andre år fremover med strengere krav til hvordan ting da skulle bygges mtp. sirkulærøkonomi og ikke minst bærekraft. Og det gikk syv år før den ble revidert første gang. Det skulle gå to hver gang. Og nå har vi fått den som heter 2017, og så skal jo den da revideres igjen, og det skulle da skje i 2020, så tipper jeg at det kommer de nok ikke før i 2024. Så det at prosessene går altfor seint, og når de da kommer så føler jeg at det blir med museskritt. Det blir så små endringer.» - E1

One the other hand, **A1** explained that the ones revising the TEK has a high environmental focus and are forward-focused, and that it was revised continuously. The informant also addressed that revising a TEK is however challenging, especially as the TEK is supposed to be precise as well as apply to everyone, whether you are a small or big firm within the sector. They are also politically driven. Another interesting perspective **A1** reflected over was that many of the elements in TEK were not being followed throughout the sector. The informant referred to these elements of TEK as “sleeping clauses” and that no one is actively monitoring them. Informant **A1** also said the formulations in these clauses are fuzzy, which means one has to interpret them the way one sees fit.

Informant **E1** emphasized that politics was also a factor. Where they found it challenging to interpret and follow laws and regulations accordingly, as the focus by politicians would often shift. Informant **E1** interpreted the laws and regulations as elusive, and that they differed between municipalities. In general, it lacked a red line when it came to sustainability in the current TEK and its corresponding laws. Another informant had a different experience in regard to politics and

explained they faced challenges due to a high level of bureaucracy within their municipality. Informant **H2** explained that agencies were giving different requirements which did not necessarily reflect the city council. For a project they had, the agencies were more focused on adjusting the borderline of the existing building, instead of determining whether they could use it. With this as their starting point, they felt they had lost even before starting. Hence, **H2** expressed that bureaucracy was a barrier, and that there was a need for more political involvement and a clear message. Informant **G2** also acknowledged that politicians often get involved too late.

Informant **B1** reflected over the predicament of when, by whom and how the laws and regulations are made may influence their ability to operate in a circular manner. The informant also emphasized that there are many different laws and regulations to operate by and imply that it will require teamwork to create awareness on how to simplify, adjust and make them more agile. They were also made at a time where reuse was not considered.

As we can tell this section, barriers regarding laws and regulations were mentioned by most informants. Many spoke of the fact that there are no laws that specifically address reuse, as recovered materials have to be treated as new materials. There are also laws in order to document and ensure product quality, which provides challenges for reuse. Current laws and regulations make it cheaper to send materials to landfills rather than reusing them. Some also reflect on some challenges specifically related to TEK, such as 1) lack of continuous updates, 2) broad generalization, 3) it is perceived as fuzzy and 4) many elements are not monitored and act as sleeping clauses.

6 Discussion

The purpose of this thesis was to establish how far the Norwegian building sector had come in implementing CE and what barriers they face today that need to be addressed for further implementation. In our theoretical framework we found existing knowledge on CE, implementation of CE in the built environment and barriers related to implementation. In the theoretical framework we established that there was insufficient knowledge related to the Norwegian building sector. Hence, we will compare our findings and analysis in chapter 5, to see if the existing literature can be related to the Norwegian building sector. We also seek to establish whether the barriers we found in our theoretical framework are coherent with what we found in our analysis. This discussion will be the foundation for answering our research question. The question is as follows:

“To what extent is circular economy being adapted in the Norwegian building sector, and what barriers need to be addressed to increase implementation of circular economy?”

6.1 To what extent is circular economy being adapted in the Norwegian building sector?

Through the course of this study, we realized the vagueness of CE by the many interrelated concepts and its many definitions. As implied by Kirchherr et al (2017), CE is hard to define due to its popularity by many different stakeholders, which in hand has made it diffuse. This is something that has been vastly criticized by many (Ghisellini et al., 2016, Blomsma & Brennan, 2017; Kirchherr et al., 2017; Murray et al., 2017). In our analysis, we found that most of the informants were introduced through interactions with non-governmental organizations, such as BNL, Byggflokken, The Norwegian Green Building Alliance and Norwegian Property. These are the same organizations we found information regarding CE in the Norwegian building sector presented in our theoretical framework. Our analysis showed that the increased focus on sustainability and environment in recent years within the sector was a factor in which most of the informants had become more aware of CE. This correlates with our theoretical framework, where we only have to go back to 2015, when the EU commission came out with an action plan regarding policies toward implementing CE (EC, 2015).

As our analysis show, reuse and recovery as a means to create less waste and use resources more efficiently was often applied when describing what they perceived as CE. This is not necessarily wrong; however, it is rather only a small part of what defines CE when comparing it to the definitions we found in **3.1.1 Defining circular economy**. The fact that several perceived CE as reuse and recovery of as much as possible, may implicate that it is hard to define for many, and

the information available to them may only imply this as the main objectives of CE. This was somewhat confirmed by the fact that one of the informants pointed out that information provided in “Road map toward 2050” and its guidelines was not necessarily clear. If one also looks to FutureBuilt’s (2019) definition of a circular building, they use keywords like resource utilization, reuse of materials and reusability. FutureBuilt is today one of the main information sources for the building sector, so it is natural that informants may associate CE with how they have defined circular buildings.

A point that a couple of informants made was how they found it hard to define what CE entails in the built environment. They implied that this was something that they were continuously trying to figure out both internally and externally. The fact that researchers, including us, find CE to some extent diffuse and fuzzy to define, may resonate with how some of these firms are finding it hard to define what CE means to them and the sector. The link between what it is and how does it apply to the building sector does not seem very apparent for the building clients we spoke to, although NGO’s have tried to give some form of guidelines on how to implement CE, as shown in **3.2.2 Implementation in the Norwegian building sector under Non-Governmental organizations**. Based on the guidelines from the Norwegian Green Building Council and Norwegian Property, we found that although these are some measures that the building clients can do, it does not address the fact that competence for doing some of these measures are not currently present in the building sector.

Assessing these measures ourselves, we found them more enabling in a way that makes them more open for implementation of CE at a later point. The measures and aspects proposed in chapter **3.2.1 Implementation in the building and construction sector** are more exact in its nature as it address the whole life cycle of the building. Comparing the two different approaches to implementation, we find the aspects proposed by Adams et al (2017a) more tangible than the ones proposed in the Norwegian building sector. As this is one of the main sources of information for implementation of CE in the Norwegian building sector, we assume that this may have a direct effect on how the sector is taking on implementation of CE.

We found that the focus on the environmental aspect of sustainability was lacking maybe outside the more central areas of Norway. One of the informants from the smaller firms spoke of how the market they worked in was currently very abject, and that it would not be sustainable for them economically to try to become more environmentally sustainable. This is a notion that was supported by another informant from the more central part of Norway, where it was stated that though it might be environmentally sustainable to perform CE, it would not necessarily be economically sustainable for the firm. As defined in our theoretical framework, sustainable

development has its guiding principle in creating environmental quality, economic prosperity, and social equity (Kirchherr et al., 2017). The notion is that you cannot dismiss one of these principles, but rather try to accomplish all three to be able to create sustainable development. The fact that it might not be economically sustainable for them is an important factor as to why one has not come further, although it does imply the economical aspect is of high importance as to why someone would be more inclined to adapt more sustainable goals and shift the focus within the firm to work in a more sustainable manner, whereby taking on CE.

From our theoretical framework we found that one the main enablers for successful implementation of CE were leadership (Acharya, Boyd & Finch, 2018; Hart et al., 2019; Leisling et al., 2018; Ünal et al., 2019). In our analysis, we found evidence of many firms having incorporated CE as part of their corporate strategy. Most firms were working consequently adopting a strategy that includes CE in 2020. For those firms who had established a thorough strategy, one may discuss if this is a key reason to the fact that they were the ones who had come the furthest in regard to implementing CE.

One of the firms followed up with emphasizing the importance of a thorough and overall strategy. The strategy has measures and objectives for all sections and roles of the firm. Hence it also encourages collaboration between functions, which Hart et al. (2019) claimed could be a potential barrier, and which they are now coping with. We interpret that they have succeeded in making common goals for the whole firm. Although this was evident in some firms, the fact that this was not something that seemed evident within many firms, it could imply that the sector as a whole still have some way to go before this enabler takes effect and will increase implementation.

For those who was currently working on a new strategy, goals and measures were also divided by project specific and overall goals. This was especially evident for the firms which were in the beginning phase of adapting their strategy towards CE. One reason might be the uncertainty to what CE entails, which make it somewhat difficult to fully commit to something you are unsure about how to execute it. Another reason could be the fact that building projects could be very different, i.e. rehabilitation vs. new building, which could imply that not all measures are suited in both areas. We also argue if they will be able to establish a thorough overall strategy, as they have to fully commit. Are the firms mature enough in regard to CE to fully take this step? As we see the focus have increased, but it is still relatively new. In general, we got the impression that their intension and willingness is however strong towards CE implementation.

BREEAM certification was mentioned by many informants as being a standard that many apply to most of their buildings today. Many also implied that they have overall goals to reach a certain

BREEAM rating for every building project as a part of their strategy. This corresponds with what has been proposed to building clients by the Norwegian Green Building Council and Norwegian Property in the “Roadmap to 2050” (Grønn Byggallianse & Norsk Eiendom, 2016). The use of BREEAM was also evident in the practical examples of implementation of CE in the Netherlands (Leisling et al., 2018). Although BREEAM may not be directly linked to CE, it works as a framework for building clients and others to perform more sustainable throughout a building process, and thereby CE can act as a tool in order to achieve a high BREEAM rating.

It is also worth mentioning that one of the firms had not considered incorporating CE in their strategy. They did explain that they did not have a general increased focus on sustainability. As one of their informants exclaimed this were basically rooted in the overall culture and the lack of focus on sustainability. The managers also rooted this in the lack of market opportunities, and the standby of the market in this specific area. We assume this would be a combined reason. We also look to the general belief that CE is more expensive, which will be furthered addressed in barriers. Along with this, lack of interest, knowledge and engagement throughout the value chain and supply chain could also be a main factor here (Adams et al., 2017b; Hart et al., 2019; Henrotay et al., 2017).

It emerges in our theoretical framework that implementation of CE in the building sector in general has not come far. There are good proposals as to how to enable and how to implement, including a few examples of how CE has been applied in some building projects, but no successful implementation today. Based on our theoretical framework, we found aspects and measures that should be addressed for implementation of CE. Full implementation of CE in the building sector would entail that all key aspects that Adams et al (2017a) identified in the different stages of the building’s life cycle. Based on these key aspects proposed by Adams et (2017a), and supported through other literature, we will discuss whether these aspects can be found in our analysis.

In the design stage, Design for Disassembly (DfD) was identified as a key aspect for CE by many (Adams et al., 2017a; Debacker et al., 2017; Ünal et al., 2019). As implied in the theory, DfD implies designing the building in a way that enables one to take it apart at the end-of-life compared to what is often the case, demolition. Standardization and modularity design are central in DfD (Adams et al., 2017a; Acharya et al., 2018). Current buildings are not made for disassembly, which makes it even more important to try to design buildings in a way that this is possible for future deconstruction, or one will have the same issue in a 100 years in regard to waste. DfD does not only apply to the end-of-life perspective, but also as a means to design for maintenance whereby using an adaptable and flexible design with standardization and modularity, one can

maintain, repair and reuse during in-use and refurbishment stage in the building's life cycle (Acharya et al., 2018).

With a DfD approach in the design stage of the building, it will minimize waste during construction and deconstruction which are the stages that in the building's life cycle that produce most waste (Acharya et al., 2018). In our analysis, we found that very few considered this aspect in regard to their building projects. Many were currently very focused on rehabilitating buildings, which does not allow for DfD to its full extent. Examples of DfD that we recognized in our analysis, was one firm where they were using bolt connections instead of welding as a means to allow for disassembly at a later point, as well as identifying internal structural components that had modularity properties to easily dismantle and remount at a later point. With the exception of these specific measures done in one project, it was not apparent in throughout our analysis that DfD was an aspect many were considering at this point. We found that some recognized it as a means to implement CE in new building projects and were planning on taking on a DfD approach in future projects.

DfD is not the only an aspect identified for CE in the design stage. Ünai et al (2019) identified Design for Recycling (DfR), Design for Remanufacturing and Reuse (DfRe), and Design for Environment (DfE) as well. These aspects can be seen with DfD, as it does not help to only design by flexibility and adaptability whereby one can dismantle the building easy if the structural components, materials, and products cannot be reused, remanufactured, or recycled after. Without considering these aspects in the design stage, one will not be able to minimize waste and utilize materials, components, and products at their highest utility at all times which is very much the essence of CE. When evaluating these aspects against our analysis, we did not find much evidence as to whether this is something that is applied in projects in the building sector today. When we say this, we are regarding these aspects as something you design and plan consciously from the very beginning, where the requirement is that it is planned in the long-term perspective. The findings we could resemble to these aspects were rather a tool one of the firms had developed to help guide the firm in choosing new products and solutions that have the capability to be reused or contains recycled material. This tool was applied in the planning phase of refurbishment or rebuild for tenants, i.e. design stage.

Although specifying reclaimed materials and recycled materials during the design stage was not brought forth by many in our theoretical framework, it is found to be an aspect one must regard during this stage (Adams et al., 2017a). What we found in our analysis was that many performed or tried to perform reuse to some extent. The degree of what this reuse entailed was very different from firm to firm. The question is whether these reclaimed materials were specified from the

design stage of the project or rather performed during the construction as a means to reduce waste. This was something that was hard for us to determine, as our analysis implied that reuse is something that most try to perform for every project without specific objectives. We find by having specific objectives of reuse in regard to certain materials or components, it would be natural to assume that this was specified already during the design stage. Based on our analysis, we did not get this impression in our analysis. There were certain projects where reuse was performed to a greater extent, where reuse involved not only inventory but also structural components and technical products. Our impression was that though these projects most likely had a certain overall goal in regard to reuse e.g. reuse 50 % of the existing materials, components and products, we still got the impression that this was not something that could be addressed specifically early in design, as it came across that the reuse was being continuously tested and performed throughout the construction stage. Therefore, it is natural to discuss the performance of reuse we found in our analysis toward the next two stages of the building's life cycle.

As for specifying recycled materials, it was more evident in our analysis that this may be specified already in the design stage. The extent in which this was applied seemed only evident in one firm, where they would require a certain amount of recycled materials specifically e.g. steel, and overall, in their building projects. By having set requirements for recycled materials for every building project, one sets the precedent that it must be addressed in the design stage.

When reflecting upon the discussion of design stage in the building's life cycle, we find that the awareness on DfD seem very novel, and as found in our analysis is only considered by a few firms. Throughout our analysis, design was not brought up directly as an aspect to consider in implementing CE. Due to this we reflect that the building sector is far from addressing this aspect at this point in time.

In the manufacture and supply stage of the building's life cycle aspects in regard to CE involved the principle of reuse and the concept of eco-design (Adams et al., 2017a). Central to manufacturing and supply stage is designing out waste, using eco-design principle where the goal is to anticipate as well as minimize the negative environmental impacts throughout a product's life cycle (YouMatter, 2019). This stage primarily involves optimizing material use and avoiding hazardous materials (Adams et al., 2017a; Acharya et al., 2018). It also addresses design for product disassembly and product standardization as a means to enable reuse. In our analysis, this was not addressed to a large extent, which could be due to the nature of this stage as it involves manufacturers and suppliers. However, we did get an impression that most firms try to use as many environmentally friendly products in their projects, and that there was a clear focus within the sector to avoid using hazardous materials. The impressions we got in our analysis is in line

with what we found in the “10 immediate measures” proposed to building clients, where they addressed that they should only purchase building products that does not contain hazardous substances (Grønn Byggallianse & Norske Eiendom, 2016). As long as the demand is there, we think this will naturally progress to no hazardous substances in all materials and products in the future.

As for design for product disassembly and product standardization for reuse, the idea seemed very novel due to the fact that many did not address it, and the impression we got was that products designed with the ability for reuse were scarce. Although the manufacturers and suppliers may not have come far, demand for such products are necessary to evolve products further. With most of the firms in our study owning industrial buildings where tenants change frequently, we found it interesting that performance economy was not addressed as a possible solution. In a practical example of implementation of CE in our theoretical framework, the building clients had implemented some performance economy in their building (Leisling et al, 2018). By demanding the function of products/services rather than owning it, it could reduce waste from refurbishment, and generate circularity as the manufacturer has to design the products in a way that enables reuse. Our impression was that this type of business model and demand is not present today. Although this was not present today in the Norwegian building sector, we found it necessary to address as a means for further implementation.

In the construction stage, we found that minimizing waste, procuring reused materials and procure recycled materials were aspects that were identified as key for implementing CE (Adams et al., 2017a). In our analysis we found that having a high average of waste separation is common, although we learned from our theoretical framework that this might not reflect what has actually been recycled (COWI, 2019). It was implied in our theoretical framework and analysis that waste management is something the Norwegian building sector has been good at for a long time; hence it is not surprising that firms could implement such high requirements on waste separation. With this in mind, we found it surprising that only a few firms had requirements in regard to the amount of waste per square meter. For the ones that had such requirement, many found it challenging to uphold due to knowledge and systems today. We argue that it also may be due to lack of planning for it in the design phase, whereby applying the design aspects discussed earlier it would inevitably enable upholding such requirements. In our analysis, we found that some addressed focusing on reducing waste by conserving residual materials and sending it back to producers, whilst others addressed reuse as a means to reduce waste during construction.

As mentioned earlier in this discussion, we got the impression in our analysis that the focus within the central part of Norway today was currently on rehabilitating buildings. This in hand has

naturally created an awareness on reuse of existing products and materials. One could compare their approach to what we found looking at one practical implementation examples we found in our theoretical framework. In regard to the renovation project we found, they had a clear vision where the end goal was to have 80% circularity of materials (Leisling et al., 2019). To be able to reach this they applied reuse of as much materials as possible, reuse of structural component e.g. steel, and use of resource passports. As for the specific projects we found in our analysis, we identified that reuse of materials and structural components were also evident as measures. As for use of resource passport, we did not identify this as something they had, although they were trying to create a material database which would enable documentation.

As already pointed out earlier in this discussion, we found that performing reuse was something that most of the firms were trying out in their projects. Our analysis of measures gave us the impression that much of the reuse that was spoken off was performed during the construction stage of the building's life cycle with a goal of creating as much circularity as possible with what can be found in the existing building. Based on our theoretical framework and analysis, we argue that there is still a need for a holistic and long-term perspective in the building sector in regard to performing reuse. As proposed in the roadmap for 2050, one should plan for future reuse, which requires focus in the design and planning phase (Grønn Byggallianse & Norsk Eiendom, 2016). Our analysis implies that some are good at testing and identifying what could be suited for reuse. This reflects that they are currently trying to find their way to approach CE. We argue that this sets a foundation for the building sector, and acts as an enabler for further implementation of CE aspects.

In regard to in use and refurbishment in the life cycle, we found that aspects such as minimizing waste, minimal maintenance of the building, easy repairs and upgrades were aspects that need to be addressed in order to implement CE (Adams et al., 2017a). In our analysis, we found that several performed reuse of inventory across their buildings either when in use or when a refurbishment would occur. Several expressed that this was a means to minimize waste for them, as the inventory in question would often still be of good quality before removal. We also found that some would involve external parties as a means to ensure that as much as possible would be reused within the building. As for the aspects of minimal maintenance, easy repairs and upgrades, we did not find that this was addressed in our analysis. As buildings today are not designed with these aspects in mind, it is natural that this is not addressed or evident.

In our theoretical framework, design tools and strategies were another enabler for implementation of CE (Decker et al., 2017; Hossain, 2018; Hart et al., 2019). Where material databases were brought as an example of such a tool. In our analysis, we found that there was several who were

currently working on developing tools i.e. databases or a digital platform to enable reuse on a greater scale. Although it was implied that these tools would firsthand be used internally as means to get an overview of what can be reused, we got the impression that by developing these tools it could be introduced externally at some point. The fact that initiatives like these are being taken by some of the clients goes to show that there is currently some way to go before reuse can be practiced at a greater scale, and until this enabler is put in place, the implementation of CE in the building sector will delay.

Supply chain collaboration is mentioned as a key enabler for implementing CE according to our theoretical framework (Adams et al., 2017a; Adams et al., 2017b; Acharya et al., 2018; Decker et al., 2017; Leisling et al., 2018; Ünal et al., 2019). In our analysis, very few addressed the importance of supply chain collaboration. As established the building sector involves many actors where all have key roles and competence in a building project. As the building sector is today, it is very fragmented (Leisling et al., 2018; Adams et al., 2017a). Implementing CE requires involvement from key actors during all the important decisions such as design and end-of-life treatment, as this competence is not something the construction client necessarily have (Decker et al., 2017). Construction clients have the ability to influence the rest of the supply chain. By avoiding detailed specifications and requirements in the contract, the clients should approach collaboration through a common goal. This could create openness and communication of how to best achieve set goals and enable innovation across the supply chain. Although we found traces of on-going collaborations across the supply chain in our analysis, we argue that this needs to have a greater focus to enable further implementation across the sector. With supply chain collaboration in mind, we argue that the building sector is currently in an early phase, where they are currently realizing that they need to approach building projects through further communication and collaboration.

Besides developing a tool that addresses reuse, some firms applied other tools as a means to enable implementation of CE. From our analysis, we identified a tool that resembles LCA. Where the software in question calculates the building's climate footprint throughout its life cycle with respect to early phase requirements. Much like LCA it identifies material flows during the different stages in the building's life cycle and its environmental impact. Based on our theoretical framework, applying a tool like this will enable implementation of CE as it supports the user in making choices that are environmentally sound. However, based on our analysis this tool did not seem evident in several firms as it was only referenced by one firm.

Another tool that was brought up was greenhouse gas analysis, which assesses the environmental impacts based on two scenarios: rehabilitating existing building or demolishing

and building a new one. The approach in itself was very interesting cause it brought up the dilemma of whether rehabilitating existing building is necessarily the best alternative in regard to its future environmental impact. Our impression from the analysis was that there was a definite focus on rehabilitating buildings in the building sector today and that this was perceived to a way to become circular. This seemed especially in the central areas of Norway. With a circular approach, building from scratch and applying the aspects as mentioned above, would maybe allow for more circular implementation.

6.2 What barriers need to be addressed to increase implementation of CE?

Throughout our study, we came across many barriers. We will address those who were coherent with our theoretical framework, and some which were discovered during our data collection. These will be the foundation in order to establish *which barriers needs to be addressed in order to increase implementation of circular economy*. From our theoretical framework we found several barriers in regard to implement CE, where we divided them by cultural, regulatory, economical, and sectoral barriers. From our analysis we found barriers in regard to economy, knowledge, market, cultural, technical and laws and regulations.

We will start by addressing the **cultural barriers** from our theoretical framework.

These barriers were focused on the human and social aspect, which include behavior, attitudes, and management across organizations. It was also established that lack of interest, knowledge and engagement throughout the value chain and supply chain is seen as a barrier (Adams et al., 2017b; Hart et al., 2019; Henrotay et al., 2017). EMF found that familiarity with CE and its principles, as well as the lack of knowledge on how to apply CE in the built environment was insufficient (Acharya et al., 2018; Adams et al., 2017a). Combined with this it was identified that there is a lack of collaboration between firms (Hart et al., 2019). COWI also address a lack of cooperation across the value chain in regard to CE, this also includes partnerships and better cooperation is especially needed in the early phase of a building project (Høibye & Sand, 2018; Ranta et al. (2018) identified barriers based upon the common consensus that CE is not an established model in the industry.

In our analysis we found that lack of awareness and knowledge of CE were evident, and there were variations in the level of awareness throughout the supply chain, with some exceptions. The lack of knowledge and awareness was especially evident for smaller firms and less central businesses. Hence, most had a common understanding of the need for more knowledge and competence. As we previous addressed in this chapter, measures are still in the piloting phase,

which indicate that there are few examples on successful implementation. Therefore, we argue this to be in combination with the lack of knowledge on how to apply CE in the built environment. We also argue that there was a lack of collaboration between firms because of the fact that there were still many that were not substantially aware of CE within the supply chain, although there are some examples on emerging collaborations between some of the firms. From our findings also mostly found that there was a need for change in attitude, especially due to lack of focus on potential processes, market, possibilities and economics. Some also reflected over the fact that there is too much focus on barriers. In regards to the fact that CE is not seen as an established model in the industry, could also be based on the general understanding within the supply chain, of the fact that it is easier to do what you are used to, especially for contractors who work on strict time schedules and budgets. Hence this is also related to attitudes. As indicated, many of our findings were based on a general lack of knowledge on CE.

Lack of collaboration between functions within organization was also seen as a barrier (Hart et al., 2019). Where functions are not necessarily aligned and work together, which makes it hard for firms to fully commit to implementing CE. At the same time Ritzén et al. (2017) found lack of communication and guidelines within the firms as to whom is responsible for initiating a change towards CE, as well as the notion that “sustainability issues” is to be directly handled by a specific department. Ranta et al (2018) also found that except for respondents working specifically with sustainability, found the concept unfamiliar and lacked an understanding of the meaning of CE (Ranta et al., 2018). As we mainly spoke to informants with roles linked to the environment, we could not directly measure this aspect. However, we see from the discussion in regard to strategy, that firms which have had focus on continuously enhancing knowledge and having goals on CE within all levels of the firm have had greater success in implementing CE. This could imply that this barrier is still somewhat evident.

Economical barriers were also presented our theoretical framework.

We found a significant economic barrier is the short-term view many in the sector have, especially those who invest, where applying CE requires a long-term view with longer collaborations and financial paybacks (Hart et al., 2019). Poor business cases or lack of business cases is also seen as a barrier (Ritzén et al., 2017; Adams et al., 2017a; Hart et al., 2019). This as a consequence creates another barrier, an unclear financial case.

In our findings we found that there often was a general belief of CE being more expensive, especially for investors and management. We reflect over if one does not know how or what economic consequences performing CE will have, it will naturally become a barrier. The fact that there also exist transactional barriers, which provides a risk is also mentioned (COWI, 2019)

Another economic barrier is the high short-term investment costs (Hart et al., 2019). This may be related to costs related to research and development that need to be done implement CE (Hart et al., 2019; Ünal et al., 2019). From our analysis we found that CE is currently costly, due to the lack of processes and methods which require “trial and error” processes a long with the lack of others performing reuse making it more expensive. One might also argue this could be related to the lack of supply chain collaboration as we addressed previously and the complexity of reuse-processes regarding technical barriers which will be elaborated in one of the following sections.

Low prices for virgin raw materials and subsequently the low end-of-life value is seen as another barrier (Hart et al., 2019). From our analysis we found this to be addressed by most as they explained that it is currently cheaper buying new rather than to reuse. Yet end-of-life value were not addressed.

COWI address the lack of economics of scale (Høiby & Sand, 2018). Our analysis did not directly reflect upon this, yet we deem this to be a logical assumption, however we argue that due to the current level of implementation in the Norwegian building sector, it will be a long time before this barrier will get increased focus.

Sectoral barriers, or as we called them, technical barriers were also present in our findings.

From our theoretical framework we found that one of the most significant barriers was lack of incentive to design for end-of-life for construction products. Lack of end-of-life considerations for the whole building’s life cycle is seen as a barrier as well as the complexity of the building, which are connected Adams et al (2017a). Many of the existing buildings has a long lifetime, this may indicate that they were not built with reuse in mind. Hence, existing buildings may also contain hazardous materials which will not be sufficient to use according to new laws and regulations (COWI, 2019). The process of dismantling a building for reuse is thereby also a complex task, and with a common lack of time, strict budget and limited space this is highly challenging. Even the process of recycling in a demolition process is challenging (COWI, 2019).

From our findings most recognized the challenge with existing buildings, either due to 1) content of hazardous materials, 2) materials not corresponding with current TEK, 3) lack of documentation for materials or 4) the building was not built with reuse in mind. It is important to mention that these were mainly related to reuse, rather than CE as a whole.

Our findings also showed that there was a lack of efficient processes for quality assurance and testing, and many also had concerns in regard to logistics and storage of reused materials. The indication was also that such processes were time consuming and required increased manual work.

In regard to recovery of materials, there were also some technical issues identified. The lack of long-term warranties of materials, lack of certification and quality assurance of both reclaimed products and recycled materials (Adams et al., 2017b; Debacker et al., 2017; Høibye & Sand, 2018; Ritzén et al. 2017). Our analysis showed that uncertainty of product quality in combination with reuse were presented as a main barrier. This provided risks and raised questions about warranties and responsibility as well as how to ensure quality. There were also challenges regarding the fact that reused products are treated the same way as new products, and this provided challenges of re-certification and CE-labelling, which will be further addressed in regard to regulatory barriers.

Theory also addressed challenges in regard to trying to reuse structural materials such as concrete and other composite products (Hart et al., 2019). From our analysis we found examples of firms that had tried this in practice, and the experiences from this were mainly related to the other sectoral barriers mentioned, especially in regard to ensuring quality and the lack of existing processes.

Lastly, a notable barrier by Hart et al (2019) is the insufficient use of design and collaboration tools. This also included development of such tools, as well as the use of information and metrics which are often combined with such tools (Adams et al., 2017a; Adams et al., 2017b; Hart et al., 2019, Debacker et al., 2017). To our impression we did not see such tools as evident in our analysis. Some elaborated on the need for more supply chain collaboration yet did not especially mention there was a tool for this which were missing. However, they mentioned a need for a register of reused and reusable materials, both internally and externally.

An interesting perspective we found in our analysis were that some reflected on the need for adjusting the way the building process is executed, and the way it differs from how it should be done in theory, and that the planning-phase need more focus. This is strongly linked to what we have addressed in terms of implementation of CE in the early phase, as well as the barrier of time has been mentioned by most.

Regulatory barriers were a main factor in our theoretical framework. A lack of consistent regulatory framework and policy support is found as a barrier in regard to implementation of CE in the built environment (Acharya et al., 2019; Hart et al., 2019).

Many existing policies and instruments today are developed from a linear standpoint, which creates a barrier for CE as it does not consider the reality of how it can affect construction of circular buildings (Henrotay et al., 2017). The laws in regard to certification and documentation is also a barrier, especially when it comes to reuse. It is also emphasized that goals and requirements for energy efficiency is also hard to operate by if the building-materials are to be reused (COWI, 2019). From our analysis we found that many relates to the fact that there does not exist laws specifically in regard to reuse, hence such materials have to be treated as new materials. There are also laws in order to document and ensure product quality, which provides challenges for reuse.

Specific barriers related to legislations and policies was found in the survey by Adams et al (2017a), where they found that policies today are too focused on landfill diversion which directly affects their ability to apply reuse. Hence, the focus is diverted from reuse. From our analysis we found that the current laws and regulations also result in the fact that it is cheaper to send materials to landfill rather than reuse them.

Another barrier is ambiguous end-of-waste regulations which was seen as a big barrier for implementing CE (Adams et al., 2017a; Acharya et al., 2019). COWI also emphasize that the current TEK is experienced to be fuzzy when it comes to reuse of materials (COWI, 2019).

Many of our informants reflected upon some challenges specifically related to TEK, such as 1) Lack of continuous updates, 2) Broad generalization, 3) It is perceived as fuzzy and 4) Many elements are not monitored and act as sleeping clauses.

As we can see from both the sectoral and regulatory barriers, most of them are related to reuse. We might argue why reuse has gained such high focus when there are clearly some substantial barriers to overcome in order for implementation of reuse to be successful. We argue that one might could have avoided these in approaching CE from a different perspective, such as from a design for future reuse perspective. Yet these barriers are important to acknowledge as we deem these to still be important to overcome in the future.

Aside from the barriers directly linked to the structure of the theoretical framework on barriers in the building sector, we found it necessary to address the **market** as an own perspective. Adams et al. (2017a) addressed that there was a lack of market mechanisms for recovery of materials, a side from this, our theoretical framework did not mention much on this area.

From our analysis we divided this by platform and demand. Where the discovered need for platform directly link to our theory as shown above. Many said that this were crucial in order for

further implementation of CE, and some have even started developing such tool themselves. We argue that this is also strongly connected to the technical barriers which we elaborated within the sectoral barriers. The lack of system, such as access to information of reused or reusable materials, storage and logistics were also in connection to this.

On the other hand, you have the aspect of demand. From our analysis we found that the demand for more sustainable and circular buildings were not substantially present among customers and end-users, especially in the housing-sector and less central areas. We argue that there is a strong correlation between this and what was presented in our theoretical framework in regard to acceptance of reused or recycled materials and products, in relation to human attitude in regard to using something that is used beforehand and that it may lack quality (Adams et al., 2017b; Ranta et al. 2018). It is easy to forget that the end-user is a part of the value chain, yet there might not be a point in designing and constructing sustainable or circular buildings if the customer are not aboard with the idea, in the end they are the ones which is going to use it and non the least pay for it.

As we found in economical barriers, CE were also currently costly which again make the price-tag of building higher, for some, especially in the housing-sector this resulted in the fact that they were more expensive than others in the market, which made the competitive conditions a barrier, which also supports the notion of how . We may argue that for those who emphasized this, the market in their area were on standby, yet it is also supported by theory. From our theoretical framework we found that there is a need for new policies and legislation that enables competitive conditions against the current linear economic model, which implies that current policies and legislations are barriers (Adams et al., 2017b).

Some informants also addressed the dilemma between environmental considerations vs. level of cost and use of time. From our previous discussion regarding the increased focus on sustainability, we saw that this is where CE have been introduced. Some of our informants reflected on the fact that CE has in general had a more environmental focus, rather than seeing it from an economic perspective. This could contribute to the economical barriers we found, as many might not see it as a business case, if the market is not aboard.

On the other hand, it was reflected over the fact that Norway has too much money, seen from a market perspective. We assume Norwegians can generally afford having the new and trending, which could reflect in and cultural barrier in regards to attitude, combined with the fact that they do not see the reason for having i.e. reused or designed for reuse products, as they could easily replace it due to their purchasing power. This is also strongly linked to the current linear economy.

7 Conclusion and Further Research

7.1 Conclusion

Early on we recalled that CE is a broad concept with many definitions. This was also reflected in our analysis and discussion. Combined with lacking availability of such information, we gather this to be the foundation of our informants. This could result in the fact that informants are biased by the way enablers such as BNL and FutureBuilt interpret the information that is shared in the sector. In that way such enablers carry a big responsibility, at the same time as they have had play a huge part in the push towards a more circular economy.

In order to answer our research question, we chose to divide this section in to two sections. First, we will answer *to what extent circular economy is being adapted in the Norwegian building sector*.

The focus on sustainability has increased in the building sector, mostly due to the push from EU. As circular economy is seen as a tool for operating in a more sustainable manner this has also gained more focus. The focus was somewhat varied. In central areas and bigger firms the focus was clearly higher, which we also argue is due to market conditions, sufficient resources and maturity.

It is clear that the wheels have started to turn in order to shift towards a more circular economy in the building sector. We were able to gather insight on specific measures towards this transition. What we realized was that there was a great focus on reuse, which is only a small part of what circular economy actually entails. We argue this to be in combination with a general focus on short term environmental winnings. There has also been an increased focus on rehabilitating buildings that could play a part in why reuse has such focus. As some of the informants also pointed out, circular economy requires one to see the bigger picture, also from a long-term perspective. In regard to this, we still feel that the building sector has a long way to go, although the initiatives are there. Yet we also believe this to be a result of the unclarity of what circular economy entails.

Currently the building sector is still in the process of trial and error, and some pilot projects have taken place. The current measures implemented is an enabler for shifting the way of thinking, and an important step in order to reflect on how things could be done differently. Construction clients should act as good examples and be enablers for this to be reflected throughout the whole supply chain. Yet we also believe the focus should be directed to the early stages of the building process,

as in the idea- and planning- phase, also called the design stage in the building's life cycle. We argue the lack of focus on this phase is highly connected to the fact that the building process today is characterized by strict timelines and budgetary limitations. If measures were considered from an earlier stage, where design plays an essential part, we believe this will result in a more long-term view, where you also could have a more holistic approach.

Secondly, we will provide overview of which barriers we found necessary to be addressed in order to increase the implementation of circular economy in the Norwegian building sector. These are presented below:

We found **cultural barriers** to be evident within the Norwegian building sector. Knowledge were among the most significant within this area, and there were variations in the level of awareness throughout the supply chain, especially for smaller firms and less central businesses. There is also need for increased supply chain collaboration.

Economical barriers were also highly evident, we found that there often was a general belief of CE being more expensive. CE is currently deemed to be costly, due to the lack of processes and methods which require "trial and error" processes. The fact that it is currently cheaper buying new rather than to reuse, is also seen as a barrier.

We found many **sectoral barriers**, mainly related to reuse, rather than CE as a whole. Recognized challenges were in regard to existing buildings, lack of efficient processes for quality assurance and testing, as well as storage of reused materials. In regard to this, time were also presented to be a key barrier.

Regulatory barriers were also present. We found that many relates to the fact that there does not exist laws specifically for recovered materials, combined with the laws in order to document and ensure product quality, which provides challenges for reuse. The current laws and regulations also result in the fact that it is cheaper to send materials to landfill rather than reuse them. There were also challenges specifically related to TEK, such as 1) lack of continuous updates, 2) broad generalization, 3) it is perceived as fuzzy and that 4) many elements are not monitored and act as sleeping clauses.

Market barriers were also deemed to be an important aspect. We discovered the need for a market platform in order to perform more reuse. The lack of system, such as access to information of reused or reusable materials, storage and logistics were also in connection to this.

On the other hand, you have the aspect of demand. Demand for more sustainable and circular buildings were not substantially present among customers and end-users, especially in the housing-sector and less central areas.

7.1 Further Research

The result of this study shows that CE has been implemented to a small degree and that there are many barriers that need to be addressed before the sector can come further. As the general knowledge on CE in the building sector is interpreted to be low, we see this as an essential first step to address in order to move further with implementation of CE. From our analysis, we found that some of the building clients are actively working both internally and externally to create awareness, share experiences and enhance competence on CE. This could be seen as a form of an enabler, although it could only be effective if all actors receive this information.

Sharing knowledge and experiences can be directly linked to supply chain collaboration, as it may enhance the knowledge and create new relationships between actors. This study found that for implementation of CE to come further, it requires greater collaboration within the supply chain. Further addressing how this can be achieved it therefore an interesting area.

We also found that while completing this study, the national strategy for CE were presented, hence it would be interesting to research how this has an effect on the further implementation of CE in the Norwegian building sector.

We also discovered many opportunities while doing this study, and due to limitation in regard to focusing on the extent of implementation and barriers, these were not addressed. Hence it could be essential to address this area in further research.

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Appendices

Appendix 1: NSD Approval

Prosjekttittel

Sirkulærøkonomi i byggebransjen

Referansenummer

806455

Registrert

13.01.2020 av Heidi Sjulstad - 222333@student.usn.no

Behandlingsansvarlig institusjon

Universitetet i Sørøst-Norge / Handelshøyskolen / Institutt for industriell økonomi, strategi og statsvitenskap

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Bengt Roland Hellberg, Roland.Hellberg@usn.no, tlf: 0046730827878

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

Heidi Sjulstad, heidi.sjtd@gmail.com, tlf: 93459048

Prosjektperiode

01.01.2020 - 15.05.2020

Status

17.01.2020 - Vurdert

Vurdering (1)

17.01.2020 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet 17.01.2020 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer

vi deg til å lese om hvilke type endringer det er nødvendig å melde:
https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 15.05.2020.

LOVLIG GRUNNLAG

Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER

NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet DE

REGISTRERTES RETTIGHETER

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER

NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet

(art. 5.1. f) og sikkerhet (art. 32). For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET

NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Kontaktperson hos NSD: Henrik Netland Svensen Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Appendix 2: Information sheet

Forespørsel om deltagelse i forskningsprosjektet

Sirkulær økonomi i byggebransjen

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke hvilke muligheter og utfordringer som ligger til grunn for hvorvidt sirkulære økonomi har blitt implementert i den norske byggebransjen. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Vi er to masterstudenter ved Universitetet i Sørøst Norge i Kongsberg som skal skrive masteravhandling innen industriell økonomi våren 2020. Formålet med avhandlingen er å undersøke og belyse hvilke muligheter og utfordringer som ligger til grunn for hvorvidt sirkulær økonomi har blitt implementert i den norske byggebransjen. Vi ønsker å se nærmere på hvordan byggherrer i Norge stiller seg til dette fenomenet i dag. Bakgrunnen for dette er blant annet at vi opplever at eksisterende forskning har utilstrekkelig dokumentasjon på at sirkulærøkonomiske tiltak i teorien har blitt benyttet i praksis i den norske byggebransjen.

Hvem er ansvarlig for forskningsprosjektet?

Universitetet i Sørøst-Norge: Institutt for industriell økonomi, strategi og statsvitenskap.
Campus Kongsberg

Hvorfor får du spørsmål om å delta?

Vi spør deg med utgangspunkt i at du jobber for en byggherre. Gjennom vårt nettverk i byggebransjen har vi blitt formidlet deres kontaktopplysninger. Dette er et utvalgskriterium som representerer aktører vi anser som betydelige i forhold til vårt forskningsspørsmål. Utvalget er derfor strategisk, og utvalget vil bestå av åtte bedrifter som blir kategorisert som byggherrer. Med to informanter fra hver bedrift ønsker vi å skape et helhetlig bilde av hvordan bedriften og bransjen stiller seg til problemstillingen vår.

Hva innebærer det for deg å delta?

Hvis du velger å delta vil du bli intervjuet om det aktuelle temaet. Vi søker informasjon som vi vil gi oss et helhetlig bilde på hvorfor situasjonen er som den er i dag, og dermed ønsker vi å utføre dybdeintervju med en til to ansatte i deres bedrift. Utenom informasjon rundt temaet vil vi samle inn opplysninger om hvilken rolle og oppgaver deltakeren har i bedriften, hvor mange byggeprosjekter deltakeren håndterer i snitt, og hvor lenge deltakeren har jobbet i bransjen. Det vil bli gjennomført et intervju per intervjuobjekt på ca. 30-45 minutter, med mulighet for oppfølgingsspørsmål i etterkant av intervjuet per mail. Dataene vil bli registrert i form av lydopptak og videre benyttet i arbeidet med masteravhandlingen.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller om du senere velger å trekke deg.

Ettersom dette i hovedsak er en undersøkelse om hvordan bransjen stiller seg til fenomenet vil ikke undersøkelsen påvirke ditt forhold til arbeidsgiver eller posisjon i bransjen, data som samles inn vil anonymiseres.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrevet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Dataen vil bli oppbevart på passord-beskyttet pc og vil kun behandles av de to involverte studentene. Veileder for prosjektet vil også ha innsyn til oppgaven. Dataene og resultatene som presenteres i masteravhandlingen anonymiseres og vil ikke kunne spores tilbake til organisasjonen eller individet.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Prosjektet avsluttes 15.05.20. Vi vil slette innsamlete persondata og lydopptak når prosjektet er avsluttet.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Universitetet i Sørøst-Norge har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?

Hvis du har spørsmål til studien ta kontakt med:

Heidi Sjulstad: heidi.sjtd@gmail.com Ane Topnes: ane.m.topnes@gmail.com

Veileder for prosjektet: Bengt Roland Hellberg, roland.hellberg@usn.no

Studien er meldt inn til NSD – Norsk senter for forskningsdata AS i samsvar med personvernregelverket.

Appendix 3: Consent form

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «Sirkulærøkonomi i byggebransjen», og har fått anledning til å stille spørsmål.

Jeg samtykker til å delta i intervju hvor det benyttes lydopptak og at opplysningene jeg deler blir presentert anonymt i masteravhandlingen.

Jeg samtykker til å motta og svare på oppfølgingsspørsmål per e-post om nødvendig etter intervjuet. Det vil ikke bli utsendt oppfølgingsspørsmål etter prosjektets slutt.

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, 15.05.2020

(Signert av prosjektdeltaker, dato)