YRKESHÖGSKOLAN
NOVIA

Circular economy in Ostrobothnia

Case: European Project Semester – Circular Economy

Jonathan Greco

Bachelor's Thesis

Degree Programme in Business Administration

Vaasa 2018

BACHELOR'S THESIS

Author: Jonathan Greco
Degree Programme: Bachelor of Business Administration, Vaasa
Specialization: International business
Supervisor: Stefan Pellfolk
Title: Circular Economy in Ostrobothnia

Date 19.1.2018 Number of pages 33 Appendices 225

Abstract

This thesis has been a study based on the report 'Circular Economy'. The report was written during my European Project Semester at Novia UAS fall semester 2017, together with Alina Reuter from Germany and Killian Durieux with Thijs Bod from the Netherlands. The report works as a pre-study for the Botnia-Atlantica program, seeking to implement CE in Finland, Sweden and Norway.

Circular economy (CE) is about sustainability and renewability by creating material loops through reusing, recycling and refurbishing in order to retain the value over time. These key features are what differ CE from the currently implemented linear economy model, where materials are simply exploited, used and thrown at the end of their life cycle.

The thesis is author emphasized using a qualitative approach, focusing on small numbers of subjects gaining more unstructured and in-depth answers on the matter. It brings the additional value of interviews with subjects from various fields connected to the construction industry. The result is their opinions and thoughts on the current state and future view of CE in Ostrobothnia, as well as realizability for Finland's 2025 goals of becoming a leader in CE.

Language: English Key words: circular economy, sustainability, Ostrobothnia, EPS

EXAMENSARBETE

Författare: Jonathan Greco
Utbildning och ort: Företagsekonomi, Vasa
Inriktningsalternativ: Internationell handel
Handledare: Stefan Pellfolk
Titel: Cirkulär ekonomi i Österbotten

Datum 19.1.2018 Sidantal 33 Bilagor 225

Abstrakt

Detta examensarbete är uppbyggt utifrån rapporten Circular Economy. Rapporten gjordes under min European Project Semester vid Yrkeshögskolan Novia höstterminen 2017, tillsammans med Alina Reuter från Tyskland samt Killian Durieux och Thijs Bod från Nederländerna. Rapporten fungerar som en förstudie för Botnia-Atlantica programmet som försöker driva igenom tankar om cirkulär ekonomi (CE) i Finland, Sverige och Norge.

CE handlar om hållbarhet och förnybarhet genom att skapa materialkedjor där man återanvänder, återvinner och renoverar för att behålla materialets värde genom tiden. Dessa nyckelfunktioner är vad som skiljer CE från den nuvarande linjära modellen, där material utvinns, används och slängs bort i slutet av livscykeln.

Examensarbetet är aktörsbetonad och framförs med hjälp av ett kvalitativt tillvägagångssätt, med fokus på ett mindre antal intervjuer som ger mera ostrukturerade men djupgående svar på undersökningen. Tilläggsvärdet från rapporten framförs genom intervjuobjekt från olika områden kopplade till byggbranschen. Resultatet är deras åsikter och tankar om nuvarande tillstånd och framtida syn på CE i Österbotten samt förverkligande av Finlands 2025 mål att bli ledande inom CE.

Språk: engelska Nyckelord: cirkulär ekonomi, hållbarhet, Österbotten, EPS

OPINNÄYTETYÖ

Tekijä: Jonathan Greco
Koulutus ja paikkakunta: Liiketalous, Vaasa
Suuntautumisvaihtoehto: Kansainvälinen kauppa
Ohjaaja: Stefan Pellfolk
Nimike: Kiertotalous Pohjanmaalla

Päivämäärä 19.1.2018 Sivumäärä 33 Liitteet 225

Tiivistelmä

Tämä opinnäytetyö perustuu raporttiin Circular Economy. Raportti tehtiin European Project Semester -projektilukukauden aikana Yrkeshögskolan Noviassa syksyllä vuonna 2017 yhdessä saksalaisen Alina Reuterin ja alankomaalaisten Killian Durieuxin ja Thijs Bodin kanssa. Raportti toimii esitutkimuksena Botnia-Atlantica-ohjelmalle, joka pyrkii edistämään kiertotalouden ajatuksia Suomessa, Ruotsissa ja Norjassa.

Kiertotalous käsittelee kestävyyttä ja uusiutumista. Luomalla uusia materiaaliketjuja, missä kierrätetään, uusitaan tai kunnostetaan, materiaalin arvo säilyy läpi aikojen. Nämä avainpiirteet erottavat kiertotalouden nykyisestä lineaarisesta mallista, jossa materiaalit yksinkertaisesti otetaan talteen, käytetään ja hävitetään elinkaaren lopussa.

Opinnäytetyö on kvalitatiivinen ja keskityttiin pienempään määrään haastatteluja, jotka antoivat jäsentymättömämpiä, mutta syvempiä vastauksia tutkimukseen. Raporttiin lisäarvoa antavat rakennusteollisuuden eri aloilta olevien haastattelut. Tuloksena ovat heidän ajatuksensa ja näkemyksensä kiertotalouden nykytilasta ja tulevien tavoitteiden saavuttamisesta Pohjanmaalla, sekä Suomen 2025-tavoitteesta tulla kiertotalouden johtajaksi.

Kieli: englanti Avainsanat: kiertotalous, kestävyys, Pohjanmaa, EPS

Table of contents

List of Appendices

1. Circular Economy (2017) by T. Bod, K. Durieux, J. Greco and A. Reuter

2. Mail correspondence with Johan Saarela

Word explanation

EPS	:	European project semester
CE	:	Circular economy
R&D	:	Research and development
UAS	:	University of applied sciences
SME	:	Small to medium-sized enterprise
CEO	:	Chief executive officer
UK	:	United Kingdom
EU	:	European Union

1 Introduction

In the fall semester of 2017 I performed an EPS at my home university Novia UAS. The EPS is a multi-national European program that aims to train and educate students, divided in multi-national teams, in various skills. This further implements their knowledge by using real-life projects and training their multi-cultural teamwork skills. More information about the EPS can be found under the chapter 2.1 ‘The EPS’.

The motivation behind my choice to participate in this kind of project, instead of writing a regular thesis, was to practice my cooperation and organization skills and optimize my teamwork performance in a real-life multicultural project situation. These motivations are based on the need of teamwork and multicultural skills in companies as an effect of the globalization of the workforce. Furthermore, a driving force behind my choice was to do something a bit different while building friendships, networks and improving my cross-cultural communication skills. The report is used as a base for this thesis.

After the first week of orientation I was assigned to the project ‘Circular Economy’, hereafter referred to as the report, together with Alina Reuter from Germany and Killian Durieux with Thijs Bod from the Netherlands, hereafter referred to as the team. The report can be found as appendix 1. Between the different projects available during the semester this was the one I was most interested in, as well as the one most suitable according to my study background. More information about the report can be found under the chapter 2.3 ‘Overview of the report’.

1.1 Purpose and problem specification

To fulfil the criteria for a thesis at Novia UAS, an additional value had to be added aside with the actual report. As the report is focused on the construction industry, with its deliverable being part of a bigger picture in the implementation of CE in the Ostrobothnia region, the goal of the thesis is to draw conclusions on:

- Current implementation of CE in Ostrobothnia;
- Future development of CE in Ostrobothnia;
- Thoughts on Finland’s goal of becoming a leader in CE by 2025.

The approach to examine the research question is based on findings generated from the report. The first question is based on the theories behind CE, see chapter 2 ‘Introduction Circular Economy’ in appendix 1.

The second question focuses on the possibilities for implementing CE in the Ostrobothnia region, on which the report works as a pre-study for, see chapter 1.2.2 ‘Purpose of the project’ in appendix 1.

The third question is based on Finland’s goal of becoming a leader in CE by 2025 mentioned in appendix 1 chapter 3.2 ‘Current situation of the Finnish construction industry’. As stated on the website of the Finnish Ministry of the Environment:

> Among the objectives of Prime Minister Sipilä’s Government is that Finland is a forerunner in the circular economy by 2025. The key project on the bioeconomy and clean solutions contributes to reaching this objective” (Ministry of the Environment, 2017)

1.2 Structure and methodology

This structure of this thesis is based on the EPS report ‘Circular Economy’. The customer for the report was Annika Glader from the R&D department of Novia UAS and the supervisor Stefan Pellfolk from the construction engineering programme at Novia UAS. The report was divided in three parts, working mainly as a pre-study for the EU funded project ‘Circular economy: a game changer for the wood building industry’, a Botnia-Atlantica program that researches the possibilities of implementing CE in the Ostrobothnia region. CE is about sustainability and renewability, aiming to keep the highest possible material value at all time. Further clarifications and a more comprehensive explanation, including the advantages and disadvantages of it, can be found under chapter 2.2 ‘Circular economy’.

Based on the criteria for CE and the tasks given by the project customer, different resource-efficient buildings were listed and presented. This was done by outlining information about their background, supply chain, influences and a conclusion on their circularity. The final list contains six CE-inspired buildings located in Denmark, Finland, Germany and the Netherlands. More information about the best practice cases can be found in appendix 1 under chapter 4 ‘Best practice cases’.

The final part of the project presented three different business ideas, developed for decreasing the usage of plastic packages in retail stores and in their supply chain. The ideas outline the introduction of a company producing reusable packages traded in a deposit-refund system, a package free supermarket and a company offering grocery delivery service in reusable packages. More information about the business ideas can be found in appendix 1 under chapter 5 ‘Business idea’.

As the additional value to the original report, the thesis brings thoughts and opinions from subjects within several fields connected to the construction industry in Ostrobothnia. It highlights their thoughts and opinions in the questions taken up in the previous chapter, drawing correlations and conclusions in the closing phase of the thesis.

1.3 Limitations

This thesis is limited to the construction industry and interview subjects are from various areas connected to it. The reason is that the report it is based on researches in the field of construction industry. Both resources and time were too limited to extend the research of the thesis on areas outside of the construction industry.

2 Previous research

This chapter highlights the previous research made during the EPS at Novia UAS. To get a better understanding on the previous research the thesis is based on, the background of the EPS is explained. Hereafter follows a chapter overviewing the report made by the team during fall semester 2017.

2.1 The EPS

The EPS, European Project Semester, is a multi-national programme offered by 18 universities in twelve countries within Europe. Engineering students are in the focus, but those from the fields of design and business are also accepted. The programme arose as ongoing integration within Europe demands young and trained professionals with experience in cross-cultural communication and teamwork. The project teams are multi-disciplinary and multi-national, giving the students an opportunity to gain knowledge of various fields while improving cross-cultural teamwork. (Hansen & Abata, 2017)

During the fall semester at Novia UAS the students took part in several courses besides working on the given project. Examples of these are teambuilding, project management and an introduction to the local language Swedish. English was the main working language for all oral and written communication during the semester.

In 2017 a total of 17 students coming from Finland, France, Germany, the Netherlands and Spain took part in the EPS at Novia UAS. The different topics offered during the semester were 3D Printing, Circular Economy, Tomato Picker and Wet Grain Package.

The tasks given to my group were to research the implementation of CE in the European construction industry, find good existing examples and present a business idea. The outcome of the report was act as a pre-study for a project that aims to implement CE in the Ostrobothnia region. The full description of the given tasks can be found in appendix 1 under chapter 1.2.1 ‘Project description & project background’.

2.2 Explanation of Circular Economy

The idea behind CE is not as new and revolutionary as one may think. Thoughts on the matter started in the late 60's in an essay published by the economist Kenneth E. Boulding, 'The Economics of the Coming Spaceship Earth'. Boulding refers to closing the material loop, usage of renewable energy sources and retaining the value over time as key matters for the success of a CE. (Frick & Hedenmark, 2016, 10-11) The closed loop system behind CE means that materials and resources are for example reused or refurbished, continuing the loop. This is achieved by creating industrial ecosystems of companies working together in a symbiosis. The currently adapted model of linear economy works with open loops where taken materials become waste after usage, further decreasing the available resources. (Frick & Hedenmark, 2016, 26-28) At present the two biggest actors promoting the transition to CE are the UK based Ellen MacArthur Foundation and the Circle Economy from the Netherlands (Frick & Hedenmark, 2016, 29-30).

Further investments in CE by the EU's member states and companies is an attractive and achievable possibility. The benefits for a transition to CE in the EU are growth of the national GDP, while at the same time lowering the cost of primary resources as well as reducing carbon dioxide emissions. The internal collaboration within the EU would lead to the creation of global standards both in procedures, design and choice of material. (SYSTEMIQ & Ellen MacArthur Foundation, 2017, 15-17)

Further information about CE can be found in the appendix 1 chapter 2 'Introduction circular economy'.

2.3 Attained outcome from the EPS-report

With a list of examples containing companies, projects and buildings that match on several circular aspects and a deeper research on six cases, the team delivered to the project customer a base for the upcoming research for the Botnia-Atlantica programme. Furthermore, the team succeeded in the development of not one, but three business ideas.

2.3.1 Best practice cases

The topics for the best practice cases were chosen from over 120 buildings that matched search terms based on the ReSOLVE framework by the Ellen McArthur Foundation. The following are the six buildings presented in the report.

Finch Buildings

Finch Buildings B.V. produces modular buildings assembled from separate modules, mainly made out of FSC-certified wood. 90 % of all materials used in the modules are suitable for reuse. The company behind the buildings aims for a high flexibility through an adjustable living area surface, adjustable interiors as well as simplified transport and relocation of the modules. According to the manufacturers, the total cost of ownership for a module is lower than the one of a competitive alternative over a lifespan of 15 years. Also, the buildings are meant to last for over a century if well maintained, and are designed to be highly energy-efficient. However, clients still often seem to opt for non-circular alternatives when it comes to the actual purchase.

This building was chosen because of its combination of modularity, the use of wood and its durability. More information can be found in appendix 1 under chapter 4.2 ‘Finch Buildings’.

Pluspuu Talot

Pluspuu Talot is a studio founded in late 2009 in Helsinki, Finland. As their main product, they offer architectural services with house packages, consisting of carefully designed log houses in various shapes, making them customizable according to the customer’s needs. Their line of products is all based on wood, that compared to other traditional building materials is renewable and combines characteristics such as insulation, ventilation and durability. Pluspuu Talot uses the manufacturing company Ollikaisen Hirsirakenne for the construction of the buildings.

As the project customer from Novia's R&D department showed interest in the circularity and the supply chain of the company, the decision was made to further research in the matter. More information can be found in appendix 1 under chapter 4.3 'Pluspuu Talot'.

Villa Asserbo

Villa Asserbo is a '3D wood printed' house, located in Asserbo, Denmark. The focus of this project was to have the smallest possible environmental footprint for a building, in aspects such as designing, building, usage and deconstruction. The villa was built out of modular segments, made with a portable CNC-machine. The machine milled multiple digitally designed sections in quick succession, out of sustainable plywood boards. The modular segments are small and light enough to be carried by two persons, which makes heavy equipment redundant and on site building possible.

The project was chosen because of its focus on circularity both in the technical and biological cycle. It also uses wood from the Nordic wood industry, and ample information was initially available. More information can be found in appendix 1 under chapter 4.4 'Villa Asserbo'.

De Fire Styrelser

De Fire Styrelser, also called Nexus CPH on technical terms, is a hub for four Danish government boards located in Copenhagen, Denmark. The building is designed as a PPP-project (Private Public Partnership) meaning the responsibility of the building is for the builder, also called the contractor. The customer pays a fixed price for using the building, which stimulates the investment into efficient and durable systems and technologies from the contractor. The building is designed to be flexible, upgradable and durable.

The building was chosen because of its form of agreement, which changes the common 'owning a property' to a leased construction and is one of the requirements for a circular economy. More information can be found in appendix 1 under chapter 4.5 'De Fire Styrelser'.

Park 20|20

Park 20|20 is the first fully operational cradle to cradle work environment, with multiple buildings on an area of 114.000 m². The main focus, besides being cradle to cradle, is the well-being of its inhabitants. The business park incorporates different circular solutions such as buildings that are designed for disassembly, the use of solar panels, a 'closed loop' water-management system, green roofs and green walls.

The business park was chosen for its use of C2C materials and the large scale of the project. More information can be found in appendix 1 under chapter 4.6 ‘Park 20|20’.

Bionorica Headquarter

The Bionorica Headquarter is situated in Neumarkt, Germany, and is a building planned to be fully recyclable. Special about the building is the supply chain, as the materials that cannot be recycled, like windows and carpets, are taken back by the supplier through a leasing agreement. What is also outstanding are the technical solutions implemented in this building as it is PVC-free. The roof and part of the façade are made out of solar modules, which produce more energy that the building actually consumes. For better thermal insulation, green façades have been installed enriching the air with oxygen and reducing carbon dioxide content.

The building was chosen for the implemented technical solutions as well as its circular supply chain. More information can be found in appendix 1 under chapter 4.7 ‘Bionorica Headquarter’.

2.3.2 Business idea: Decrease of packages in supermarkets

Several brainstorm sessions were held by the team in order to come up with an original idea that would match the aspects of CE. As the operation area did not have to be restricted to the construction industry, the chosen topic was decreasing the package usage in supermarkets. The area is remarkably large and withholds several opportunities, therefore three promising ideas were developed.

Idea No. 1: Reusable package producer

This business idea aims to create a company that will produce a reusable package solution, trying to make it a standardization on the market. The company will offer the reusable package solutions to manufacturers and retailers, for usage by the final customer. Manufacturers and retailers will not buy the products but rent them, like the system behind the Euro pallets by EPAL. The boxes can be returned to a recycle station, as the ones seen in Finland for the deposit-refund 'pantti' system by PALPA. More information can be found in appendix 1 under chapter 5.2.1 'Business idea No. 1: Reusable package producer'.

Idea No. 2: Package-free store

The second business idea aims to establish a package-free store, which is a grocery store that is plastic free. The overall concept of this store is that all products offered are unpackaged, and the customer can buy any amount of a certain product. There are several sale options for different products, as well as various package systems to carry the shopping. To ensure that during transportation the products are not stored in non-reusable plastic containers, the overall aim of the store is also to interact directly with the manufacturers. More information can be found in appendix 1 under chapter 5.2.2 'Business idea No. 2: Package-free store'.

Idea No. 3: Delivery service

The third business idea aims to create a company that offers a delivery and retrieval service using a reusable or biodegradable material for wrapping the orders. The customer orders a desired quantity of the products online and the company then collects these items from the wholesalers, where the products are still to be packaged, putting them in reusable packages and performing a delivery to the end user. At the time of the delivery, the used packages from former orders will be retrieved and brought back to be cleaned and reused. More information can be found in appendix 1 under chapter 5.2.3 'Business idea No. 3: Delivery service'.

3 Method and approach for giving the additional value

A qualitative research method was chosen to examine the research questions. It emphasises a subjective, in-depth and unstructured view of a research question compared to an objective, broad and structured view offered by a quantitative research method (Oak Ridge Associated Universities, n.d.). In this chapter the theoretical framework of the thesis will be further explained, and the development of the questions highlighted.

3.1 Interviews through a qualitative approach

As mentioned previously, a qualitative research method empathizes an unstructured, deep and subjective overview. Commonly known, interviews performed using a qualitative research method are a chat between two beings, the interviewer and the interviewee. While often perfect strangers, the interviewer needs to build up questions open enough to give a fluent conversation between the two. The questions should not be too specific to be answered with a simple 'yes' or 'no'. The interviewer should be flexible and fluent in the questioning. This is what gives the insight that makes a qualitative approach more enriching in small quantities compared to a quantitative one. (Seale, Gobo, Gubrium, & Silverman, 2004, 15-17)

The questions list built up for the interview should be containing keywords covering the issue of the interview. Nevertheless, the focus should not be completely on the questions but on the conversation, in other words guided according to the one interviewed. The usage of a tape recorder keeps the focus on the conversation and not on taking notes. Furthermore, it is important to take the focus away on the conversation being 'on the record' to give a natural and subjective result from the interviewee. (Seale, Gobo, Gubrium, & Silverman, 2004, 17-20)

Conclusions can be drawn through analysing the conversation, searching for structures and correlation in between the interviews and previous data collected. Understanding the data is the first and foremost step. The next step is to organize the data and make a structure of the results, in order to make it easier to be interpreted. The last step is to gain correlations and draw conclusions from the data, answering the research question. (Seale, Gobo, Gubrium, & Silverman, 2004, 153-156)

3.2 Building up the questions

After becoming familiar with the process of a qualitative research method, the following step was to create questions for connecting the theory from the report to current progress and views. The questions were made quite 'open' in order to create a dialogue on the interviewees' personal view of the implementation of CE in Ostrobothnia:

Current state

Characteristics:

> As an important part of the current state is how it can be characterized, this was a suitable first question. The connection to the report comes in appendix 1 chapter 2.7 'Reasons for circular Economy' and chapter 4.1 'Research topics'.

Significance in purchase, sales and supply chain:

> Chosen to clarify current interests when choosing a supplier by actors connected to the construction industry. Can be connected to appendix 1 chapter 3.8 'Supply chain'.

Enablers and barriers - Technological, institutional, internal action and influence by the market:

> The question seeks to highlight current progress and barriers seen by the interviewees. Can be connected to appendix 1 chapter 3.4 'Enablers', chapter 3.5 'Barriers' and chapter 2.10 'Advantages and Disadvantages for companies and customers'.

Future development

From linear to circular economy:

> First and foremost, this question seeks a description of the transition towards CE-principles. Can be connected to appendix 1 chapter 2.2 'From linear to circular economy' and chapter 2.8 'Linear economy vs. circular economy'.

Implementation of CE-principles in the biological and technical cycles:

> Aims to highlight the future implementation of CE-principles in currently existing and future cycles. It can be connected to appendix 1 chapter 2.3 ‘Two cycles’ and appendix 1 chapter 4.1 ‘Research topics’.

Influencing factors:

> As a follow up to the previous question, this question highlights what factors will influence the transition. Can be connected to appendix 1 chapter 2.11 ‘Influencing factors for implementation of CE in SMEs’.

Supply chain:

> Chosen to give an insight of the differences between the future state and demand by the supply chain with its current development. Can be connected to appendix 1 chapter 3.8 ‘Supply chain’, chapter 4.1 ‘Research topics’ and chapter 5 ‘Business idea’.

Geographical influences:

> Seeks to highlight if any there are locally any geographical influences that will enable or hinder the conversion towards CE. Can be connected to appendix 1 chapter 4.1 ‘Research topics’.

Thoughts on Finland’s goal of becoming a leader in CE by 2025

Construction industry:

> As both thesis and report were limited to the construction industry, it was a natural questioning whether and how the 2025 goal will affect the sector. Can be connected to appendix 1 chapter 3.2 ‘Current situation of the Finnish construction industry’.

The strategic priorities:

> As it is not clear whether the sum reserved by Finland for achieving the goal is enough or not, this is a suitable question. Can be connected to appendix 1 chapter 3.2

‘Current situation of the Finnish construction industry’, where the sum reserved for the strategic priorities is further explained.

Realizability:

There was a need for a closing question to finalize the interview. As it is just seven years to the goal, a view on the realizability of Finland’s future towards CE would be a suitable topic for closing the interview.

4 Result

Following the creation of the questions, several interview subjects that could have a valuable input were asked to participate in an interview. The subjects were chosen from several fields, in order to give a higher validity to the research topic. Due to the fact that time for composing the thesis was limited after having performed the report, only four subjects were interviewed. Noticeable is the interview with Johan Saarela being less consistent, as it was a mail correspondence due to the subjects' lack of time for an actual interview.

In the following subchapters their thoughts and opinions are presented.

4.1 Annika Glader, Novia UAS

In order to get opinions from the ones researching the field of CE, Annika Glader was chosen for an interview. She is a researcher and project manager at the R&D department at Novia UAS. The interview took place on the 21th of December 2017 at Novia UAS in Vasa. In the following subchapters follows a summary of the discussion about CE in Ostrobothnia.

4.1.1 Current state

Characteristics

There is an existing broad base of companies and materials that could be easily moved towards CE. A practical definition of CE is needed in order to create for example terms of delivery in the supply chain, as companies are not aware of what CE is in practice. For the moment there is a situation of uncertainty for what measurements to use as classifying when a building material is circular and when it is not. In other words, the question arises for where the threshold needs to be set. This issue needs to be taken up and discussed in order to simplify the implementation of CE.

The thought of recycling waste has been around for several decades. An example is the so called 'Ekobyn' in the village of Singsby. There, individuals could create new building materials using old machinery for processing the materials, often recycled or eco-friendly produced. Nevertheless, this cannot be called completely circular as one of the criteria for

CE materials is that it should have a low carbon footprint, even for raw- or recycled materials used. Furthermore, issues regarding the health-aspects arise, as one cannot use whatever material without being exposed to intoxication. Therefore, further research needs to be performed in order to clarify thresholds for circular materials. The Botnia-Atlantica project 'Circular economy: a game changer for the wood building industry' is trying to determinate the thresholds, looking at more successful countries in CE like Denmark and the Netherlands. The threshold for circularity cannot be set too high, otherwise the conversion from linear to circular becomes too difficult. Nevertheless, it cannot either be set too low as it would lead to a situation where everything would be classified as circular.

Sweden is ahead of Finland in the topic of lowering the impact through the Life Cycle Assessment, LCA, a method for achieving a comprehensive picture of the overall environmental impact during a product's lifecycle. In Finland there are some places that consider LCA but not yet in Ostrobothnia.

Significance in purchase, sales and supply chain

Some companies, often hotels, find themselves willing to adopt sustainable solutions as they want to stick out as eco-minded in their marketing campaigns.

Property owners are not always good on imposing requirements in sustainability aspects by suppliers in public procurements. There are specific projects made in order to help property owners understand the quality and sustainability aspects in the procurements. In this way, the final decision does not only rely on the lowest price offered.

Municipalities are starting to 'wake up' and realize that their buildings, like hospitals and schools, often are found having moisture problems. This leads the priorities to a search for more long-term solutions, as one cannot further build in this poor way as before.

Enablers and barriers: Technological, institutional, internal actions and influence by the market

Individuals working in projects handed out by the Ministry of the Environment find the procedure disappointing, as the Ministry do not reckon problems even when highlighted by their own research. The troublesome results are based on the fact that the threshold for the lifespan of a building is currently set for 50 years. This short-term strategy reflects on the

design and material selection, which arises issues in the buildings not many decades after being built. In the end, buildings are being demolished rather than repaired as the costs would be similar. Government institutions needs to see over their strategy for approaching CE.

4.1.2 Future development

From linear to circular economy

Constructing in wood is getting an even bigger importance as more fairs are organized all over Sweden. There, municipalities are creating general infrastructure plan around wood buildings, leaving those not wanting to construct using wood giving a clarification in the matter. This was not meant as an intentional step towards CE but more as a 'good thing' as people have always built using wood, which gained the wood industry more significance. This strategy is looked at by several actors wanting to implement CE in Ostrobothnia.

Companies show interest for becoming international actors, which in a way contradicts the thought of CE as materials should be harvested locally and the transport distance should be kept to a minimum. Future CE companies will become more niched while working in the a 'local' area, which in the case of Ostrobothnia is the Botnia-Atlantica region.

Implementation of CE-principles in the biological and technical cycles

The wood industry is a main choice for CE as wood is a renewable material both in the biological and technical cycle. Its various usages and characteristics creates the possibility to lower the use of energy-demanding materials, such as concrete.

Influencing factors

Customer demand, by property owners in the case of the Botnia-Atlantica project, will be one of the biggest influencing factors towards the implementation of CE. Demand creates local supply, which creates cycles and a step towards a circular society.

Supply chain

Circularity in Ostrobothnia is currently only researched on the surface, as funds for the Botnia-Alandica project plan were limited. Several companies showed interest in CE, but

they did not really understand how that could be implemented in practice. Further research will be performed as the project got additional funds granted. The future goal is to contact more companies, industry unions and trade organizations, plan workshops and show good examples of CE-thinking in order to find matching examples. The vision is to create several CE-cycles of companies that work together in the Botnia-Atlantica region.

Geographical influences

Standing alone, Ostrobothnia does not have the resources needed for a well working CE. This means that a collaboration with the nearby regions is needed in order to create supply cycles, as they are not fully operating yet in Ostrobothnia itself.

Actors for the disassembly phase are yet to be found. This means that building materials are mostly sent to waste disposal stations for creating energy or used as landfilling.

4.1.3 Thoughts on Finland's goal of becoming a leader in CE by 2025

Construction industry

Eight years is a short time for Finland to become a leader in CE, but the construction industry is faster to adapt compared to for example the university environment.

Refurbishing and reusing of materials and products is not always possible, as current ones are not designed to be durable. The choice should be made to reuse such quality materials that hold their characteristics over time.

The strategic priorities

The funds will probably need to be increased, but it is hard to make accurate predictions at the moment. The important thing is to raise awareness, be willing to adapt and eventually invest more as time goes by.

Realizability

The internal circular thinking is a milestone that will most probably be achieved. Nevertheless, the road to a circular society will still be long as circular supply cycles will not be functioning properly by 2025. The goal is still not impossible to achieve if the governing entities create a favourable environment for it, removing barriers for the progress of CE. The change to CE should not be enforced by adding new laws, but incentivized through removing or simplifying current ones. This would facilitate the rise of new innovative solutions.

As shown during the conference 'World Circular Economy Forum 2017' held in June 2017 in Helsinki, the interest in CE is high and people are curious in its implementation in future society. Different actors explained how they overcame the struggle to transit from a linear to a circular way of working, creating inspiration for others.

Finland aims high, which is good for making progress. Unfortunately, Denmark and the Netherlands have quite a lead at the moment, so Finland will not be able to surpass them in such a short time span.

Finland has the disadvantage of generally not being as open minded for rapid changes, as for example Sweden. This is a general disadvantage but can be changed in case companies see clear advantages with CE.

4.2 Göran Östberg, VASEK

Second on the list was to get opinions on the implementation of CE in Ostrobothnia from the public sector. Therefore, the obvious choice was Göran Östberg from Vaasa Region Development Company, VASEK. The company promotes regional growth and competitiveness under the ownership and guidance of seven regional municipalities. Göran Östberg is project manager for 'Cirkulär ekonomi Korsholm', a project aiming to raise awareness and create a successful CE cluster based in the industry area Fågelberget in the municipality of Korsholm (VASEK, 2017). The interview took place on the 19th of December 2017 at the VASEK headquarter in Vasa.

4.2.1 Current state

Characteristics

Companies are currently not aware that some or their working methods might be circular.

In Sweden people are more concerned about CE compared to Finland. The Swedes have been environmentally aware, working with environmental issues for a very long time, due to the successful marketing in the matter. The leading entities have consciously worked to make the Swedes appreciate the value of circular service. If there are economic benefits one could consider it quickly here too, but Ostrobothnia is still too rural. People would consider extensive circular solutions quite ridiculous at the moment. Better conditions for CE are to be found in the major Finnish cities.

Significance in purchase, sales and supply chain

Customers do not ask for how the waste is handled; the price is the important aspect. One is concerned about quality and delivery, but in the end the price is what determines the choice. In other words, the price surpasses circular thinking. In Sweden the case is often the other way around, since the consumers are more aware of eco-thinking. Unfortunately, in Finland the implementation of this thinking before purchasing is lagging behind.

Enablers and barriers: Technological, institutional, internal actions and influence by the market

People’s thinking needs to be changed by highlighting the problem so that they can create a market demand. Many in Ostrobothnia say it's important to choose ecological and local made products, but eventually when making the purchase decision at the stores they still buy the cheapest product.

If a large or important customer demands circular principles by a supplying company, the company has no choice but to change its system as a condition of delivery. If then a law imposed requirements of circular labelled materials in construction and products, companies have no choice but to follow.

4.2.2 Future development

From linear to circular economy

In the behaviour we are taking a lot from Sweden here in Ostrobothnia, but the development of going towards circular economy has been slow. The implementation will take a long time to, as the trend of choosing recycled before new is not yet popular. When that happens, it will be a return to the previous agricultural community: products are designed and built so that they can be repaired, wasting as little as possible. Now it is said that circular economy is something new and revolutionary, although it is an old thing. Previously everything could be repaired, but nowadays it's done too hard or expensive to repair, so it's more convenient for the consumer to throw away and buy new products.

Implementation of CE-principles in the biological and technical cycles

This will occur through combination and cooperation between different parties in the Ostrobothnia society.

Influencing factors

Energy requirements are high compared to, for example, the Netherlands. This prevents for example the reuse of doors and windows in buildings. Use of such materials could be implemented in secondary buildings, or otherwise some kind of refurbishment solution, in order to meet the energy requirements, could be incentivized. As the government cannot lower the energy requirements because it would lead to a higher energy consumption, it becomes a difficult equation to match. Products that meet high energy requirements are also more difficult to produce, with the process often consuming a lot of resources. A balance point needs to be found.

One has to make the people use the term of circular economy in order to highlight the subject, make them think circular and create willingness to make a change. Finns feel often willing to adapt to new systems and manners.

Supply chain

In the area there are several companies with good circular possibilities. These companies have been located since the start of the project 'Cirkulär ekonomi Korsholm', with the goal of sharing networks and ideas for creating a circular cooperation in Ostrobothnia. Already existing examples are a company making used oil into new saw chain oil and a company that upcycles old plastic bags into bio-fuel. In the future the project aims to create a possibility to reuse waste heat and water from an incinerator for the further growing of local artificial fish breeding. Also, the planning of a shopping mall for high-end refurbished products is on the agenda. One of the goals of the project could be said being about creating a brand such as the so-called 'energy cluster' Vasa is known for, in which a consortium of already working companies existed before the term was given.

There are not only energy companies with opportunities in circular economy, as many promising examples of companies working in different industries have been found. It's about combining new things, you do not need any research skills. So, the important thing is to highlight the concept.

Geographical influences

There is a strong culture and driving force for establishing companies in Ostrobothnia. People here are used to being handymen combining different skills. Many companies originate from impulses received during a stay abroad, like those of people who emigrated and then moved back.

The wood industry is not particularly outstanding compared to the rest of Finland, but of course there are a lot of wood resources to be harvested.

4.2.3 Thoughts on Finland's goal of becoming a leader in CE by 2025

Construction industry

The way of thinking in the construction industry needs to be changed, one must start reusing more instead of just throwing everything. The sorting of demolition waste at a construction site is a big future challenge.

The construction industry has made a mistake when not investing in building maintenance. Previously, there were employees who performed periodic maintenance work. Nowadays, consistent savings in the matter stretches out the need of maintenance until the very end. This often leaves building in such a condition that they cannot be repaired but must be demolished. The phenomenon is now seen very often, even in relatively new buildings. Predictive and systematic maintenance, such as the one performed on cars, must be enforced.

The strategic priorities

More incentives and money must be put on the implementation of the circular economy. The sums added so far are too small, especially if Finland wants to reach the 2025 goals. The advantage is that the country has a small population, so changes are easier to apply and can happen more quickly.

Realizability

There is a quite considerable risk that Finland will force circular economy on the population through laws and regulations. The problem is then not resolved, as it provides no alternative use or procedures. The result for those concerned is a struggle to in some way or another solve the situation or pretend to be in order until one gets caught. In other countries, such as Sweden, Denmark or the Netherlands, one gives the opportunity to choose and through a good marketing campaign create a demand, which naturally creates a voluntary transition to circular economy.

The 2025 goals are too ambitious. They have put a lot of attention on Finland around the world, including in the report by Ellen MacArthur Foundation, which has been quite interesting. Looking at what has been done since the statement, there is not much development in terms of what the goals are. One has succeeded in gathering companies in different areas and market them as circular, without giving the matter any further substance so far.

By 2025 Finland will have succeeded in raising the matter concerning circular economy, making people think in such paths. Sitra, the finnish innovation fund, has already done very well so far. But, that the country would become a world leader in as little as 8 years is something unrealistic.

4.3 Mikael Anderssén, Drytec

In order to get a view of the private sector the company Drytec Oy Ab was contacted. They are an SME dealing with humidity-related issues in buildings (Drytec, 2009). Their CEO Mikael Anderssén was interviewed on the 22nd of December 2017 at the company headquarter. Here follows the discussion about the implementation of CE in Ostrobothnia.

4.3.1 Current state

Characteristics

CE is slowly breaking through, with its thoughts becoming more acknowledged over time. Even so, its importance in the construction industry is still small, as the consumers demand from the suppliers is not yet significant. The topic does not often come up in agreements as it is also not yet considered as a significant competitive advantage. Customers need to raise the demand before CE can make a substantial breakthrough. As the overall sustainability-acknowledgement by users becomes bigger, CE will gain more importance.

Previous collaboration with several Swedish companies has given an insight in their way of working and the conclusion that they don't have a bigger focus on CE than here in Ostrobothnia.

There are a lot of possibilities for CE thinking, both for creating new products and for creating procedures for implementing CE. Noticeable is the need for new procedures in the field of reconstruction and refurbishing, especially in moisture related damages. There, the traditional procedure has been to throw away everything and replacing it with new materials, without even asking the question of what could be reused. The technology has improved over time resulting in several new methods for saving materials, as for example drying and encapsulating, with results in only organic materials being replaced with new ones. Some steps forward have been taken but still there is a lot to be improved to further lower the material waste.

Significance in purchase, sales and supply chain

Currently there are some good initiatives of companies that implement CE principles, like a producer of PVC-carpets that collects them after usage and recycles them. The effective communication in between the customers and suppliers led in this example also for the

replacement of an unwanted material in the production. In other words, the changes came as a response to the customer demand for a better product.

Enablers and barriers: Technological, institutional, internal actions and influence by the market

When implementing CE in the region, one major question is who should be the responsible driving force in the matter. An enabler could be said municipalities demanding CE aspects from the suppliers, especially in the construction sector. This could be connected in the field of moisture related problems with the usage of more modern drying technologies in order to save resources and materials.

Even if the technologies need to be refined, what it comes down to is the motivation for adopting circular principles and investing in local resources. Municipalities always blame that there is no money for refurbishments, but somehow money is always found when a significant problem situation arises. It is all about priorities and long-term planning in order to use resources more effectively and reduce the final 'bill'.

4.3.2 Future development

From linear to circular economy

The roles of the ones who will invest most resources in taking CE from theory to practice needs to be clarified. Should the responsibility be on the government agencies, or could companies eventually be interested on investing in the matter if a competitive advantage could be found? This could be initially regulated through demanding CE-aspects in the public procurements.

Implementation of CE-principles in the biological and technical cycles

It is difficult to give an opinion on the matter as the current state is that one does not see any particular activity in rising up the matter in everyday life. This will change over time, but in what way, how and through which contributors is hard to predict.

Influencing factors

The influencing factors depend on who will take the biggest role in the conversion to CE. The ideal situation would be a rising demand from the consumers that would lead to an adaptation by the suppliers.

The ideal situation would be a good foresight in order to save money and lower material usage. Currently in the examples of moisture damaged buildings owned by municipalities, decisions are often harsh as the problem escalates. The time is not enough to plan the best possible solution, as initial long-term planning is lacking, which results in a lot of efforts made in vain. As the problem is thought to be solved through substantial time, material and money investments in a total overhaul, there is nothing that totally guarantees the success of the action.

Supply chain

At the moment, there is no local company that could be predicted in becoming a CE-pioneer in the region.

Geographical influences

There are good existing logistical connections in the area for building up a CE.

4.3.3 Thoughts on Finland's goal of becoming a leader in CE by 2025

Construction industry

A good quality assurance in the planning phase will increase the overall lifetime and conditions of the buildings. Even so, it is not simple to predict what the outcomes will be in practice, as it depends a lot on how the market will react.

In the construction industry there are a lot of changes that needs to be done. The process is quite long, even if it is in some aspect already starting to be considered in the planning phase. As constructing, one should build in such a way that the building is possible to be taken apart, and not necessarily like the 'old way' where everything becomes waste.

The industry relies a lot on the development of the technical solutions for different material usage, currently dictating the way things are build today. It is difficult to find a good balance for the material usage, as some support the usage of wood while others prefer concrete as the primary building material. Collaboration needs to be established between the different material lobbyists, but the more involved the harder it gets to find a solution.

The strategic priorities

How the actual sums will affect the implementation of CE in practice is hard to say without further research in the matter.

Realizability

Its realizability does not only depend on Finland but also on how the other countries act and who will invest the most. To succeed there needs to be an ideal combination of guidance from government agencies and motivation from users.

4.4 Johan Saarela, Stormossen

Last but not least an opinion on CE by a local waste management company would complete the view on CE in Ostrobothnia, giving the ability to answer the research question. The company Ab Stormossen Oy is the regional actor, located in the municipality of Korsholm, that treats the waste of the six municipalities that owns the company (Stormossen, n.a.). As a verbal recommendation given by Göran Östberg, development engineer at Stormossen Johan Saarela was contacted. Mail correspondence on the 22nd of December 2017, see appendix 2, gives the following summary of the discussion about the implementation of CE in Ostrobothnia.

4.4.1 Current state

Characteristics

Seen through the perspective of the waste disposal industry, the use of sludge and bio-waste for creating biogas and soil enriching compost is a good starting point. However, large quantities nowadays end up in the waste incinerator, which has become the new trend after the more traditional landfilling.

Enablers and barriers: Technological, institutional, internal actions and influence by the market

The government institutions will demand a higher grade of recycled materials, which creates an enabling opportunity for a step towards CE.

4.4.2 Future development

From linear to circular economy

Waste that can be recycled into a new material, like bio-waste and plastic, will be done in much larger scales. This will lead to a decrease of materials ending up in the waste incinerator.

Influencing factors

The attitude towards CE among producers and consumers can be seen as both a possibility and an obstacle. If the attitude towards locally produced goods, renewable energy sources and renewable materials becomes more positive it will influence the economical choice. There will lead to good opportunities for developing new products.

Supply chain

An enabler is the variety of services needed for different purposes, as they create opportunities for SMEs.

Geographical influences

Finland’s low population and the long journeys from a logistics perspective hinders its implementation because of the higher prices.

4.4.3 Thoughts on Finland’s goal of becoming a leader in CE by 2025

Realizability

Finland’s low population numbers, long transport distances, slow bureaucratic process and uncertainty in the attitude towards CE leads to the conclusion that the goal is hardly achievable. The country has a negative setting towards adapting to new technologies. An example is biofuel for vehicles, that was only introduced after the EU's tax reform requirements on Finland in the early 2000s. Another example worth mentioning is Uber, a circular principle as you share your car for two purposes (private use and work), which recently encountered legislation barriers and shows the unwillingness to adapt by the governmental institutions.

5 Conclusion

This thesis has been realized based on the report 'Circular Economy', which was done together with Alina Reuter, Killian Durieux and Thijs Bod as a part of the EPS at Novia UAS fall semester 2017. The report was divided according to the three main tasks: researching the implementation of CE in the European construction industry, finding best practice examples and building up a business idea. The report works as a pre-study for a the Botnia-Atlantica program, in which Novia UAS is a main partner, that seeks to raise awareness on CE and create material loops in regions of Finland, Sweden and Norway.

CE is currently a topic of high interest, even if the theoretical thoughts date back over half a century. The goals of CE are sustainability and renewability. They are reachable through creating material loops that reuses, recycles and refurbishes materials back into the loop at the end of the lifecycle, retaining the highest possible value over time.

To create an added value to the original report, several interview subjects that could give a valuable input were asked to participate in an interview. The subjects were chosen from several fields connected to the construction industry, with questions focusing on a qualitative approach having fewer individuals and gaining more unstructured but in-depth answers. The results are opinions and thoughts on the current state and future view of CE in Ostrobothnia, as well as realizability of Finland's 2025 goals of becoming a leader in CE.

In the following subchapters the research questions are answered by drawing conclusions on correlations from the gathered data given by the interviewees.

5.1 Current state

As said in chapter 2.2 'Circular economy' and confirmed by both Glader and Östberg, CE is nothing neither new or revolutionary. Theories date back over half a century and it is basically about going back in time. Currently products are too complex and not designed to be durable, while back in the days things were made simple, durable and repairable.

The region of Ostrobothnia has some potential for building up a CE according to all the interviewees, who also agree that waste is yet not treated as a resource. Anderssén, Glader and Östberg firmly points out that CE is yet at a beginning phase and much needs to be done. The first step is to raise awareness and create a demand, as in the construction industry the

supplier is almost always chosen based on the lowest price criteria. There are existing companies in the region, often unaware of CE principles, working with interesting ideas and concepts that could be combined to create the beginning of material loops.

Geographically the region has good connections abroad according to Anderssén, even if long-distance transports tend to make the prices go higher in the opinion of Saarela. The inhabitants are pointed out by Östberg to be so called 'handymen' with knowledge in various areas, with strong traditions for establishing new companies and business ideas inspired from abroad. Furthermore, Östberg points out that the Finns are open and willing to adapt to new technologies, while Saarela claims the opposite.

Sweden, the foremost choice by Finland when looking for a role model, has a lead towards CE in some aspects according to Glader and Östberg. This as the matter has been more incentivized over the years. Even so, Anderssén claims no noticeable lead has been seen when doing business with companies from oversea.

5.2 Future development

As the stakes for the 2025-goals are set high, there are quite some things that needs to be done. Glader, Saarela and Östberg points out that the government need to see over their approach on CE with the legislations. Their role is to give guidance and not to make the things too complex or to force it on the population, as the case has often been in the past. All the interviewees claim that a natural conversion needs to be enabled through rising the awareness of CE. The customers are the ones who will play the biggest role in a conversion as demand controls supply in this matter, so they need to be aware of why it is needed.

As mentioned by Anderssén, Glader and Östberg one of the first step towards CE is to be done by the municipalities. As major infrastructure-owners, they need to change the requirements in public agreements on their buildings. Construction, maintenance, demolishment or refurbishment procedures needs to be set requiring CE-aspects by the supplier of the service. Furthermore, long-term strategies needs to be implemented in the maintenance of the buildings to better hold their shape and value over time. As claimed by Anderssén and Glader, the current 50-year lifespan for new constructions is too short.

Ostrobothnia as a region is not self-sufficient according to Glader. As awareness is risen and material loops are starting to take shape, the region will need to further look at companies in the Botnia-Atlantica area to fill all the 'positions' required.

Glader explains how wood offers several good qualities as a material for the construction industry, compared to the similar but more energy-demanding concrete. Furthermore, locally there are a lot of wood-resources to be harvested according to Östberg. Even so, Anderssén points out how it will be hard to find a good balance and collaboration between the different material lobbyists. The opinions quite differ on the material of choice: some prefers the usage of wood, others the one of concrete.

5.3 Thoughts on Finland's goals of becoming a leader in CE by 2025

All the interviewees shared the same thought on the 2025 goals: they are very ambitious. Glader and Östberg describe the success in rising the awareness on CE as the most likely scenario reached by 2025. Glader points the reason out to be that Finland will have a very hard task in surpassing the more developed countries in CE. It all depends on how the other countries will react according to Anderssén.

Finland needs to show the willingness to adapt to changes, actively incentivize the conversion towards CE and invest into innovative technologies. This because they are all crucial steps to achieve the 2025-goals according to Anderssén, Glader and Östberg. Legislation needs to be used as a tool to incentivize and rise the demand, not to force it on the citizens. A good combination of guidance from the state through legislation and customer demand from the companies would be the optimal scenario for a successful and natural conversion towards CE.

6 Critical review and discussion

Combining the thesis and the report became harder than I first expected. Even so, I reckon to have created an added value to the original report, answering the research questions and delivering the result expected out of a bachelor thesis. It is to notice that if more time would have been available then a more extensive research with more interviews could have been performed. The theory parts in the chapters regarding circular economy and qualitative research method could have been made more extensive. I preferred not to write more information as the one found in the report, together with the workload put into the realisation of both report and thesis, is by me recognized to be what is requested by bachelor thesis.

Together with my team I managed to succeed into the realization of a report that will be used to further implement CE in the Ostrobothnia region. Working in English in a multinational team with students from different faculties turned out to be very fun and enriching. As with every team we had our laughs and fights. We managed to keep a good morale and sort out issues that arose over time when working closely with other people, succeeding into achieve a good result and long-lasting friendships.

If there is by chance a student reading this that is considering the participation in an EPS, at home or abroad, I highly recommend it even if ones' field of study is not engineering. It may not be ones' main subject one will end up working on, but there is always a lot to be learned. In the future working environment, one will always have to deal with people working in other fields. Understanding them is an appreciated virtue.

7 References

Drytec. (2009). *Home: Drytec* . Taken 05 01 2018 from http://www.drytec.fi/

Frick, P., & Hedenmark, M. (2016). *Vad är cirkulär ekonomi? En inspirationsbok om den cirkulära ekonomins möjligheter.* Stockholm: Re-Makers.

Hansen, J., & Abata, D. (08 12 2017). *Introduction: European Project Semester*. Taken 05 01 2018 from European Project Semester: http://europeanprojectsemester.eu/info/Introduction

Ministry of the Environment. (01 12 2017). *Circular Economy: Ministery of the Environment.* Taken 22 12 2017 from Ministery of the Environment: http://www.ym.fi/sv-FI/Miljo/Cirkular_ekonomi

Oak Ridge Associated Universities. (n.d.). *Differences Between Qualitative and Quantitative Research Methods: Oak Ridge Associated Universities*. Taken 23 12 2017 from Oak Ridge Associated Universities: https://www.orau.gov/cdcynergy/soc2web/Content/phase05/phase05_step03_deeper_qualitative_and_quantitative.htm

Seale, C., Gobo, G., Gubrium, J. F., & Silverman, D. (2004). *Qualitative research practice.* SAGE Publications.

Stormossen. (n.a.). *The company: Stormossen*. Taken 05 01 2018 from http://www.stormossen.fi/The_Company

SYSTEMIQ, & Ellen MacArthur Foundation. (2017). *Achieving 'Growth Within'.* SYSTEMIQ.

VASEK. (2017). *Cirkulär ekonomi Korsholm: VASEK*. Taken 05 01 2018 from https://www.vasek.fi/regionutveckling/cirkular-ekonomi-korsholm

Appendices

The following chapter consist of two appendices mentioned in the thesis. These are appendix 1 ‘Circular Economy (2017) by T. Bod, K. Durieux, J. Greco and A. Reuter’ and appendix 2 ‘Mail correspondence with Johan Saarela’.

Appendix 1

YRKESHÖGSKOLAN NOVIA

Circular Economy

Thijs Bod
Killian Durieux
Jonathan Greco
Alina Reuter

Final report for the European Project Semester

The Degree Programme of Novia University of Applied Sciences

Vaasa/Novia UAS 2017

European Project Semester – Final report

Authors: Thijs Bod, Killian Durieux, Jonathan Greco, Alina Reuter
Degree Programme and place: European Project Semester, Vaasa
Specialization Alternative: -
Supervisor(s): Stefan Pellfolk
Title: Circular economy

Date: 11.12.2017 Number of pages: 177 Appendices: 40

Abstract

This is a report written as part of the EPS project at Novia UAS. The report is divided in three main parts and works as a pre-study for the EU funded project 'Circular economy (CE): a game changer for the wood building industry (2018-2020)', part of the Botnia-Atlantica program researching implementation possibilities for circular economy in the Ostrobothnia-region.

A general introduction to CE defines its characteristics as restorative and regenerative, aiming to keep the highest value at all time. CE is further clarified with a deeper explanation as well as the advantages and disadvantages of it.

Based on the criteria for CE and the tasks given by the customer of the project, different, resource-efficient buildings are listed and presented. The list contains six CE-inspired buildings that are located in Denmark, Finland, Germany and the Netherlands, outlining information about their background, supply chain, influences and conclusions.

The final part of the project presents three different business ideas, developed for decreasing the usage of plastic packages in retail stores and their supply chain. The ideas outline the introduction of a company producing reusable packages traded in a deposit-refund system, a package free supermarket and a company offering grocery delivery service in reusable packages.

Language: English Key words: Circular Economy, European Construction industry

Preface

This project was executed by four students participating in the European Project Semester from the 4th of September 2017 until the 18th of December 2017.

We want to acknowledge the support and guidance of the team coach Stefan Pellfolk and the project customer Annika Glader. Furthermore, we want to thank Roger Nylund, Peter Menger and Hanna Latva for the lectures concerning project management, personal development and academic English speaking and writing.

We would as well like to acknowledge all other contributors to this project and the research and development department of Novia UAS for this assignment.

Table of Contents

List of figures

List of tables

List of abbreviations

3D	:	3-Dimensional
AG	:	Aktiengesellschaft, in English: stock corporation
B.V.	:	Besloten Vennootschap (private company)
BAR	:	Business and Research
BREAAM Method	:	Building Research Establishment Environmental Assessment
C2C	:	Cradle to Cradle
CAD	:	Computer-Aided Design
CAM	:	Computer-Aided Manufacturing
CE	:	Circular Economy
CEO	:	Chief Executive Officer/Chairman
CI	:	Construction industry
CLT	:	Cross-Laminated Timber
CNC	:	Computer numerical control
DEA	:	Danish Energy Agency
EESC	:	European Economic Social Committee
EI	:	Energy Index
EIB	:	European Investment Bank
EPAL	:	European Pallet Association
EPC	:	Energy Performance Coefficient
EPEA	:	Environmental Protection Encouragement Agency
EPS	:	European Project Semester
ETA	:	European Technical Approvals
EVA	:	Earned Value Analysis
FSC	:	Forest Stewardship Council
GDP	:	Gross Domestic Product
GWP	:	Global warming potential
ICT	:	Information and Communication Technology
LCC	:	Life Cycle Costing

LED	:	Light Emitting Diode
LEED	:	Leadership in Energy & Environmental Design.
NGO	:	Non-Governmental Organisation
NOM	:	Zero on the meter
PEFC	:	Programme for Endorsement of Forest Certification Schemes
PPP	:	Private Public Partnership
PV	:	Photovoltaic
PVC	:	Polyvinyl chloride
R&D	:	Research and Development
ReSOLVE	:	Regenerate, Share, Optimise, Loop, Virtualise, Exchange
SDG	:	Sustainable Development Goals
SMART	:	Specific, Measurable, Achievable, Realistic, Time-bound
SME	:	Small and medium-sized enterprise
SPF	:	Spray Polyurethane Foam
SWOT	:	Strengths, Weaknesses, Opportunities, Threats
TCO	:	Total Cost of Ownership
UAS	:	University of Applied Sciences
UN	:	United Nations
UV	:	Ultraviolet
VOC	:	Volatile organic compounds
WRAP	:	Waste and Resources Action Program
ZAE	:	Centre for Applied Energy Research

1 Introduction

The following chapter provides an overall introduction into the topic, with a description of EPS and an overview of the project. There is an explanation about the origin of the project as well as the project charter, project constraints and exclusions. The time and cost management part include the project schedule, workload, time and budget follow up. The risk management and the project closing provide the lessons learned. At last a reflection on the teamwork is added, based on the Strengthfinder workshop and Belbin results.

1.1 European Project Semester

The European Project Semester (EPS) is a multi-national programme that is offered by 18 universities in twelve countries within Europe. The target groups are students studying in the field of engineering as well as students from other faculties. The basic motivation for establishing such a system is globalization. The ongoing integration within Europe demands young and trained professionals. Aside from the core skills, there is also a need for expertise in the fields of cross cultural communication, social skills and team skills. As the project teams are multi-disciplinary and multi-national, EPS provides the opportunity to train both the education and the multi-cultural team working part.

Beside working on a given project in teams there are also courses such as teambuilding, project management, the Strengthfinder workshops, English academic writing and the local language Swedish. The working language for all oral and written communication during the semester is English.

In 2017 a total of 17 students from Finland, France, Germany, the Netherlands and Spain attend the EPS program at Novia University of Applied Sciences (UAS) in Vaasa. The topics offered in the autumn semester 2017 are: 3D Printing, circular economy (CE), Tomato Picker and Wet Grain Packaging. (Nylund & Ehrs, 2017)

1.2 Overview and Background

This chapter contains the project description and background as well as the project purpose. There is also the project charter provided which has been approved by the team and the coaches in the beginning of the project. The constraints and exclusions outline the borders of the project.

1.2.1 Project description & project background

The EPS topic 'circular economy' is settled in the field of research projects. The following text describes the project idea and background. It was created and handed over to the team of supervisor Stefan Pellfolk and customer Annika Glader.

"Recycling is a precondition for circular economy. Materials and resources can be recycled, returned back to the economy and used again. Material and resources that are now considered as waste, can be reinjected to the market. To fully realize the potential of these so called secondary raw materials, we have to remove the existing barriers to their trade and our way of thinking. Only then will the market be able to use the full potential of circular economy.

Construction industry deals with large amounts of material flows. Over the next ten years, the demand for global construction is expected to increase by 70 %. This is a challenge in a world where resources are becoming scarce. For companies, this means introducing new business models based on maintenance, repair, re-use, refurbishing, remanufacturing and recycling. For customers, this means replacement of worn products with sustainable products or services. The goal is to maximize the use of renewable materials within biological systems, and to extend the life of non-renewable materials within technical systems.

Circular economy is about looking at a system as a whole and seeing how it is all connected. This involves both company and customer perspectives. Ensuring that supply meets demand and demonstrating the role of material development and product design are essential for achieving a shift towards circular economy. Customers must demand sustainable products and services, and industry must offer them. Since circular economy is based on the idea of material circulation, the customer must be included in the process in order to succeed with truly circular economy innovation.

The original project tasks:

Research the implementation of CE in the European Construction industry:

- regional differences, why?
- is CE included in agreements and contracts;
- CE supply chain, find examples and key actors;
- 'end users' involvement strategies;
- CE property maintenance solutions in order to extend building lifetime.

1. Find good examples of CE-thinking in the European real-estate market:

- biological- or technical cycle (or both);
- best practice cases;
- economic incentives.

2. Money makes the world go around, and will it make the economy circular as well?

- present your own business idea."

(Pellfolk & Glader, 2017)

1.2.2 **Purpose of the project**

The project outcome will be used as a pre-study for an EU (European Union) funded project called 'Circular economy: a game changer for the wood building industry (2018-2020)'.

This project is part of the Botnia-Atlantica EU program (2014-2020) that finances cooperation projects between regions in Sweden, Finland and Norway (see Figure 1) (European Union, 2017).

Figure 1. Map of Scandinavia (European Union, 2017)

1.2.3 **Project charter**

Table 1 shows the project charter for the project 'circular economy' which is approved by team coach Stefan Pellfolk as well as the team itself.

Table 1. Project charter

Project Charter		
Project name:	Circular Economy	
Stakeholder:	Annika Glader, Stefan Pellfolk	
Date:	26.09.2017	
Project Description: *High-level description of project*		
The project is about researches in the current implementation of CE in the European construction industry. It is a contribution to the project 'Circular Economy – A Game Changer for the Wood Building Industry'' as part of the EU funded Botnia-Atlantica 2014-2020 project. Furthermore, an own business idea has to be developed.		
☐ Innovative ☐ Sustainable ■ Research		
Business need: Reason for the project, external, internal (strategically intention)?		
The project is a contribution to the project 'Circular Economy – A Game Changer for the Wood Building Industry'' as part of the EU funded Botnia-Atlantica 2014-2020 project.		
Project Goal: *SMART*		
See Appendix		
Requirements:	*High-level list*	
- Motivated team members - Accessible sources - Supporting team coach Stefan Pellfolk and customer Annika Glader		
Organisation:		
Project Sponsor:	Annika Glader	
Team coach:	Stefan Pellfolk	
Project team:	Thijs Bod, Killian Durieux, Jonathan Greco, Alina Reuter	

Schedule:	
Start Project:	04.09.2017
Milestones:	24.10.2017 Midterm Report + Midterm Presentation 11.12.2017 Website finished 11.12.2017 Video finished 11.12.2017 Final Report finished 18.12.2017 Final Presentation
End of Project:	18.12.2017
Resources:	*High-level estimation*
Project Budget:	0 €
People:	Thijs Bod (100 %) Killian Durieux (100 %) Jonathan Greco (100 %) Alina Reuter (100 %)
Other:	
Project Risks:	*High-level list (Basis for Risk-Analysis)*

The risk analysis is shown in the appendix.

Team-related:

- Lack of communication;
- Language barriers;
- Poor team dynamics.

Task-related:

- Overly optimistic schedule;
- Insufficient resources;
- Friction between project team and customer;
- Scope creep;
- Lack of knowledge;
- Bad planning.

Others:

- Sickness.

1.2.4 Project constraints and exclusions

Constraints

There are four team members working on the project. The workload for each team member should be around 37,5 hours per week.

There is no budget planned for the project. The project must be finished until 18th December 2017.

Exclusions

The exclusions are parts which, in agreement with the team coach and client, will not be included in the project. The following parts/ topics will not be included:

- The website does not contain information about the following research (Circular economy: a game changer for the wood building industry);
- The business idea will not be situated in the field of the construction industry;
- A maximum amount of six examples are chosen for deep research due to the limited resources.

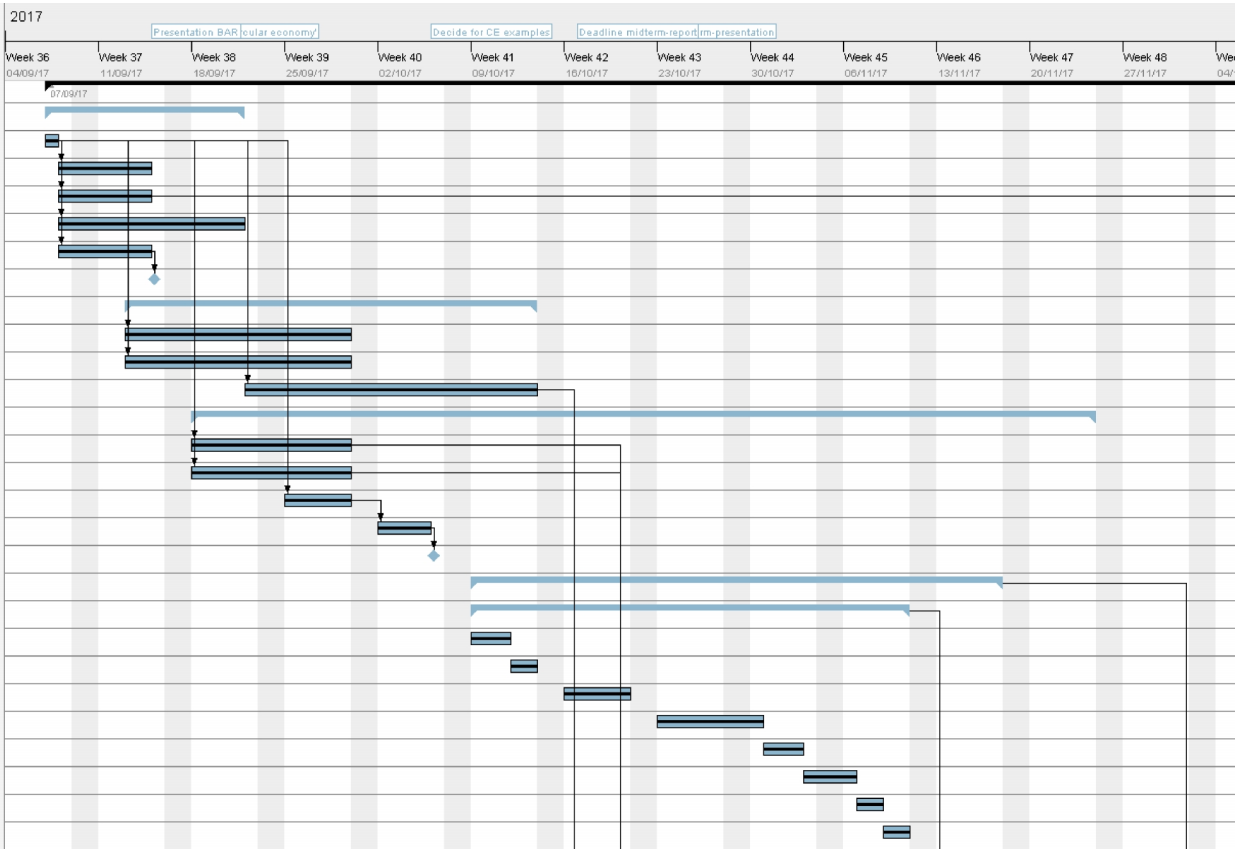
1.2.5 Time and cost management

The project schedule, meaning the Gantt-chart is the first part of the time and cost management chapter. There are also an earned value analysis (EVA), which follows up the budget as well as a summary of the hours worked on the project.

1.2.5.1 Project schedule

The software used for the project time scheduling is called GanttProject. It is a free version for creating Gantt-charts and similar to Microsoft Project. The program provides the opportunity to track the work progress. A red line shows the current date and for every task the percentage of fulfilment (between 0 % – 100 %) can be added. The Gantt-chart is shown in Figure 2.

Name	Begin date	End date
Circular Economy	07/09/17	15/12/17
Initiation Phase	07/09/17	21/09/17
Kick Off Meeting	07/09/17	07/09/17
Define Rules	08/09/17	14/09/17
Make Risk Analysis	08/09/17	14/09/17
Make Initial research	08/09/17	21/09/17
Prepare for Presentation BAR	08/09/17	14/09/17
Presentation BAR	15/09/17	15/09/17
Orientation Phase	13/09/17	13/10/17
Define SMART Goals	13/09/17	29/09/17
Make Work Breakdown Structure	13/09/17	29/09/17
Create PM report	22/09/17	13/10/17
Execution Phase	18/09/17	24/11/17
Define 'circular economy'	18/09/17	29/09/17
Define 'construction industry'	18/09/17	29/09/17
Decide for search terms	25/09/17	29/09/17
Search for CE examples	02/10/17	05/10/17
Decide for CE examples	06/10/17	06/10/17
Research on CE examples	09/10/17	17/11/17
Deep research park 20|20	09/10/17	10/11/17
Search and write about the gen...	09/10/17	11/10/17
Search and write about the por...	12/10/17	13/10/17
Search and write about the sup...	16/10/17	20/10/17
Search and write about the tec...	23/10/17	30/10/17
Search and write about the eco...	31/10/17	02/11/17
Search and write about legislati...	03/11/17	06/11/17
Search and write about geogra...	07/11/17	08/11/17
Write rating and conclusion	09/11/17	10/11/17



Deep research finch buildings	09/10/17	10/11/17
Deep research Villa Asserbo	09/10/17	10/11/17
Deep research De fire styrelse	09/10/17	10/11/17
Deep research Log Vila	09/10/17	10/11/17
Deep research Bionorica SE	09/10/17	10/11/17
Reviewing	13/11/17	17/11/17
Make Business Plan	20/10/17	24/11/17
Define 3 basic ideas	20/10/17	03/11/17
Current implementation in the EU...	10/11/17	17/11/17
Realizable in Finland?	20/11/17	24/11/17
Closing Phase	09/10/17	15/12/17
Prepairing webinar	04/12/17	07/12/17
Presenting webinar	08/12/17	08/12/17
Compile midterm-report	11/10/17	16/10/17
Compile midterm-presentation	09/10/17	16/10/17
Deadline midterm-report	17/10/17	17/10/17
Midterm-presentation	24/10/17	24/10/17
Compile video	24/11/17	01/12/17
Compile website	24/11/17	01/12/17
Review all work	24/11/17	01/12/17
Write conclusion and reflection	27/11/17	01/12/17
Compile report	24/11/17	01/12/17
Compile presentation	24/11/17	01/12/17
Deadline final report	11/12/17	11/12/17
Final presentation	18/12/17	18/12/17

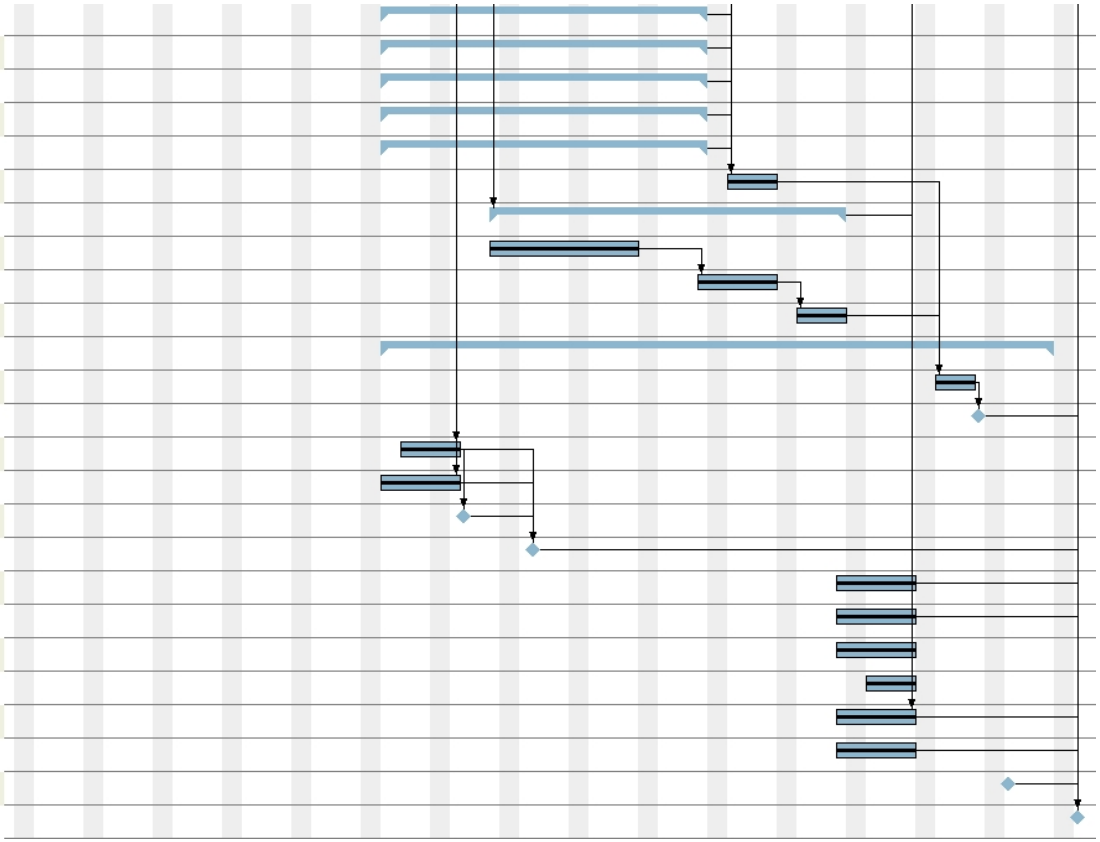


Figure 2. Gantt-chart

1.2.5.2 **Budget follow up – Earned Value Analysis (EVA)**

The earned value analysis is a tool to keep track of the progress in a project and the costs made in relation to the project plan and budget. As the project does not have a budget and costs in terms of money, the hours spend on working on the different tasks are considered as budget.

Figure 3 shows the actual costs (AC) which are the hours spent on the tasks, the planned value (PV) and the earned value (EV).

One can see that the created value and hours spend is higher than scheduled. This is due to the fact that the team performed two additional tasks at the end:

- 8th December: Webinar with Annika
- 11th December: Presentation in front of first-years-students at Novia UAS

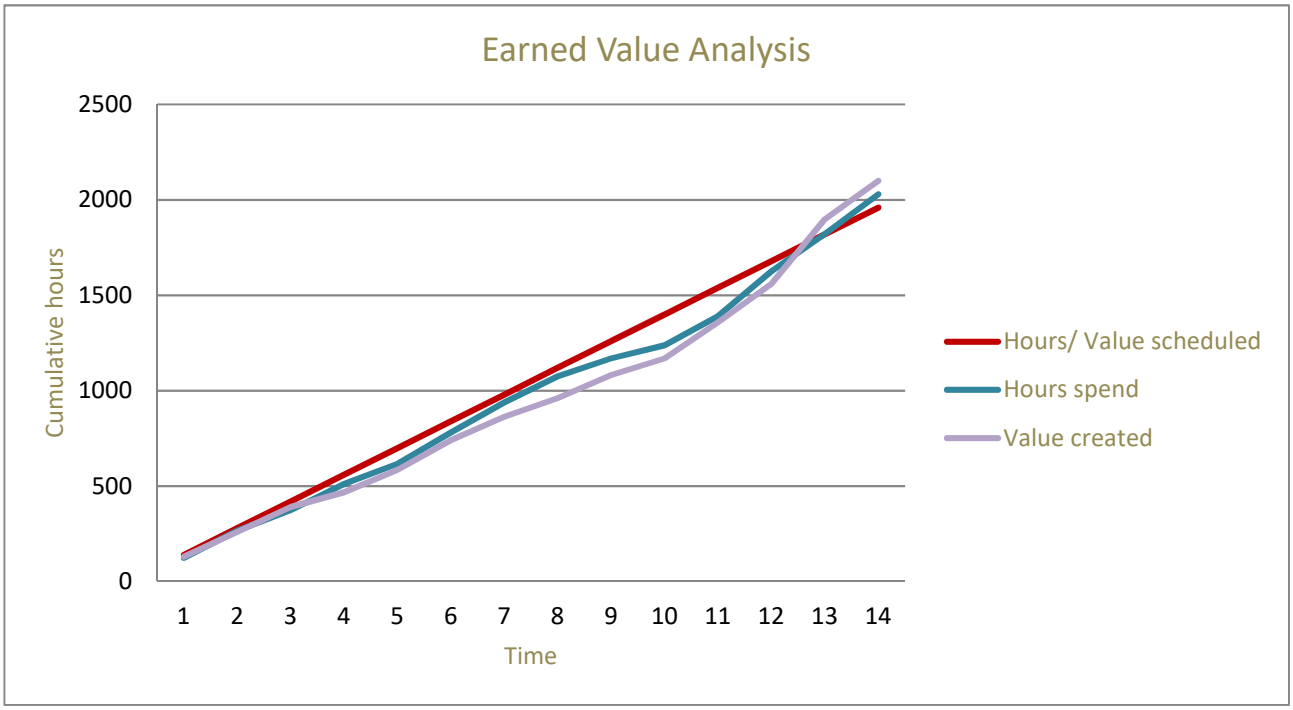


Figure 3. Earned value analysis

1.2.5.3 **Workload**

Figure 4 and Figure 5 show the weekly working hours spent on the project and the cumulative number of working hours spent on the project for each team member.

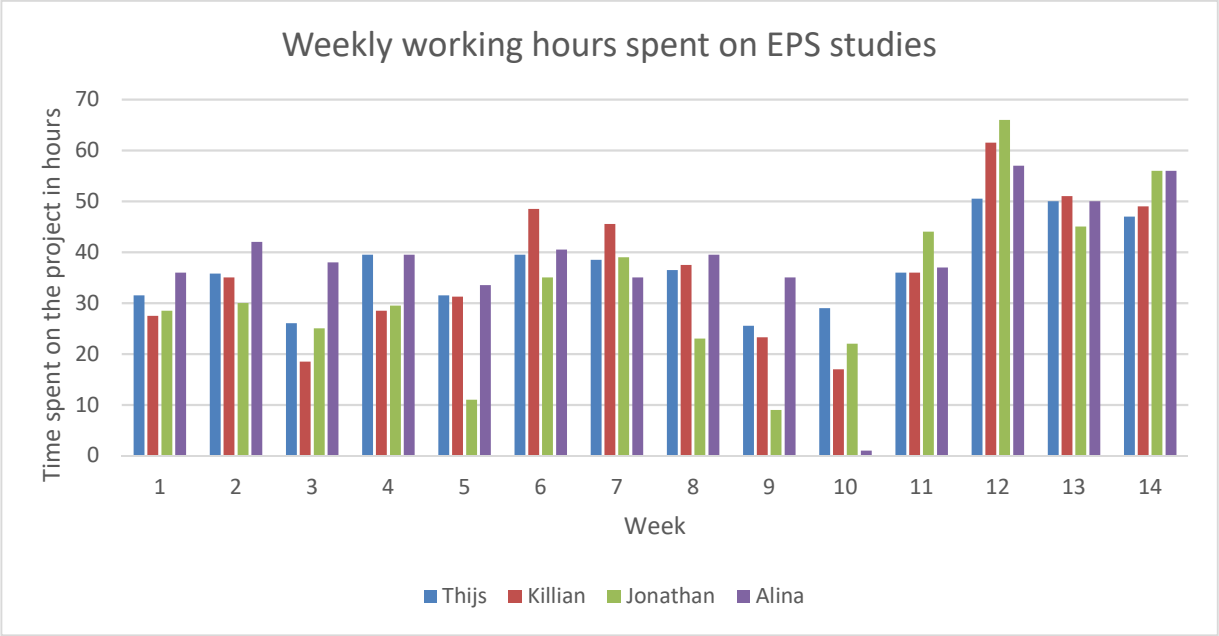


Figure 4. Weekly working hours spent on the project

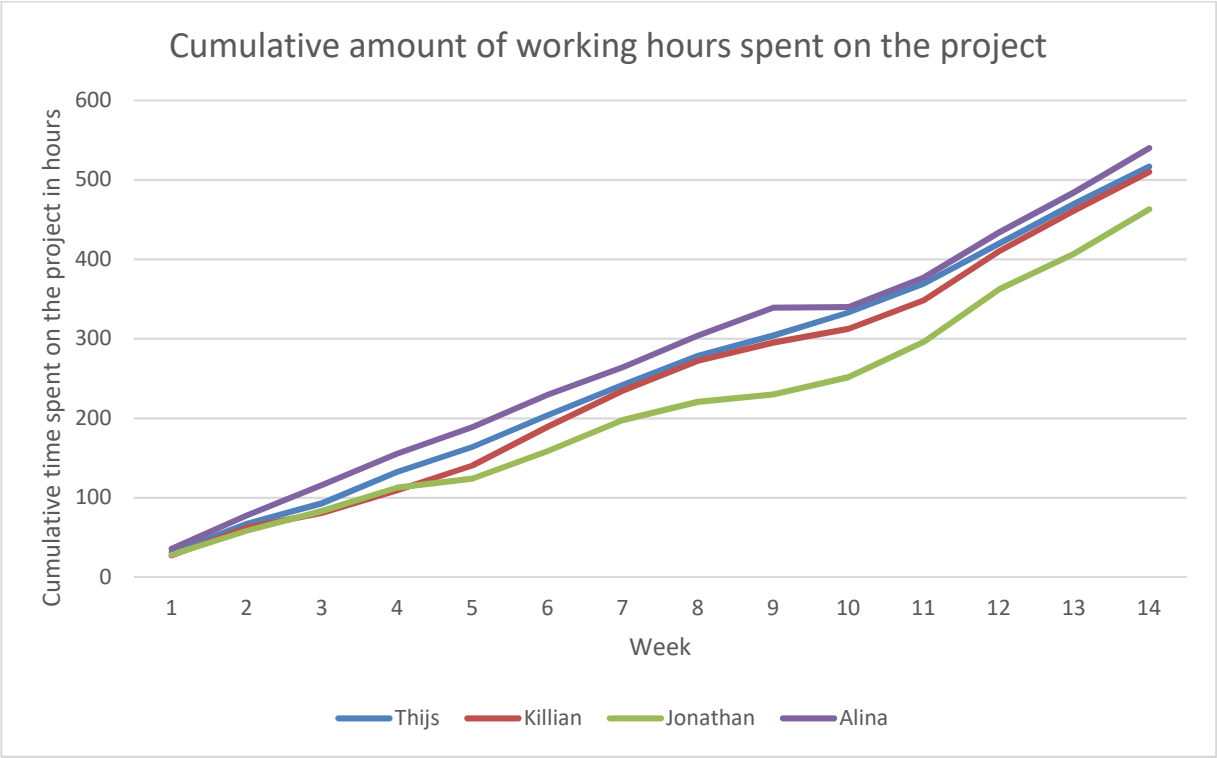


Figure 5. Cumulative amount of working hours spent on the project

1.2.6 **Risk monitoring and control**

Figure 6 shows the summary of the risk analysis, which can be found in detail in the appendix. This analysis was made in the beginning of the project. At that time, there were three possible main risks that have the highest probability and impact on the project, namely 'Insufficient resources', 'Scope creep' and 'Bad planning'.

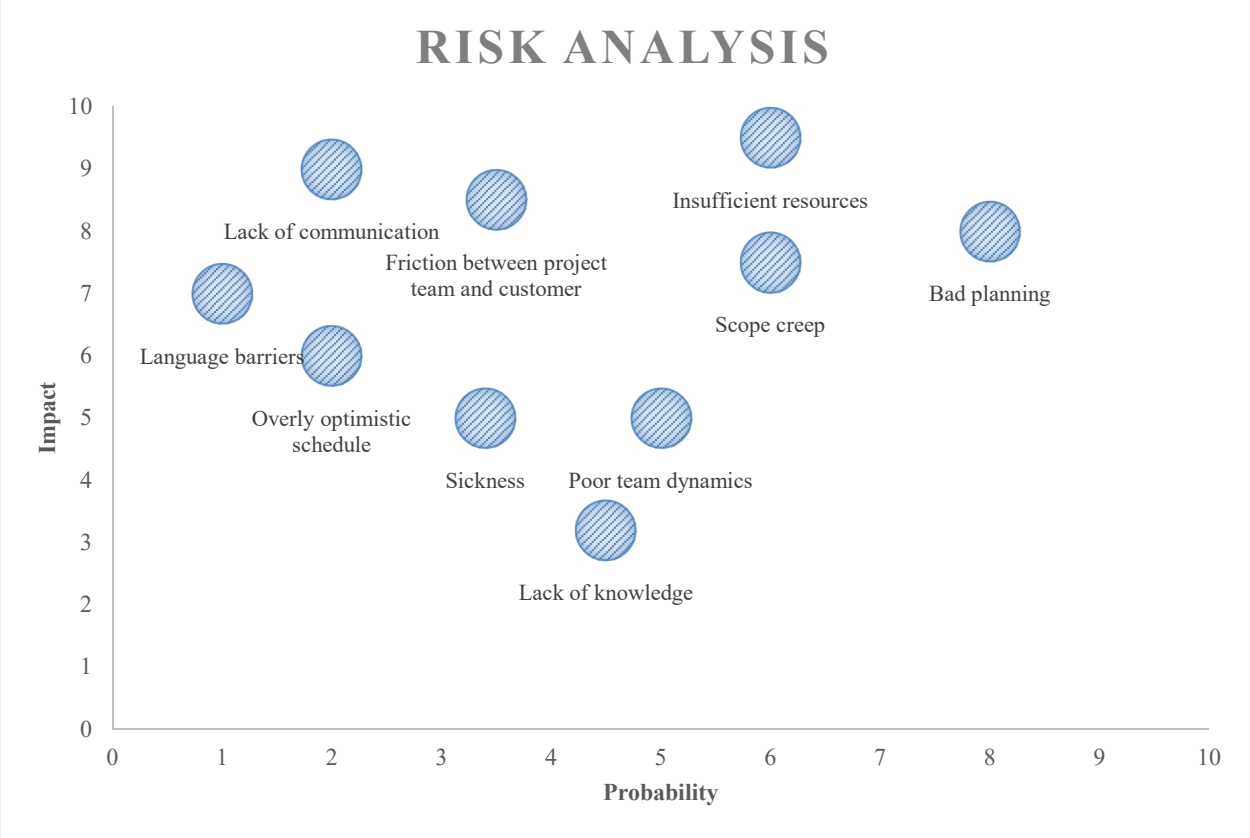


Figure 6. Risk analysis

Reflecting on the risk analysis after finishing the project resulted in Table 2 which shows all the risks with its status and measures that have been taken in order to overcome it.

Table 2. Risk monitoring and control

Risk	Status	Measures
Team-related		
Lack of communication	Not appeared	None
Language barriers	Not appeared	None
Poor team dynamics	Not appeared	None
Task-related		
Overly optimistic schedule	Partly appeared; the team was behind the planed schedule from time to time	The team needed to work harder in other weeks to catch up the schedule
Insufficient resources	Not appeared	None
Friction between project team and customer	Partly appeared; it took a long time to define the SMART goals	None
Scope Creep	Partly appeared; the SMART goal is still not completely SMART	None
Lack of knowledge	Not appeared	None
Bad planning	Not appeared	None
Others		
Sickness	Not appeared	None

In Figure 7 the risks that partly appeared are visualized.

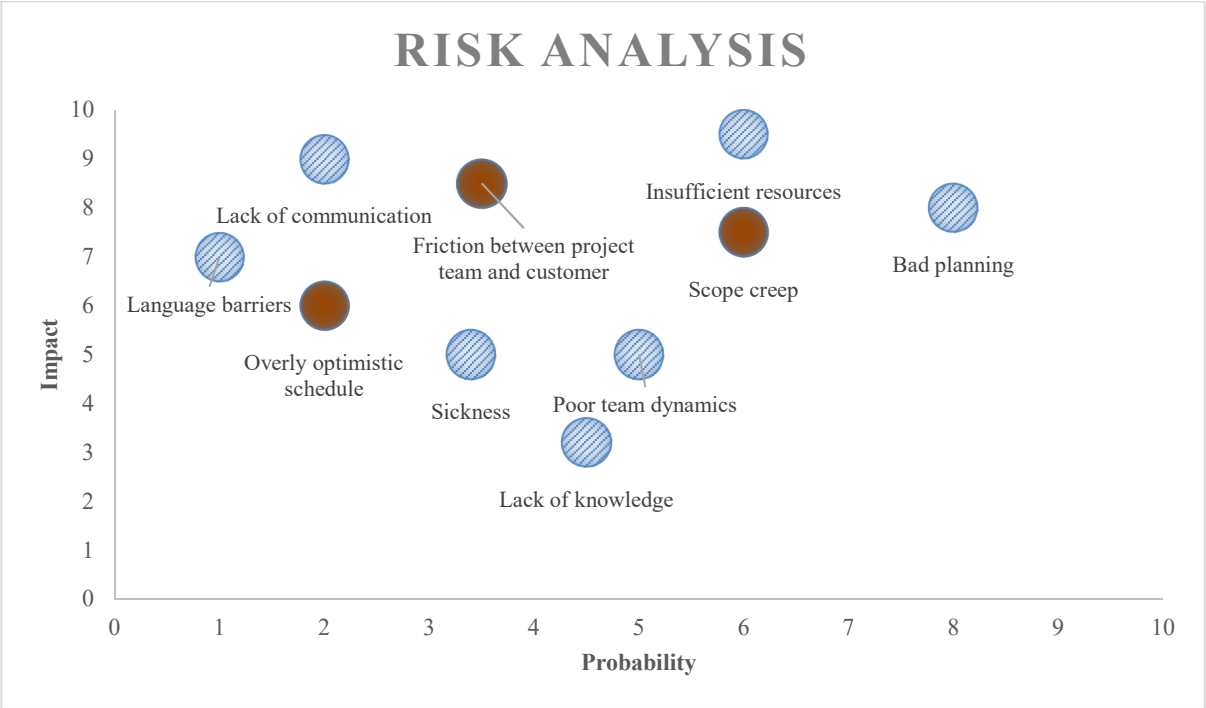


Figure 7. Risk monitoring and control

As a conclusion, the identified risks from the beginning did not affect the project on any large scale. Nevertheless, there have been some obstacles the team had to deal with. At the beginning the missing SMART goal prevented the team from working efficient and focused. As no team member is experienced in time planning the schedule was too optimistic. Though, the team managed to get started with a small-time delay and had to work more in the following weeks to catch up the schedule.

1.2.7 **Lessons learned**

Table 3 shows the lessons learned based on the risk analysis. First, the SMART goal is of a paramount importance to get started with a project. Second, the weekly meeting with team coach Stefan Pellfolk, keeping track of the project plan and wanting to see results, motivated the team from week to week. The same applies to the meetings with the client Annika Glader who made the team stay on track. The peer review is a system, the group installed when doing the researches. Every written text was reviewed by another team member giving feedback.

Table 3. Lessons learned

Number	Lessons learned	Description
1	Defining SMART goal	Defining the SMART goal is of a great importance to get started with the project. In this project, it took a long time, so there has been a lot of uncertainty which made the team work not as productive as possible.
2	Maintain weekly meeting	The weekly meetings with the team coach are very useful in terms of informing him and been given new input for the task.
3	Manage client closely	Several meetings with the client helped the team to stay on track and being able to deliver the desired information.
4	Keep track of project plan	Having a weekly look at the project plan and following up the work progress draws attention to differences between planning and reality.
5	Peer review	Having reviewed the texts written or the results found on a task generates a better outcome as different opinions and thoughts are considered.

2 Introduction Circular Economy

This chapter explains the basics of CE, advantages and disadvantages of CE, influencing factor(s) and requirements complemented with CE examples.

2.1 Circular economy definition

The following paragraphs show different definitions for the term ‘circular economy’:

The Ellen Macarthur Foundation understands circular economy as "restorative and regenerative by design, [which] aims to keep products, components, and materials at their highest utility and value at all times." (Ellen Macarthur Foundation, 2017)

For the Waste and Resources Action Program (WRAP) circular economy is about keeping "resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life." (WRAP, 2017)

On the website of the European Commission, CE is defined as an economy that maintains the value of products and materials for as long as possible. "Waste and resource use are minimized, and when a product reaches the end of its life, it is used again to create further value." (European Commission, 2017)

2.2 From linear to circular economy

What all definitions above have in common and what the name circular economy implies is the trading of materials, products and services in closed loops, so to say ‘cycles’ (see Figure 8, right). Opposite of CE is the linear model of production and consumption (see Figure 8, left), also known as the ‘take-make-dispose’ model which dominated the economies worldwide for the past centuries.

Within a linear economy, products are made from raw materials and after its use any waste is thrown away. The reason why linear economy has been widely implemented until now is because it was the easiest way to provide economic growths by using large quantities of cheap, easily accessible materials and energy. Nowadays, things have changed and resources are

finally perceived as finite. Price volatilities, supply chain risks and growing pressure on resources are now reasons for the need of circular economy.

The aim of CE is to decouple global economic development from finite resource consumption and eliminate waste. There needs to be an understanding that cycles cannot longer be seen separate from each other, but influence each other. This creates the need for system thinking, which means products must be designed and produced in a certain way so the value of components remains qualitatively preserved, e.g. through eco-design, sharing, re-using, repairing, refurbishing and recycling. At the end of lifetime, the initial resources or raw materials can then be returned into the circulation.

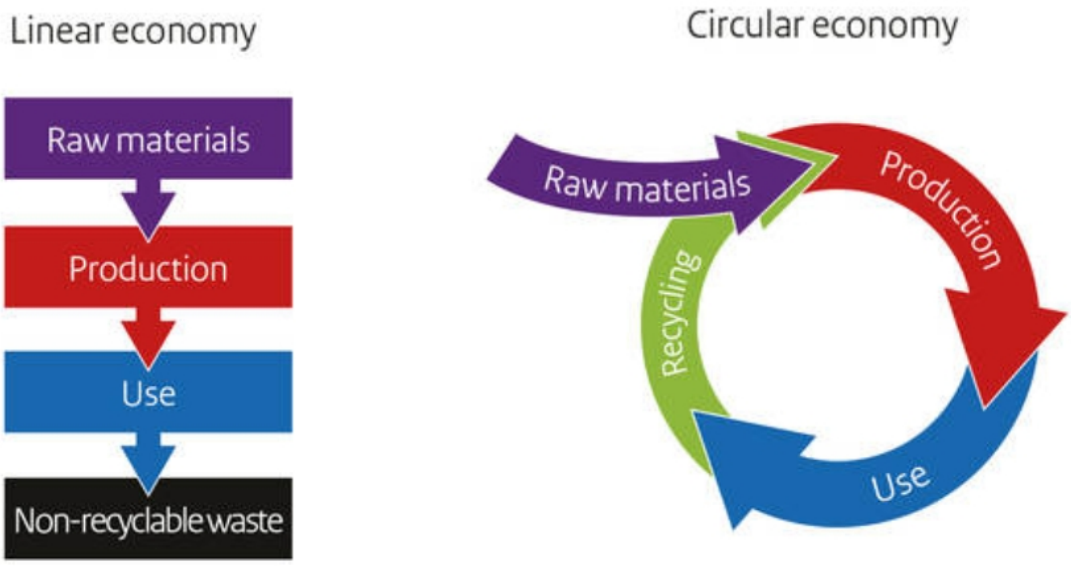


Figure 8. Linear economy vs. circular economy (Government of the Netherlands, 2017)

2.3 Two cycles

Circular economy can be divided into two cycles:

- biological cycle; and
- technical cycle.

Figure 9 shows consumption products belonging to the biological cycle in circular economy. This means that resources are regenerated and the flow of biological nutrients is encouraged while not exceeding the capacity of the natural systems. ” In the biological, life processes regenerate disordered materials, despite or without human intervention” (Ellen MacArthur

Foundation, 2015). As a result, the value of the natural capital is kept and the requirements for regeneration are met.

On the other hand, products that do not fit in the biological cycle are counted to the technical cycle. At the end of their lifetime these products are recovered and restored.

(Ellen MacArthur Foundation, 2015)

Figure 9. The two cycles of circular economy (Beckers, 2016)

2.4 Three key principles

According to the Ellen MacArthur Foundation, circular economy follows three main principles, which can also be seen in Figure 10:

> Principle one: 'Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.'

This means resources are selected with renewability and efficiency of products and services in mind. It is also an approach of circular economy to create conditions for regeneration, for example soil.

> Principle two: 'Optimise resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles.'

The aim is to keep the value of resources used in products as long as possible as high as possible. This means the focus for developing products should be on extending lifetime and on the other hand on remanufacturing, refurbishing and recycling.

> Principle three: 'Foster system effectiveness by revealing and designing out negative externalities'

The negative human impact on the nature, such as air and water pollution, land use, release of toxic substances must be reduced to a minimum.

(Ellen Macarthur Foundation, 2017)

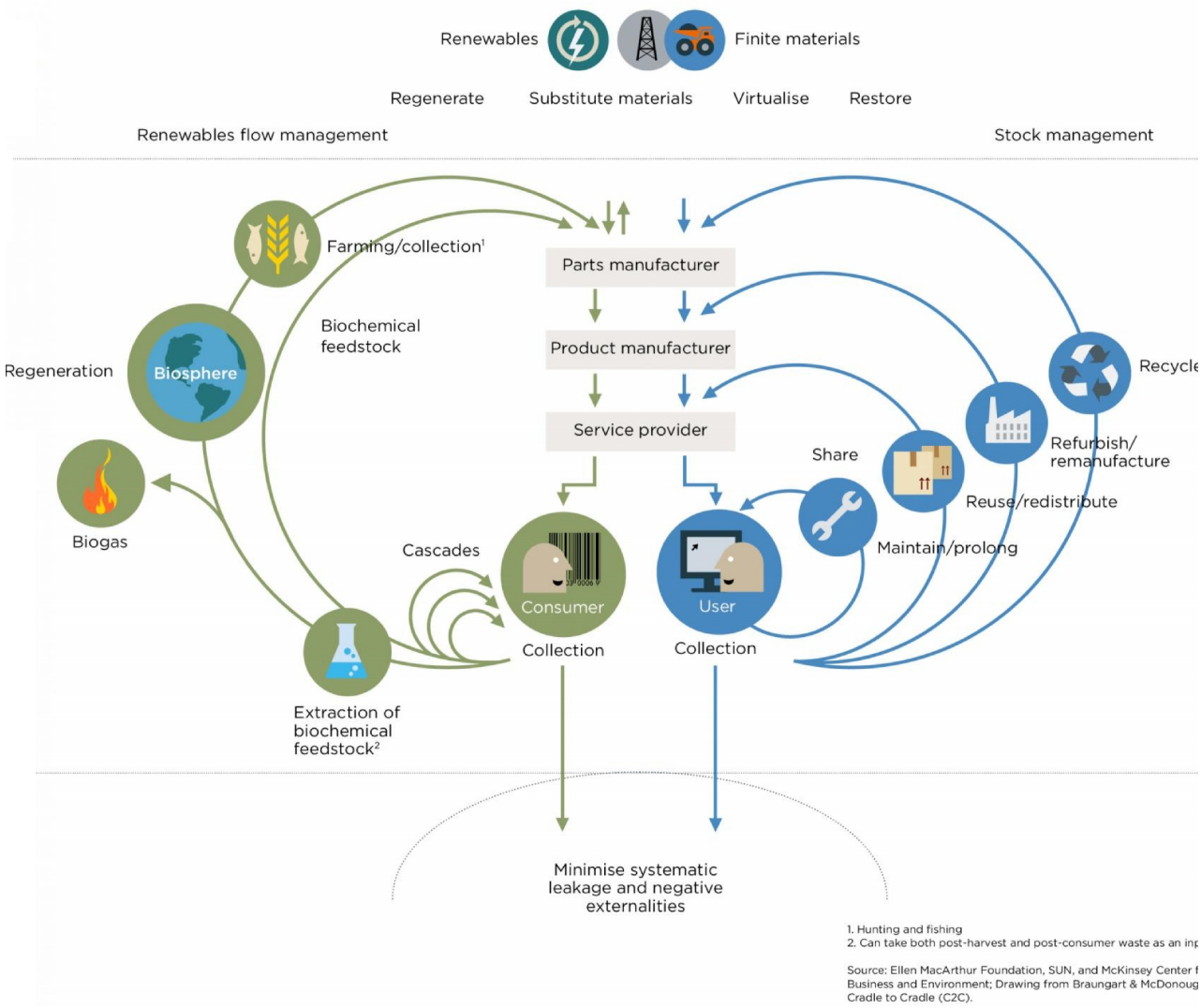


Figure 10. Two cycles of circular economy in detail (Ellen Macarthur Foundation, 2015)

2.5 ReSOLVE framework

The ReSOLVE framework is based on the three principles of circular economy. It is a set of business actions meaning that "each of the six actions represents a major circular business opportunity" (Ellen MacArthur Foundation, 2015). The aim of every action is to use the existing assets and increase their lifetime by shifting the finite resource use to the use of renewable sources (Ellen MacArthur Foundation, 2015).

Figure 11, next page, explains the ReSOLVE framework by giving short explanations to the action key words 'Regenerate', 'Share', 'Optimise', 'Loop', 'Virtualise' and 'Exchange'.

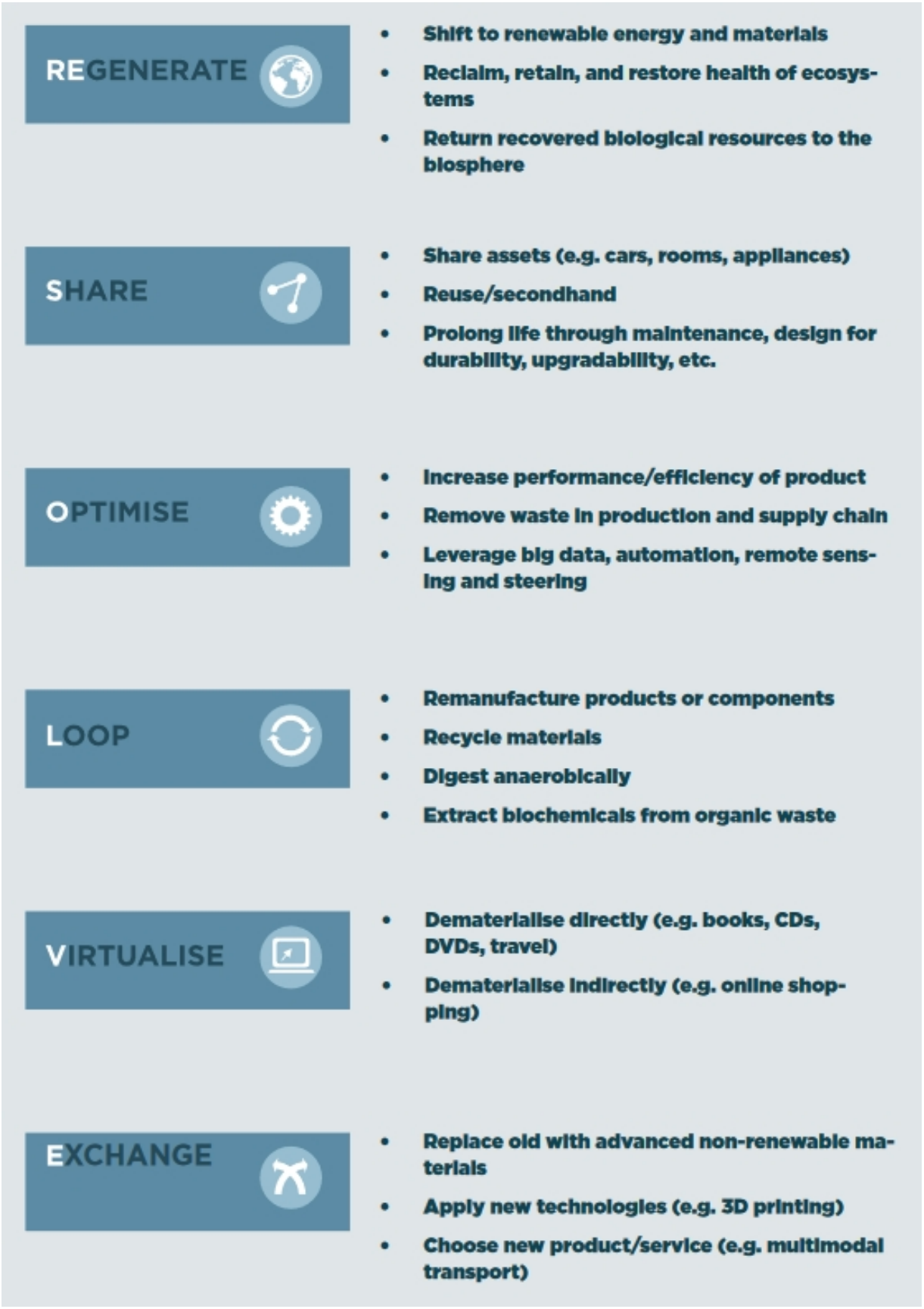


Figure 11. ReSOLVE framework (Ellen MacArthur Foundation, 2015)

2.6 Product / service requirements

To make a circular economy work, products or services must meet new requirements. Several demands are listed below and visualized in Figure 12.

- **Increased product lifetime**: long product lifetime can be increased through high quality, ageless design, modular construction and easy maintenance and reparability (Hartmann, 2017);
- **Use of renewable energies and resource efficiency**: products and services need to be as resource efficient as possible while being produced or provided using renewable energy sources;
- **Extending value chain**: circular economy moves away from the typical sales model, where the value chain ends with the delivery of the product, to leasing and rent models, where services are provided and value is added when the customer already owns the product. (Lutter, Giljum, & Randles, 2016)

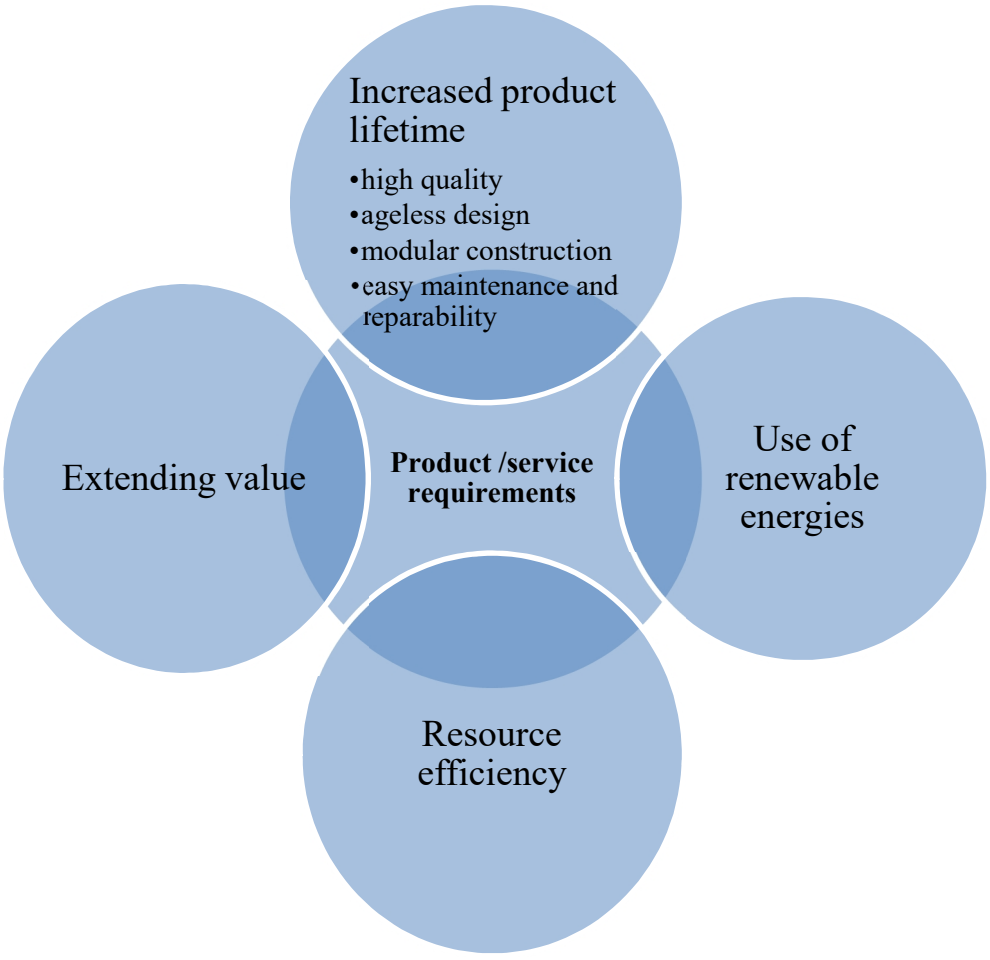


Figure 12. Product/ service requirements

2.7 Reasons for circular economy

There are many reasons why the circular model needs to be implemented in our economy. The following text shows only some of the main motives:

- **Growth of world population**: The significant growth of the population worldwide demands for solutions in the field of food, water and prosperity preservation;
- **Urbanisation**: Since more people are residing in cities, making CE more feasible, e.g. through cheaper sharing services and bigger supply of end of use materials to be recycled; (Ellen MacArthur Foundation, 2015)
- **Natural systems degradation**: The linear model which was practiced for a long time and still is 'state of the art' for some companies has an enormous negative impact on the environment. The Ellen MacArthur Foundation describes a selection of four elements contributing to the environmental pressure humans put on the environment and their impacts (Ellen MacArthur Foundation, 2015):
    - **Climate Change**: The "risks of climate change to human livelihoods and health, agricultural productivity, access to freshwater and ecosystems include: increased storm surges, coastal flooding and sea level rise; inland flooding; extreme weather events; extreme heat; and the loss of marine, coastal, terrestrial and inland water ecosystems" (Ellen MacArthur Foundation, 2015);
    - **Loss of biodiversity and natural capital**: The biodiversity declines results into losses in the value of ecosystem services;
    - **Land degradation**: In spite of increased fertiliser usage, the "agricultural productivity growth has been steadily declining" (Ellen MacArthur Foundation, 2015);
    - **Ocean pollution**: The mass of plastic waste and other rubbish in the oceans endangers, reduces or already destroys biodiversity and valuable materials, but also affects the fisheries sector and tourism in a negative way.
- **Limited amount of resources leading to price risk and supply risk**: The environment provides a limited amount of resources. Continuing with the linear economy would at any time mean, that we run out of raw materials. The shortage of resources is already visible in the increasing prices of raw materials like oil. Due to the difficulty of estimating how long the reserves will last, it is of paramount importance to

save the remaining reserves and reuse the already used resources; (Ellen MacArthur Foundation, 2015)

- **Decrease of lifetime of products**: The lifetime of products is steadily decreasing since consumers want new products more quickly and are using their old products for a shorter period of time. Consequently, more and more products have to be pushed on the market in order to satisfy the customers demand, while at the same time old products turn into non- or poorly-recyclable waste. To meet both challenges - satisfying the customer with continuous new products and reducing or eliminating waste of old products - circular economy is the answer;
- **Value loss**: In today's economy, a lot of product value is wasted, for example: waste-based energy recovery captures only five percent of the original raw material value (Ellen MacArthur Foundation, 2015).

Figure 13 sums up the points mentioned above and shows main reasons for the implementation of circular economy.

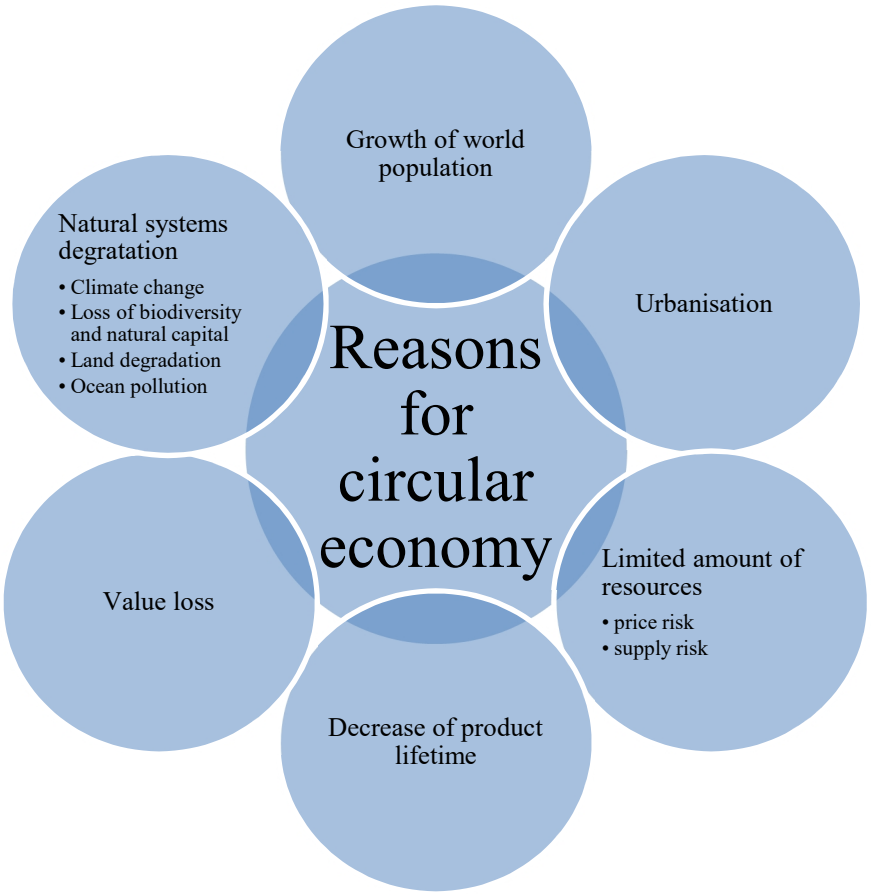


Figure 13. Reasons for circular economy

2.8 Linear economy vs. circular economy

Table 4 compares the linear model to the circular economy. The categories which are considered are:

- '**Step plan'**: what is the overall approach of the model?
- '**Value chain'**: where does the value chain end?
- **'Waste'**: is waste produced?
- **'Lifetime of pure materials'**: how long/often are pure materials used for (different) products?
- **'System boundary'**: what time span does the model consider?
- **'Sustainability'**: which actions are taken to ensure sustainability
- '**Quality of reuse practices'**: what reuse practices uses the model and what impact does it have on the value of the finite resources?

Table 4. Linear economy vs. circular economy (Het Groene Brein, 2017)

Issue	Linear economy	Circular economy
Step plan	Take-Make-Dispose	3R approach: Reduce, Reuse, Recycle
Value chain	Value chain ends with product delivery/ sale to the customer	Value chain can be extended through leasing or maintenance offers
Waste	Yes, after usage the products turn into non-recyclable waste	No, as value of the components remains qualitatively preserved
Lifetime of pure materials	Pure materials are used for one product only	Pure materials are used for several times by retaining the value of the materials.
System boundary	Short term, from purchase to sales	Long term, multiple life cycles
Sustainability	Through eco-efficiency, meaning maximizing economic profit with minimal environmental impact: ➔ postponing the moment of system crash	Through eco-effectivity, meaning radical innovations and system change

Quality of reuse practices	Downcycling (using former product for a lower graded purpose): ➔ reducing the value of materials	Functional reuse, Upcycling or Retain or enhance value of material
Example	Concrete is shredded and used for road filament	Concrete from walls is grinded into grains and used to build a similar wall or a stronger construction element

Table 5 shows a comparison between the current status and the scenario with circular economy in the fields of 'mobility', 'food' and 'living space'. Table 5 shows the differences in forms of economy using three examples.

Table 5. Comparison current status vs. scenario with circular economy (Stuchtey, 2016)

	Current status	Scenario with circular economy
	Optimization of every individual system	Optimization of systems and their interdependences
Mobility 	Private top-featured vehicle as dominant means of transport ➔ traffic congestion and depletion of resources	Multi-vehicular mobility, car-sharing, mobility concepts for sustainable transport networks Design focused on longevity
Food 	Greater intensification and specialisation ➔ no rehabilitation of agricultural areas, no nutrient recovery	Closed nutrient cycling Preserved natural capital
Living space 	More efficient supply chain Energy efficiency Increased use of areas	Smart urban planning by using deducible areas in cities Sharing living space and modular buildings

2.9 Present examples of CE implementation

Three examples to show the implementation of CE into business models.

2.9.1 Renault ‘Indra‘ and ‘Choisy-le-Roi‘

The company states: “We are using fewer natural resources in vehicle production by trying whenever possible to replace natural resources with materials that have already been used” (GROUPE RENAULT, 2017). Additionally, the company has two programs to give parts and vehicles a ‘second life’. One program which is ran by Indra, a subsidiary owned jointly with ‘Suez Environnement’, dismantles vehicles before reusing and selling the parts as spare parts. The ‘Choisy-le-Roi’ plant near Paris remanufactures engines, gearboxes, injection pumps and also uses them as standard replacement parts. (GROUPE RENAULT, 2017)

2.9.2 Philips ‘Pay per lux’

The business idea of the Dutch company ‘Philips’ is called ‘pay per lux’ meaning that customers do not pay for the product (e.g. LED lamp) but for the service ‘light’. Clients pay a regular fee to Philips for caring about the lighting service. That includes design, equipment, installation, maintenance and upgrades while still only paying for the consumed light, so to say ‘lux’. By now the ‘pay per lux’ service model is only available for business customers. The long-term plan of the company is to provide the service to any household.

The lighting consists of energy-saving products that can be returned at the end of the contract. Philips production process than reuses the raw materials, optimise the recycling process and therefore reduces waste. (Goldapple, 2016)

2.9.3 **Epson ‘PaperLab‘**

The machine ‘PaperLab’ can convert waste paper into new paper. Firstly, the waste paper is defibrated, bind and at last formed to a new paper. The production machine can e.g. be used to transform confidential documents into new paper instead of paying for the disposal. (EPSON, 2017)

Figure 14. Epson PaperLab (EPSON, 2016)

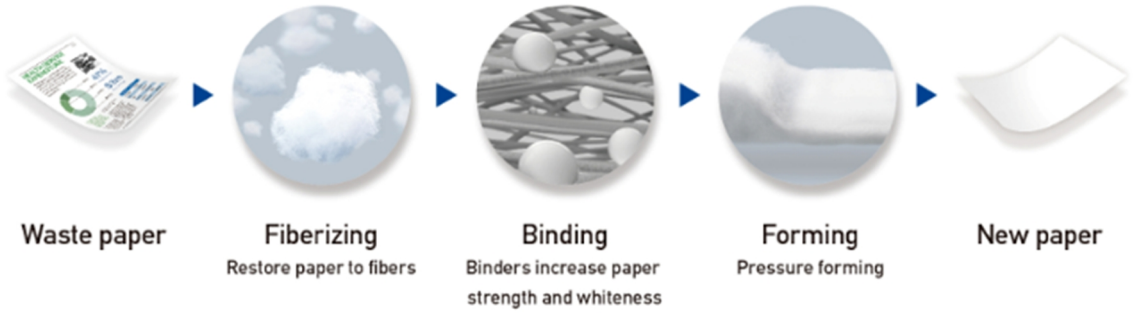


Figure 15. Epson PaperLab (EPSON, 2016)

2.10 Advantages and Disadvantages for companies and customers

This chapter describes the advantages and disadvantages for both companies and customers when switching from a linear model to a circular model.

2.10.1 **Advantages**

As seen in the previous chapters, the implementation of CE will create several of advantages:

- **Economic growth**: through CE activities which provide more value and lower costs of production through the more efficient uses of inputs. "European GDP could increase as much as 11 % by 2030 and 27 % by 2050, compared with 4 % and 15 % in the current development scenario"; (Ellen Macarthur Foundation, 2015)
- **Increased competitiveness of Europe's industry**: for example, better societal outcomes including an increase of € 3,000 in household income, a reduction in the cost of time lost to congestion by 16 %, and a halving of carbon dioxide emissions compared with current levels; (Ellen Macarthur Foundation, 2015)
- **The creation of jobs**: "In analysis conducted on Denmark, modelling suggested that ten circular economy opportunities could unlock, by 2035, 7.300–13.300 job equivalents, or 0,4 – 0,6 % relative to a 'business as usual' scenario"; (Ellen Macarthur Foundation, 2015)
- **Reduction of environmental impacts**: a 48 % reduction of carbon dioxide emissions by 2030 across mobility, food systems, and the built environment, or 83 % by 2050. A reduction in land use, air, water and noise pollution, release of toxic substances, and climate change; (Ellen Macarthur Foundation, 2015)
- **Preserved natural resources**: trough recycling of waste and the extended product lifetime. Even more so given the existing model of production and consumption and the growing world population. At the current rate of growth and levels of resource intensity we would need three planets' worth of resources by 2050; (Lacy, 2015)
- **Minimising dependency on imports**: Recycling of materials will decrease the vulnerability from importing raw materials; (European Environmet Agency, 2016)
- **Decrease in price levels and volatility**: Recycling gives less demand for new resources and therefore more price stability;

- **Cost savings**: "In the sectors of complex medium-lived products in the EU the annual net material cost savings opportunity amounts to up to USD 630 billion in an advanced circular economy scenario"; (Ellen Macarthur Foundation, 2015)
- **Increased income**: The income of an average European household could increase through the reduced cost of products and services and reduction in congestion costs;
- **Increased value of materials and products**: because of restorative use of resources;
- **Improved working conditions**: An increase in welfare of employees is often demanded in CE practices which involves the use of materials and labour in third world countries; and
- **Innovation**: The benefits of a more innovative economy include higher rates of technological development, improved materials, labour, energy efficiency, and more profit opportunities for companies.
  (Ellen Macarthur Foundation, 2015)

2.10.2 Disadvantages

Apart from the advantages, the implementation of CE it will also bring challenges:

- **New models and patterns**: Fundamental changes throughout the value chain, from product design and production processes to new business models and consumption patterns; (European Environmet Agency, 2016)
- **Frictions from change**: between the existing linear system and the new approaches are bound to arise. These may be perceived as threats by some stakeholders, but as opportunities by others; (European Environmet Agency, 2016)
- **Change of business models**: Remodelling of business models, which requires an organizational and cultural shift; (European Environmet Agency, 2016)
- **Need for more knowledge**: for a transition on aspects such as production structures and functions, consumption dynamics, finance and fiscal mechanisms and technological and social innovations. This is necessary to inform decision making on environmental, social and economic impacts; (Lacy, 2015)
- **Need for technological innovations**: The circular economy necessitates the development of radical new products, technologies and materials. We need to understand on the material level how to deal with stocks, flows of energy and materials; (Lacy, 2015)

- **Possible financial risks**: There is a different financial risk in a circular business models. For instance, the timing of cash flows, creditworthiness of clients and a larger need for working capital; (European Environmet Agency, 2016)
- **Less competitiveness**: Information-sharing along the supply chain can raise questions about information security and competitiveness within companies; and (Ellen Macarthur Foundation, 2015)
- **Design barriers**: The barriers in design technology are:
    - Limited attention for end-of-life-phase in current product designs;
    - Limited availability and quality of recycling material;
    - New challenges to separate the bio- from the techno cycle; and
    - Linear technologies are deeply rooted. (Ellen Macarthur Foundation, 2015)

2.10.3 Government as a market player

In addition to drawing up specific policies, the government can also act as a market player to stimulate the development of circular economy. In this case the government specifically requests circular and sustainable products. (Het Groene Brein, 2017)

2.11 Influencing factors for implementation of CE for SMEs

Given the advantages and disadvantages of the implementation of CE, there are a number of influencing factors that can support or obstruct the adoption of CE. For a circular economy to work it requires both effort of citizens, businesses and government worldwide to adopt a new way of thinking to change production and consumption patterns.

2.11.1 EU government

The European Commission plays an important role in the implementation of CE in Europe.

On 2nd December 2015, the European Commission adopted an ambitious new circular economy package. This package will help European businesses and consumers to make the transition to a stronger and more circular economy, in which resources are used in a more sustainable way. This package included legislative proposals on waste management, with long-term targets to reduce landfilling and increase recycling and reuse. In order to close the loop of product lifecycles, it also included an action plan. This plan needs to support the circular economy in each step of the value chain. From production to consumption, repair and manufacturing, waste management and secondary raw materials that are fed back into the economy.

After the Circular Economy Stakeholder Conference held in Brussels on 9-10 March 2017, the Commission and the EESC jointly launched the European Circular Economy Stakeholder Platform. A platform for gathering knowledge on circular economy and a place for dialogue among stakeholders.

The EU has also been working on an Economy Finance Support Platform with the European Investment Bank (EIB) bringing together investors and innovators. There is been guidance issued to Member States on converting waste to energy. The commission has proposed a targeted improvement of legislation on certain hazardous substances in electrical and electronic equipment.

(European Commission, 2017)

2.11.2 **Additional influences**

Several additional influences can affect SME's during their implementation of CE.

- **Sustainable Development Goals**: The UN has formulated 17 Sustainable Development Goals (SDG's) that describe targets for all participating countries, leading to a more sustainable world. Target 8 (decent work and economic growth) and target 12 (responsible production and consumption) are strongly related to the achievement of a circular economy. (Het Groene Brein, 2017)
- **Learning from nature (ecomimicry)**: Nature has known a closed, well-functioning system for millions of years. What can we learn from natural cycles, co-dependency, and processes such as growth and decay? (Het Groene Brein, 2017)
- **Practical understanding**: The question 'what does CE means on practical level' is important for businesses and organisations to make a proper transition. This includes more clarity of the terminology. (Het Groene Brein, 2017)
- **Unwillingness among some businesses**: To truly flourish, the circular economy needs to be part of a bigger effort to tackle wasteful consumerism and undemocratic power structures in the global economy. It needs to be geared to the real needs of all people rather than the excessive consumption of a few, and to be underpinned by more cooperative mechanisms rather than controlled by a small number of powerful companies. (The Guardian , 2017)
- **Policies barriers**: Current policies and legislation are generally written in and for a linear economy. They may (unintentionally) hinder the transition to a circular economy. (Het Groene Brein, 2017)
- **Customer adoption**: The adoption of circular practices and products by consumers and society takes effort. Some barriers are lack of knowledge, lack of enthusiasm and a lack of awareness that a transition is necessary and. Two other important barriers are the appreciation for ownership and attractiveness of refurbished and re-used products. (Het Groene Brein, 2017)

3 Introduction to construction industry

The history of the construction industry started from the first signs of human activity and is still visible in the current time. Techniques for describing a building may vary depending on the age and the amount of information available. A lack of written records for ancient buildings means that its description is based entirely on the archaeological recordings and interpretation made by the researchers. The procedure is simpler on recent buildings since there is a lot of material on record: pictures, models and even interviews with those involved in the actual phases of the building (Construction History Society, 2014).

As a matter of fact, the construction industry along with the infrastructure works, compared to other sectors, stand together for the highest resource usage as well as emissions of polluting waste products. The numbers vary depending on the country, but generally one could assume that these sectors obtain a share of 30 % to 50 % in energy consumption and stand for about 40 % of the CO_2 emissions while 15 % to 40 % of its waste ends up as landfilling (Net Balance Foundation, 2017).

3.1 Construction industry definition

The construction industry within the European Union can be defined, in compliance with the International NACE classifications, as the following subsectors:

- Architectural and engineering activities together with related technical consultancy
- Site preparation
- Building of complete constructions or specific parts
- Building installation
- Building completion
- Renting of construction or demolition equipment together with an operator

The construction industry is very labour intense, while having a low productivity over time in comparison with the other manufacturing sectors. Future development in the sector will be characterized by an increased influence of energy savings, resource depletion as well as increased variety of materials and technology. Upcoming land reforms, restructure of the property market, the further growing international market and the lower demand for workers,

led by the further automatization, will also play a key role in the further development of the sector. (Methodological Centre for Vocational Education and Training, 2008)

3.2 Current situation of the Finnish construction industry

The Finnish construction industry is characterized by manufacturing construction materials, building constructions, building repairs, construction of roads and waterways. The biggest players in the industry are YIT-Yhtymä Oyj, Skanska Oy, Lemminkäinen Oyj and NCC Finland Oy, with the central federation Rakennusteollisuus RT r.y. representing the entire construction sector (Lindberg, 2008).

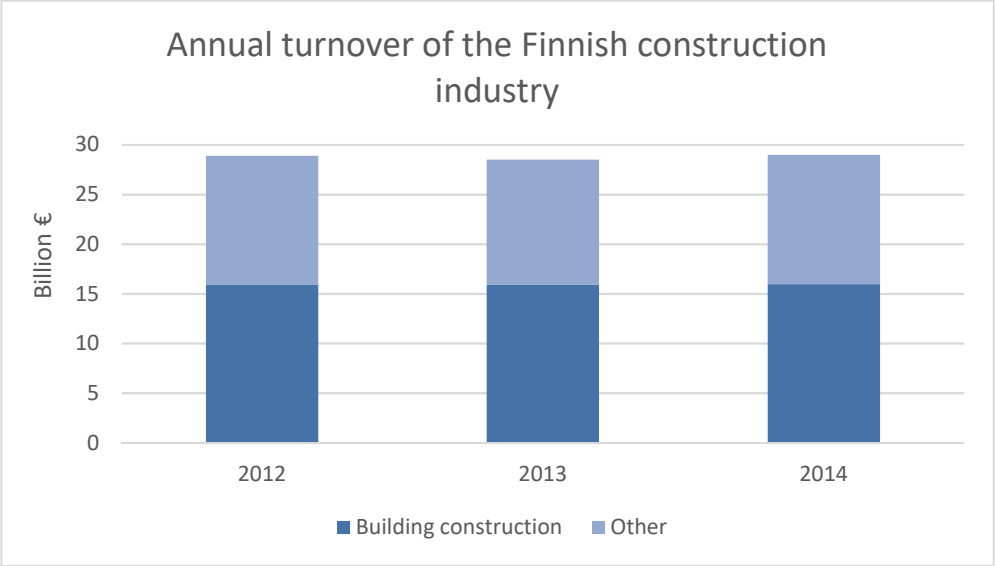


Figure 16. Turnover of the Finnish construction industry

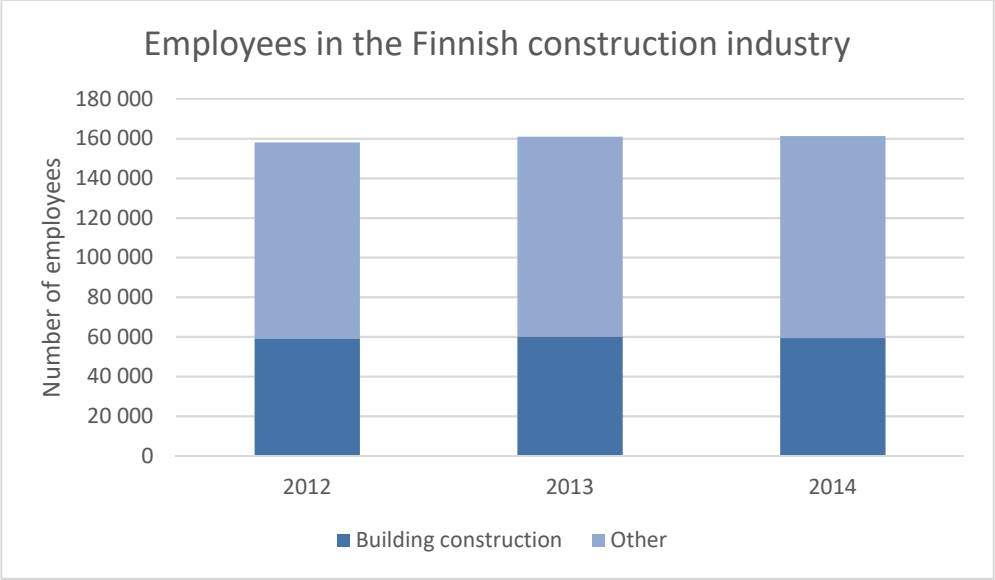


Figure 17. Employees in the Finnish construction industry

The sector has been in a stable situation of neither growth or decline in the past few years, both in turnover and number of employees, as seen in Figure 16 and Figure 17. The turnover, as seen in Figure 16, was almost € 30 billion in 2014 (Statista, Statista: Annual turnover of the construction industry in Finland from 2010 to 2014, 2017a), of which € 16 billion were in the building construction sector (Statista, Statista: Annual turnover of the building construction industry in Finland from 2010 to 2014, 2017b). In 2014 the construction industry in Finland had approximately 161.000 employees (see Figure 17) (Statista, Statista: Total number of employees in the construction industry in Finland from 2010 to 2014, 2017c), 59.000 of those allocated in the building construction sector (Statista, Statista: Total number of employees in the building construction industry in Finland from 2010 to 2014, 2017d). One can therefor say that roughly one third of the employees stand for half of the turnover in the sector.

In the beginning of 2017 the European Commission published guidelines regarding the implementation of CE in its member states. Shortly after, the Finnish government led by the Prime Minister Juha Sipilä announced their vision of making Finland one of the leading countries in circular economy by 2025. This announcement is believed to be realized through a bigger contribution in the strategic priority of bio economy and clean solutions (Ministry of the Environment, 2017).

The governments' goal is to ensure sustainable economic growth, improve employment and ensure the financing of public services and social security through the implementation of key projects and law reforms. A total of € 1,6 billion has been reserved for these projects, of which € 1 billion is allocated to the main strategic priorities of employment and competitiveness (€ 170 million), knowledge and education (€ 300 million), wellbeing and health (€ 130 million), bio economy and clean solutions (€ 300 million) and digitization, experimentation and deregulation (€ 100 million) (Finnish Government).

3.3 Opportunities

Money makes the world go around. Therefore, innovative technologies are broadly implemented. The advantages of circular economy can be very much characterized in the so called green buildings. The knowledge of the benefits from these green buildings is getting more and more widespread. In general, the benefits can be divided in three areas: environmental, economic and social.

Taking it down to the basics, the environmental benefits of green buildings are a decrease in the greenhouse gas emissions through savings and efficient usage of both energy and resources. Efficiency is a focus as the world is facing a resource depletion. Lower running costs and lower construction costs result in more money for other usages. Also, according to the World Green Building Council based on gathered facts and statistics, lower running costs give the building a higher occupancy rate and therefor an increased propriety value. These economic aspects alone should be able to convince people to invest in green buildings. Apart from the environmental and economic aspect, green buildings care for the health and wellbeing of its occupants. They are proven to give a positive social impact, which in turn leads to a healthier, happier and more productive live for those who work or live in the buildings.

(World Green Building Council, About Green Building: The benefits of green buildings, 2016)

3.4 Enablers

Four core enablers are listed for supporting the advance of CE in the construction industry. They answer the questions what, who, how and why supporting circular economy in the construction industry. Those enablers are technological, institutional, internal actions based and the final enabler is the influence by the market.

Hard and soft technologies, knowledge and information categorize the technological enablers. These are the means and opportunities to make changes providing a knowledge base and a technical capacity while answering to the question what.

The government, professional bodies, professional and educational institutions are all part of the institutional enablers. They provide a guidance and stimulation to the environment which can both boosts and enforce changes, answering the question how.

Interests, commitment, policies, management, resources and capabilities are all part of the internal action enablers. These actions provide a strong platform with all the resources and capabilities needed for acting, answering to the question who.

Demand is what controls the available supply and vice versa, so in other words the customer has a strong market influence with its demand affecting the market. Making circular buildings more affordable would incentivize the customers and the industry towards more sustainable buildings. In other words, why should customers follow circular principles - because it is more affordable, and why should the market follow circular principles - because there is a request for it.

(Abidin, Yusof, & Othman, 2013)

3.5 Barriers

The same enablers listed in the previous paragraph can also become barriers in case they are not incentivized. A shortage of locally-harvested green technologies can lead to a barrier in the technological aspect of the matter, due to eventually high prices for the imported products. A slow bureaucratically progress and an absence of incentives from the government becomes a major barrier for the institutional aspect. Not prioritizing the matter is an issue out of the internal aspect, while a great low-cost demand is a main barrier both out of the internal aspect and the one of the market (Abidin, Yusof, & Othman, 2013).

3.6 Rating tools

There are several different certification schemes for rating buildings that corresponds to a certain requirement. As for the topic of this research the World Green Building Council, a global network supporting green building technology, recognises up to 40 different building rating tools. These different tools are both under the administration of the World Green Building Councils' but also consist of individual organisations. The World Green Building Council points out that each rating tool has a certain usage in a certain area, therefore they do not take sides on considering one overall rating tool.

Among the different rating tools, the most known ones are BREEAM and LEED (World Green Building Council, About Green Building: Rating tools, 2017). Building Research Establishment Environmental Assessment Method, BREEAM, was established year 1990 in the UK and measures the environmental performance of non-domestic buildings. Leadership in Energy and Environmental Design, LEED, is an internationally known green building certification system established year 1993 in the US. They promote sustainable practices in the building industry aiming for an improved performance on the usage of energy, water, general resources, as well as lower the CO_2 emissions and higher the indoor environmental quality. (European Green Office, 2011).

3.7 Dependencies

The construction industry is dependent on a couple of factors. Most of the factors are shared by the rest of the manufacturing industry, but there are a couple of construction industry specific factors (Bankvall, Bygballe, Dubois, & Jahre). These will be specific in the following numeration:

- Pooled interdependencies of resources such as equipment and locations;
- Sequential interdependencies of steps within the building process; and
- Mutual interdependencies based on a finish start dependency of tasks.

3.8 Supply chain

A supply chain comprehends everything involving the production process of a product from supplier to the client/ customer. Every kind of resource (people, information, goods and activities) will be visualized as a step in the supply chain. This allows for the improvement of the process by streamlining the flow of goods and improving co-operation between different companies. A supply chain can be used for both a linear or circular economy business process, where re-used materials can enter the chain in the same way as new materials.

The construction industry uses in general the following supply chain:

(Koskela & Verhoef) characterized the supply chain in construction as:

- Converging at the construction site where the object is assembled from incoming materials;
- Temporary producing one-off construction projects through repeated reconfiguration of project organizations separated from the design;
- Typical make-to-order supply chain, with every project creating a new product or prototype.

The supply chain for the construction industry deviates from the manufacturing industry due to the following points (Segersteds & Olofsson):

- **One of a kind product**: this requires very high flexibility and is therefore not suited for continued or batch production. It limits the efficiency of the production process;
- **Temporary organisation**: building for example a house requires a lot of different materials as well as a lot of different skills to use to materials. This results in either a construction company with many diversely skilled employees or in outsourcing the jobs. The latter is chosen most often, since it also lowers the risk of failure for both the client and the company; and
- **Site production**: the production of a building generally takes place on site. This means that the production method for building the house has to be flexible and mobile. This makes the use of production lines vary hard, with the solutions being pre-fabricated parts and modular designing for customising.

4 Best practice cases

In order to fulfil the assignment, cases of CE-thinking in the European construction industry were found, and a further research into six European CE buildings was performed. The number of examples was chosen by taking the available time for this project into account. The buildings were selected from a generated list of European CE buildings. The complete list of all the buildings can be on the website: https://thecircleeps.wordpress.com/startseite/ce-in-european-construction-industry/

The general criteria for selecting the buildings were the following:

- Diversity in the type of building (Residential, Office, Private or Public);
- Diversity in the ReSOLVE themes applied in the buildings (Regenerate, Share, Optimise, Loop, Virtualise and Exchange)

Additionally, there are more selection criteria concerning the projects support for the Botnia-Atlantica EU project:

- Related to the wood industry;
- Related to maintenance (since this is an actual subject in the Ostrobothnia region);
- Examples with closed supply chains;
- Buildings close to Finland (or the Netherlands) for visiting;
- Applicable to the Ostrobothnia region (not to complex case)

The six buildings chosen based on the above criteria for further research are both in the field of residential and office buildings:

Residential

- Finch Buildings (Regenerate, Share, Optimise, Loop, Exchange)
- Pluspuu Talot (Regenerate, Share, Optimise, Exchange)
- Villa Asserbo (Regenerate, Optimise, Loop, Virtualise, Exchange)

Office

- De Fire Styrelser (Share, Optimise, Exchange)
- Park 20|20 (Regenerate, Optimise, Loop, Virtualise, Exchange)
- Bionorica Headquarter (Regenerate, Optimise, Loop, Virtualise, Exchange)

4.1 Research topics

The researches have been carried out on all six buildings concerning the following topics:

- **General information**: proving name, location, construction year, architect, manufacturing company, type of building, area, tags from the ReSOLVE framework and a link for further information.
- **Project goals**: giving an insight of which goals were pursued by establishing the building.
- **Supply chain**: pointing out the supply chain and the companies involved.
- **Biological and technical cycle**: explaining the implementation of biological cycles and technical solutions and in detail.
- **Law and incentives**: looking at the legislation and restrictions in the country where the building is situated.
- **Geographical influences**: looking at the environment in the country where the building is situated.
- **Rating and Conclusion**: giving a conclusion about the building based on the ReSOLVE framework.

4.2 Finch Buildings

Finch buildings are modular buildings made by Finch Buildings B.V. (see Figure 18). The company aims to construct high-quality, flexible, comfortable and affordable buildings made from durable and environmentally friendly materials. The buildings, which are made of separate prefabricated modules (see Figure 19), can be transported by road and are suitable for various target groups and locations. The surface area of the modules can be adjusted and due to a flexible utility system and the interior of the modules can also be adjusted to the customer's needs. According to the company the buildings have high energy efficiency and a lifetime of over 100 years (Finch Buildings, 2017). The main material used in the buildings is FSC (Forest Stewardship Council) and/or PEFC (Programme for Endorsement of Forest Certification Schemes) certified wood, and according to the company about 90 % of all materials used in the modules are suitable for reuse. In addition, the total cost of ownership is lower than competitive alternatives over a lifespan of 15 years, according to Joran van Schaik, responsible for the Research & Development at Finch Buildings B.V. (Van Schaik, 2017). An example of how a ground plan for a module looks like can be seen in Figure 20.

FINCH
evolutionary wooden buildings

Figure 18. Logo Finch Buildings B.V.

4.2.1 General information

Figure 19. Finch buildings (Finch Buildings, 2017)

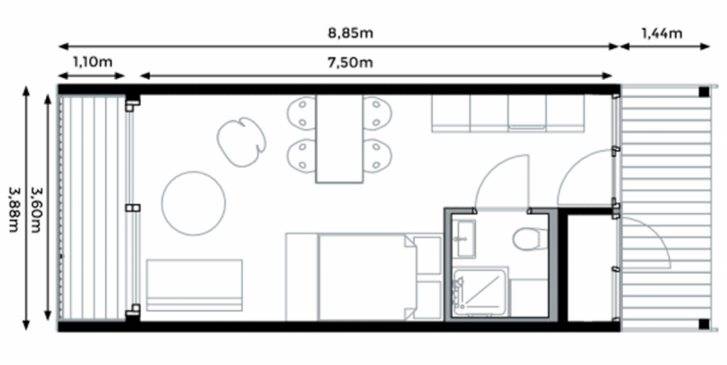


Figure 20. Finch buildings ground plan (Finch Buildings, 2017)

Name:	Finch Buildings
Visiting location:	Amsterdam, the Netherlands
Building locations:	Cornelis Lelylaan, Amsterdam Java-eiland, Amsterdam Sumatrastraat, Leiden
Construction year:	2015 - Cornelis Lelylaan 2016 - Java-eiland 2017 - Sumatrastraat
Client:	Finch Buildings B.V.
Founder & architect:	Jurrian Knijtijzer
Manufacturing companies:	De Groot Vroomshoop Groep Loohuis Groep Timmerfabriek De Mors
Type of building:	Residential building
Area:	Approximately 29 m^2
Tags:	Regenerate, Share, Optimise, Loop and Exchange
Link:	http://www.finchbuildings.com/

4.2.2 Project goals

The aim of Finch Buildings B.V. is to build high-quality, flexible, comfortable and affordable buildings made from durable and environmentally friendly materials. The buildings should serve multiple target group and application, such as a studio, a three-room apartment, an office, a health care department or a hotel. (Finch Buildings, 2017).

4.2.3 Supply chain

To achieve circularity in the supply chain, environmental friendly materials are chosen for the buildings were possible, and during construction and transportation environmental aspects are taken into account. Actions include separated waste disposal, reusable packaging and good communication with the local area as well as its residents. (Finch Buildings, 2016).

The suppliers of Finch Buildings stay involved in the realized products. They want to keep learning from developments in the market and further improve the products. According to Schaik, the suppliers and Finch Buildings B.V. together strive for circularity in the supply chain. (Van Schaik, 2017).

De Groot Vroomshoop Groep

De Groot Vroomshoop Groep (Figure 21) produces the modules for Finch Buildings and is a vital part of the construction company VolkerWessels. De Groot Vroomshoop Groep has more than 85 years of experience, there are approximately 200 professionals employed and the company has a production site area of eight hectares. De Groot Vroomshoop Groep consists of three departments: construction systems, glued wood construction and wood construction. Through close cooperation with this company the product has been designed in detail. (Finch Buildings, 2016).

Figure 21. Logo De Groot Vroomshoop Groep (De Groot Vroomshoop, 2017)

Loohuis Groep

Loohuis (Figure 22) supplies and designs the installation technique for the Finch buildings. The company strives for the quality of living and working through the application of suitable installation technology. They provide solutions from design to realization, as well as maintenance and management of all technical installations in and around the buildings. The company meets all the requirements of innovation, quality and safety standards, while being a certified installer as well as a family enterprise with a history of over 60 years. (Finch Buildings, 2016).

Figure 22. Logo Loohuis Groep (Loohuis, 2017)

Timmerfabriek De Mors

De Mors (Figure 23) produces durable products made out of wood. They are specialized in woodwork and carpentry. Their core activities are the production of frames, windows and doors. De Mors also supplies interiors, unit building and produces sandwich panels. The 'myCUBY' bathrooms, used in the Finch Buildings, are assembled according to a new and sustainable method which is a result of years of experience in prefabricated units and panels. (Finch Buildings, 2016).

Figure 23. Logo Timmerfabriek De Mors (De Mors BV, 2017)

4.2.4 Biological and technical cycles

The following paragraphs will outline achievements that Finch Buildings B.V. accomplished concerning the integration of CE in their buildings, as well as other relevant information.

4.2.4.1 Configuration model

The configuration model of Finch buildings consists of five elements: the hull, exterior, balcony, interior and technical installations.

The hull

The hull is made of large cross-laminated timber (CLT) panels, which serve as a solid construction product due to the bonded single-layer panels (Figure 24). The panels can be screwed together to create different thicknesses, with a minimum of three panels, depending on the thickness needed for the hull. (Finch Buildings, 2016).

Figure 24. Cross-laminated timber (Finch Buildings, 2017)

Due to the standard dimension of the hull the modules are stackable, switchable and easy to connect to each other. Also, vertical connections can be made which add more possibilities to the layout. If the hull (Figure 25) is made with 140 mm thick walls, up to five modules can be stacked on top of each other. It is also possible to construct the hull with 100 mm thick walls, which allows up to two modules to be stacked on to each other. The solid wood walls also function as a fire separation and meet all sound requirements. (Finch Buildings, 2017).

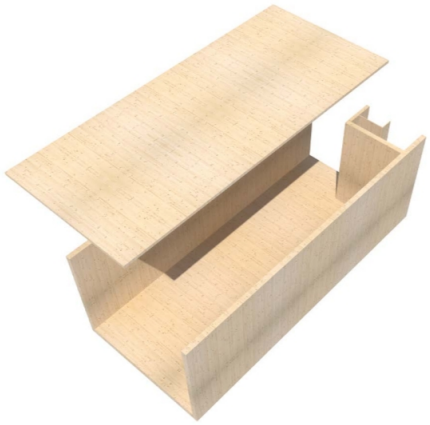


Figure 25. Hull (Finch Buildings, 2016)

The exterior

The applied facade coating is made of western red cedar and is used vertically. However, are multiple cladding options such as aluminium, brick or durable wood (Figure 27). In case of the wooden facade cladding, it is attached to the prefabricated wall insulation module (Figure 27). Finch Buildings usually carry the frames out in meranti wood with triple glazing. For the layout of the porch sliding doors are used, but conventional doors and windows are among the options too.

The Finch module is supplied usually with a fixed gallery of Azobé. The gallery on the ground floor can be left out, making it possible to get direct access to the street.

(Finch Buildings, 2016).

Figure 27. Exterior (Finch Buildings, 2016)

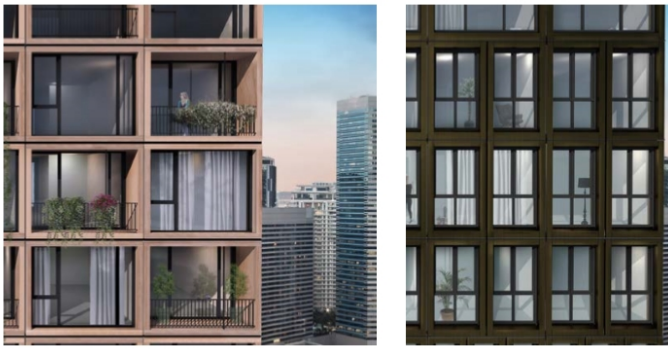


Figure 26. Exterior cladding (Finch Buildings, 2017)

The module can be equipped with a 3,8 m² balcony (Figure 28). Access to the balcony is provided by large glass sliding doors. The balcony is trimmed with the same facade cover as the outside of the module. (Finch Buildings, 2016).

Figure 28. Balcony (Finch Buildings, 2016)

The interior

The interior consists of the bathroom module, the kitchen and the floor (Figure 29). Due to the modular construction system and the smart floor in which all pipes are laid, the kitchen and bathroom can be placed throughout the module.

Figure 29. Interior (Finch Buildings, 2016)

The functional interior (bathroom and kitchen) is supplied as a prefabricated product and installed at the factory. However, this can be easily adjusted afterwards. By default, Finch Buildings install a four kitchen blocks with cabinets.

For the bathroom there are two size options. The bathroom module is optimized and circularly designed. The wet cell can be placed in its entirety and removed in parts. The standard interior finish of the bathroom is white, but also coloured foils can be chosen.

A separate toilet belongs to the possibilities, as well as the installation of interior walls to create rooms. The floor is covered with linoleum flooring, but also a bamboo or wood finish are possbile. (Finch Buildings, 2016).

The technical installations

The technical system of the module consists out of installations for heating, hot water and ventilation, but also the electrical closet, sewage and drainage systems (Figure 30). The smart floor allows improvements in technology and electronics in the future.

Due to the design of the technical area, the rooms can be vertically connected to each other. The design has largely taken into account fire separation, noise and ease of use. When designing the meter box, extra space was left for a home battery.

Figure 30. Technique (Finch Buildings, 2016)

The modules can be delivered as Zero-energy buildings NOM, which means they are self-sufficient in terms of energy. A heat pump can be chosen which provides heating for the rooms (radiators or underfloor heating) and the hot water. Also, solar panels can be installed on the roof.

(Finch Buildings, 2016).

4.2.4.2 **Flexibility**

In this chapter, the flexibility of the buildings will be described.

Transportation

The modules of Finch Buildings are easy to transport by truck and delivered in one piece, fully equipped, making them ready to move in immediately. As it can be seen in Figure 31, the modules can be picked up and placed using a crane. (Finch Buildings, 2017).

Figure 31. Placement of the module (Finch Buildings, 2017)

Multifunctionality

As said before, the Finch Buildings modules are suitable for multiple applications to serve multiple target groups and locations, as an example in Figure 32.

Figure 32. Holiday homes at sea (Finch Buildings, 2016)

This is possible because the modules themselves are 'plug play', which makes them easy to be assembled and relocated. Application options include student and family homes, elderly homes, offices and homes for the recreation sector. Finch Buildings has worked out four variants based on one type of module, the ´studio´ (Figure 33), living, working, care and recreation. (Finch Buildings, 2016).

Figure 33. Studio (Finch Buildings, 2016)

If the customer wishes, an extra half or a whole module can be added as an extension (Figure 34). These adjustments can even be made years after the original building was placed. (Finch Buildings, 2016).

Figure 34. Finch 2 (Finch Buildings, 2016)

4.2.4.3 **Sustainability**

Finch Buildings took several measures to realise a sustainable building as described below.

Circular design

The modules are designed according to circular principles. This means that more than 90 % of all materials used in the module are suitable for reuse and therefore help to close material circuits. Almost all materials are natural and emission-free**.** Furthermore, Finch buildings produce barely any waste due to prefabricating.

The base of the building, which consists of the walls, floor and ceiling, is made of massive CLT (Cross-Laminated Timber). CLT as a product is highly suitable for reuse and the glues used are environmentally friendly (Van Schaik, 2017). The panels are machined as little as possible, which creates large untapped solid wood panels after the manufacturing operation. Furthermore, the panels are interconnected by means of screws, which results in a high rate of reuse and residual value at the end of the operating period. Another example of circularity are the walls of the bathroom that are fitted with Velcro fasteners to the hull to easily remove them. (Finch Buildings, 2016).

Wood

For the Finch buildings, wood is chosen as a main construction material. All wood types used for the construction of the Finch module are FSC and/or PEFC certified. Wood as a building material is chosen because it is renewable and it is the only building material that stores CO_2 instead of producing it. One module can store up to 20 tonnes of CO_2. In addition, a Finch module hardly uses steel and doesn't use concrete, both materials that would emit CO_2. Also, for every three trees used five trees are replanted. As a result, a Finch module is 60 tonnes carbon negative. (Finch Buildings, 2016).

Energy efficiency

By using high-quality construction and insulation materials, Finch buildings modules have a low energy requirement and primary energy consumption. For example, wood is a good insulator, which reduces energy demand. This can be further reduced by applying advanced installation technologies and the use of solar panels. The module is 'all-electric': which implies using electricity for all home appliances (heating, cooking and hot water supply). An 'all-electric' building can be fully powered by green energy, which means that the module does not emit CO_2. For lighting, energy-efficient LED luminaires can be used for both indoor and outdoor lighting. The balcony of the module functions as a passive awning, which keeps the house cooler in the summer by creating shadings and warmer in the winter by letting sunlight directly enter through the windows. (Finch Buildings, 2016).

Durability

The hull is made from wood, a solid foundation that can be used for longer than 50 years as stated in the Dutch Building Regulations. According to the construction company, the hull can last for over 100 years if well protected from weather,

The building is made resistant to several factors like fire, excessive rain and typhoons. For example, the CLT forms a layer of char when exposed to fire, which is heat insulating and protects the wood underneath. This is better than more conventional constructions, such as concrete, that require more fire protection measures.

CLT is protected from rain and other external moistures damages thanks to the instalment of a rain screen. However, the wood is exposed to moisture from the indoor environment, but this is normally a controlled environment with a set temperature and humidity that does not result in higher moisture content in the wooden panels.

The wood has a low risk of being attacked by termites, due to a protecting foil wrapped around it which is only visible from the inside of the building. This also provides for a long-term duration of the visual aspect.

The buildings have a typhoon resilient design, as it can withstand relatively high wind speeds and after a typhoon it can be brought back to its original state relatively easy.

(Finch Buildings, 2016) (Finch Buildings, 2017).

4.2.4.4 **Human well-being**

An important aspect of the Finch Buildings modules is the healthy living environment, which can be seen through the choice of materials. Wood has a positive effect on human health, psyche and well-being, for example by lowering stress. It is moisture regulating, as it absorbs moisture from the environment if there is an excess of it, and releases moisture as soon as a room becomes too dry. Thanks to this balanced humidity there is a decreased risk of infections, bacteria and fungi. Wood also feels warm, unlike walls of stone, because of its low heat conductivity. Besides, a lot of thought has been put into the design of the Finch buildings to realize an attractive form that appeals to the customer and the people who live in and around it. Finch Buildings B.V. describe their style as 'warm modernism' (Figure 35). Finally, the buildings are not exposed to toxic radon gas. This gas that is emitted by radium increases the risk of lung cancer when inhaled. Good ventilation can reduce the risk of accumulation in closed areas. (Finch Buildings, 2016).

Figure 35. Interior (Finch Buildings, 2017)

4.2.5 **Economics viability**

After a lifespan of 15 years, the modules are cheaper and more durable than competitive alternatives. This is mainly due to the fact that the critical parameters are beneficial to the total cost of ownership (TCO) calculation. These critical parameters consist of high quality, relatively cheap and guaranteed high residual value materials, as well as adaptability of the building, low relocation costs, excellent energy efficiency scores and limited maintenance costs. (Van Schaik, 2017) (De Architect, 2017)

The displacement costs are unprecedentedly low in modular construction. Finch buildings do not have to be disassembled when relocated or located and the building can be placed or lifted with one hoist. (Finch Buildings, 2016).

The extra investment to make Zero-energy buildings is currently not easily profitable. (Van Schaik, 2017)

4.2.6 **Influencing factors**

The following chapter describes several influencing factors in the execution of Finch buildings.

4.2.6.1 **Legislation influences**

Some legislation barriers for the implementation of CE in the Finch buildings are:

1. The Finch modules have to comply with the strict permanent requirements of the Dutch Building Decision 2012, allowing them to be used for permanent or multiple temporary operating periods. (Finch Buildings, 2016)
2. Finch buildings do not qualify for the EPV (Energy Performance Fee) compensation. Schaik says:" The buildings can meet all the requirements of the EPV except one, the maximum energy consumption per m^2. This is due to the very small surface area of the unit which results in a much higher energy demand per m^2 compared to a 100 m^2 house." (Van Schaik, 2017)

4.2.6.2 **Customer and society influences**

Different parties are not yet prepared to pay for a high-quality product that last long, despite all positive reviews available. According to Schaik, customers value sustainability and circularity significantly in the procurement phase, but ultimately, corporations and developers still choose the non-circular alternative, even if they know the Finch Buildings are eventually less costly based on the TCO. (Van Schaik, 2017)

Finch Buildings B.V. are trying to find partners that want to form a coalition to represent the interests of sustainable spaces, both for permanent or temporary alternatives. (Van Schaik, 2017)

4.2.7 **Rating and conclusion**

According to the ReSOLVE framework by the Ellen MacArthur Foundation, the modules by Finch Buildings B.V. cover the following aspects of circular economy:

Regenerate	About 90 % of all materials used in the module are suitable for reuse and emission-free. The wood types used for the construction of the Finch module are FSC and/or PEFC certified and the use of wood makes the buildings a CO_2 buffer. For every three trees used, five trees are planted back.
Share	The building will last for over 100 years when well protected from weather influences.
Optimise	The buildings produce almost no waste through smart design and prefabricating. A high level of modularity and flexibility in the buildings is achieved, which makes the buildings suitable for multiple applications, target groups and locations. For example, the surface area and the interior can be adjusted, due to the modular construction systems and a smart floor. Finch modules have a low energy performance by default and are easy and cheap to transport by road.
Loop	Non-permanent connection techniques in the modules make the rate of reuse high. The company is working together with its suppliers to achieve circularity in the supply chain.
Exchange	The modules are 'all-electric' which makes them suitable to operate entirely on green energy. The balcony also provides better energy performance through the passive blinds. A heat pump and solar panels on the roof are optional.

Influencing factors such as legislation and customers affect the realisation of the project. For example, customers value sustainability and circularity significantly in the procurement phase, but ultimately corporations and developers still choose the non-circular alternative at the end, even when the TCO is lower over a period of 15 years. To solve this problem Finch Buildings is trying to find partners that want to form a coalition to represent the interests of sustainable (permanent or temporary) spaces. Additionally, from a legislative point of view, there is an EPV

(Energy Performance Fee) compensation for energy saving buildings which cannot be met by the Finch buildings. One rule about the maximum energy demand per m^2 cannot be applied to the Finch buildings because it does not consider that small spaces by default have a higher energy consumption compared to large spaces.

Information on the influence of other legislations on the realisation of the project has not been found and some questions still remain, such as: which parties are involved in the final phase of the building? How did Finch Buildings gather their know-how? In addition, more detailed information about the technical aspects of the buildings might be useful for further use in the Botnia-Atlantica project.

Finch Buildings B.V. does not have neither BREEAM or LEED certificates.

4.3 Pluspuu Talot

The company focused on in this chapter is named Pluspuu Talot, a Helsinki-based studio founded in late 2009. It is formally known as Pluspuu Oy and it offers architectural services with house packages as their main product (Fonecta, 2017).

Their house packages consist of carefully designed log houses, made using a durable material and in various designs to make them suitable both as homes and holiday residences. Furthermore, they offer also small saunas.

Traditionally, log houses are built using single trunks as well as laminated logs. The particularity of Pluspuu Talot is that they offer the latest in Finnish log technology, a non-settling log system, combined with cross laminated timber panels and tailored structural solutions in order to match the customers' needs.

As Pluspuu Talot is a design studio they collaborate with the Tampere-based Ollikaisen Hirsirakenne Oy, a construction company with a long history in log-constructions, to carry out the construction of the residences from paper to actual life.

Circular economy comes in place as Pluspuu Talot follows the principles of sustainable development in quality, aiming to offer high quality rather than low price, and choice of material, as wood is a durable, renewable and recyclable material. All residences are hand built on site, aiming to minimize the waste of materials.

(Pluspuu, Pluspuu: Pluspuu, 2017a)

Figure 36. The company's logo (Pluspuu, 2017a)

4.3.1 General information

Figure 37. Log chalet Iniö 100 (Pluspuu, 2017b)

Company name: Pluspuu Oy

Location: Helsinki, Finland

Founded: 2009

CEO: Markku Miettinen

Manufacturer: Ollikaisen Hirsirakenne Oy

Location: Tampere, Finland

Type of buildings: Residential and holiday residences

Area: 20-126 m^2

Tags: Regenerate, Share, Optimise, Exchange

Link: http://www.pluspuu.fi/en/

4.3.2 **Project goals**

As noticeable under the previous heading, Pluspuu Talot is a newly started company, with less than ten years on the market, that offers modern log houses of high quality and using sustainable materials as well as innovative techniques. Concerning vision and goals, the following is what the company states on their website:

> "Pluspuu offers a wide range of modern log houses for quality-conscious customers. Pluspuu houses transcend our conventional notions of traditional log houses. The elegant architectural design, the mitred corner joints and narrow seams between logs all contribute to the image of a light and modern wooden building. Logs walls are durable and long-lasting and offer a healthy indoor environment" (Pluspuu, Pluspuu: Modern Log Houses, 2017c).

During the research phase the company was contacted for clarifications about certain aspects of their circularity, such as maximising the value at the e*nd of* their useful *life* trough upcycling, recycling, maintaining and upgrading, as well as possible future improvements. The company stated that they were busy and could not answer any questions. This leads to the conclusion that the research is based only on the available information online, since crucial information by the company, that would possibly have changed the outcome of the research, might be missing.

> "Reliable quality and unique design with more than 35 years of experience" (Ollikaisen Hirsirakenne, Ollikainen: Incredibly ecological, 2017a) is the slogan of Ollikaisen Hirsirakenne.

The construction company firmly points out the quality and experience in the field as well as an overall corporate mission of green values, using wood as their primary material, and waste reduction programs.

4.3.3 Supply chain

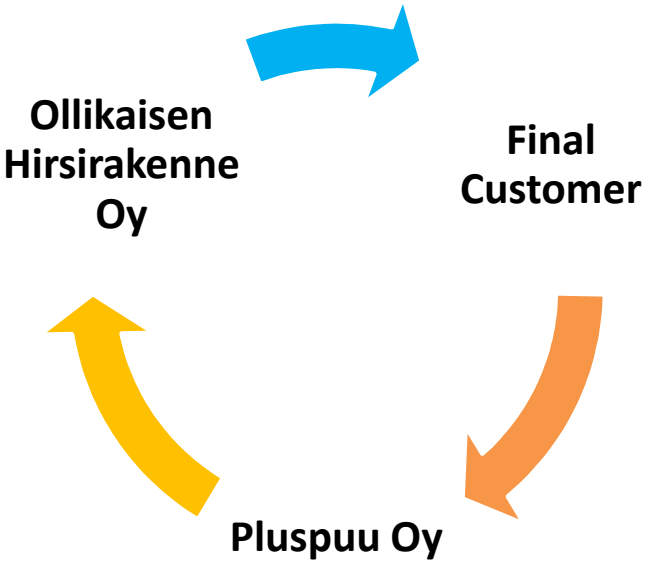


Figure 38. Simplified structure of the supply chain

As shown in Figure 38, the supply chain can be described as the following:

- **Final customer**: Places the order, follows up the progress
- **Pluspuu Oy**: Designs, plans, sales
- **Ollikaisen Hirsirakenne Oy**: Chooses the materials, produces, executes the construction

The company did not answer the question of the existence of an actual loop after sales in between the three entities. The possibility of such a loop is not to be neglected, as the company is newly established, and its already constructed products are still 'young'. However, further research is needed to clarify the roles in the supply chain.

As already mentioned in the introduction chapter, Pluspuu Talot takes the services of Ollikaisen Hirsirakenne for constructing the structures. They are said to be a company with superior knowledge in both woodworking as well as log constructions, granting for a final product of high quality (Pluspuu, Pluspuu: Pluspuu, 2017a). The logs used are carefully selected in the local area near the construction company to minimize the carbon footprint from the transport, then sawn, dried and made into their final shape by a subcontractor of Ollikaisen Hirsirakenne.

Through the recognition of current ecological problems, they are aiming to evolve their production into a more sustainable direction, without their operations drawing unnecessarily energy from the environment. “Our goal is to ensure that future generations can enjoy the same rich and pure nature [that we have] today” (Ollikaisen Hirsirakenne, Ollikainen: Incredibly ecological, 2017a).

The production line of Ollikaisen Hirsirakenne takes advantage of a newly introduced CAD-CAM system by the German Hundegger Maschinenbau GmbH, a leading manufacturer in the field of eco-friendly woodworking machinery, to work on the wood. The CAD-CAM system, meaning Computer-Aided Design/Computer-Aided Manufacturing, is a CNC software that allows for an optimized material usage while keeping stable and predictable results in the production. (Ollikaisen Hirsirakenne, Ollikainen: Incredibly ecological, 2017a)

4.3.4 **Biological and technical cycles**

“Wood is the only building material whose amount is constantly increasing [trough replanting]. By using wood, the consumption of non-renewable materials can be reduced and/or completely avoided” (Wood Products, Wood Products: Wood is a renewable natural resource, n.d.a). Wood buildings are known for their durability as we can find log houses, that are still in use, dating back to the 15th century. Furthermore, the use of logs removes the need of additional synthetic insulation material, as the logs insulates when thick enough (Ollikaisen Hirsirakenne, Ollikainen: Incredibly ecological, 2017a). Today’s advanced adhesive compound allows wood to breathe naturally, as massive logs do, maintaining a comfortable indoor climate and humidity (Ollikaisen Hirsirakenne, Ollikainen: Superior quality and special proprieties, 2017b).

Pluspuu Talot offers different solutions and technologies in order to meet the customer’s needs, reaching new grounds in the market for timber house constructions. Further information about the implementation of renewable energy sources, such as geothermal energy or solar panels, could not be found, and comments on the question were not given by the company upon contact.

Stated on their website, the following wood construction options are offered to the customers:

- **Non-settling log:** made of spruce or pine, differs from traditional laminated logs by having vertical lamellas in the middle part of the log, shown in Figure 39. This removes the need of post-construction adjustments of various parts since wood swells and shrinks during normal circumstances. Additionally, this technology removes the need of outer wall supports, which makes it more suitable for urban environments.

Figure 39. Non-settling log (Pluspuu, 2017d)

- **CLT solid wood panels:** commonly found in multi-storey timber buildings, the technology of Cross Laminated Timber solid wood panels is particularly useful in ceilings and floors since they remove the need of supporting braces, shown in Figure 40.

Figure 40. CLT solid wood panel (Pluspuu, 2017d)

- **Solid logs:** obtained from thermal dried pine logs, shown in Figure 41. This traditional material for building log houses is referred by Pluspuu to be the most ecological construction material. This because there is no need for an extensive manufacturing process as well as the use of synthetic materials. The logs are likely to crack over time, which is a natural development that only affects the esthetical aspect of the building.

Figure 41. Solid logs (Pluspuu, 2017d)

- **Laminated logs**: preferably used in log house walls by several manufacturers, this material is less likely to show sights of cracks and residues over time. Lamella logs with no signs of horizontal joints on visible surfaces, shown in Figure 42, are offered to the customers by Pluspuu Talot.

Figure 42. Laminated logs (Pluspuu, 2017d)

- **Mitred corner joints:** offered aside with the traditional full-scribe joints, mitred corner joints, shown in Figure 43, remove the need of overlapping joints due to its thickness, weight and sealing performance. This makes them more suitable for the construction of log houses in urban environments.

Figure 43. Mitred corner joints (Pluspuu, 2017d)

(Pluspuu, Pluspuu: Log house structures, 2017d)

4.3.5 **Influencing factors**

The following chapter describes several influencing factors in the execution of Pluspuu Talot.

4.3.5.1 **Legislations**

The Finnish Government imposes legislation on the construction industry to ensure that the available information by the designers and developers is made in a reliable and comparable way, promoting the sales both in the Finnish market as well as abroad. Finland follows the EU Construction Products Regulation, applied in all the member states of the European Union. The basic requirements for construction products are related to resistance, stability, safety, hygiene, health, environmental impact, sustainability, accessibility, noise protection, heat and energy savings. These requirements also action as a foundation for the ETA, European Technical Approvals, a uniformed standard in the European Union. (Ministry of the Environment, Ministry of the Environment: Legislation on building products, 2016)

Housing design

Under this heading in the Finnish National Building Code one can find specific information about the housing design. It is stated that the design and construction of residential spaces are to be ensured to be done in a way that fits the purpose, while being pleasant and comfortable. The design needs to be developed according to the requirements of the residents, while being ready for various future changes in their needs and conditions. There is a demand to show that both environmental and natural factors are taken into consideration when choosing the

location of the building, its arrangement with the different spaces as well as other topics associated to the housing design (Ministry of the Environment, Ministry of the Environment: The National Building Code of Finland, 2017b).

The National Building code of Finland

The Finnish building procedure is specified in the Land Use and Building Act. More detailed, one can find here the overall guidelines for building, relating technical requirements, applying for a building permit and the construction supervision carried out by the authorities. The relating technical requirements section for the buildings address for example strength, stability, fire safety, accessibility and energy efficiency. There is also information available about the decision making in issues regarding guidelines in the use and maintenance procedures.

Traditionally, the regulations apply only to newly erected buildings, while for renovated and alternated buildings the regulations only apply when extended measures are taken - if no other specific regulation occurs. As the code is constantly being revised, the decrees are changing to better clarify in which class they will be applicable. (Ministry of the Environment, Ministry of the Environment: The National Building Code of Finland, 2017b)

According to the Ministry of the Environment, approximately 40 % of the country's energy consumption is traceable to buildings. There are currently energy legislations promoting efficiency and renewable energy sources to meet the European Energy Efficiency Directives, as well as Finland's own goals of reducing the country's energy consumption and carbon footprint. (Ministry of the Environment, Ministry of the Environment: Legislation on the energy efficiency of buildings, 2017c)

The decrees on building are going to be revised during the year 2018, with the objective to make the regulation of buildings more comprehensible, the application of it more consistent and predictable, and reduce the existing regulations to make it easily understandable (Ministry of the Environment, Ministry of the Environment: The National Building Code of Finland, 2017b).

4.3.5.2 **Geography**

Finland has the highest percentage of forest area within the EU, covering three quarters of the country's soil (Finnish Forest Association, Finnish Forest Association: Finnish forest resources, 2016a). Wood made from the Finnish forestry has a good status due to its quality and sustainable development value (Ollikaisen Hirsirakenne, Ollikainen: Incredibly ecological, 2017a). This means that geographically Pluspuu Talot and its manufacturing company Ollikaisen Hirsirakenne are both located in a suitable location for the kind of solution they offer.

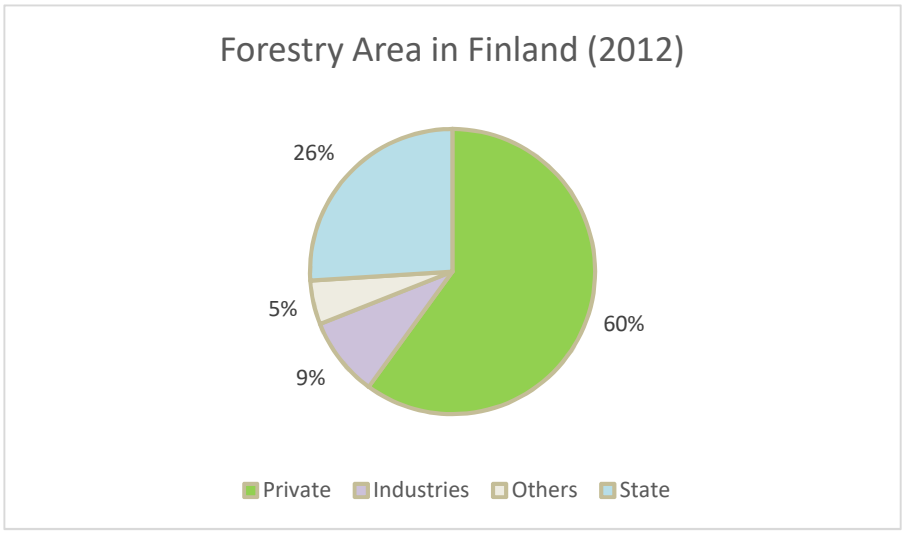


Figure 44. Share of the forestry area in Finland (Finnish Forest Association, Finnish Forest Association: Forest ownership, 2016b)

By 2012, most of the forestry area in Finland, approximately 60 %, was owned by private individuals and families. Normally a property consists of several owners sharing it. As noticeable in Figure 44, private industries held a 9 % share, other entities a 5 % share while the state held the resting 26 % of the Finnish productive forests land. The state-owned forests consisted of almost 50 % by protected forests, mostly situated in the northern part of the country. (Finnish Forest Association, Finnish Forest Association: Forest ownership, 2016b)

"Finland is one of the best areas in the world for tree growth. It belongs to the cold climatic belt in which sub-zero winters alternate with warm summers. The summer season lasts only 100 days, during which the trees grow. The short growing season means slow growth, which may last 60-120 years. […] The result is a hard, tough and straight-grained timber with low tension and few internal cracks. The low-resinous, evenly patterned Finnish wood is first-class material

for many purposes." (Wood Products, Wood Products: Strong wood from the northern coniferous forest belt, n.d.b)

The characteristics of the Finnish wood are a high resistance to various weather variations as well as being a natural breathing building material (Ollikaisen Hirsirakenne, Ollikainen: Incredibly ecological, 2017a). Since the country is located in the boreal coniferous zone, only a few tree species have been able to adapt due to the acid-poor soil. Most of the forests are a mix of several species, with approximately 50 % consisting of pine and the resting half dominated by spruce, downy birch and silver birch (Finnish Forest Association, Finnish Forest Association: Finnish forest resources, 2016a).

The Finnish productive forestland grows more than its harvested, which creates opportunities to diversify the usage of wood. However, harvesting opportunities are not fully taken advantage of, which might lead to a shortage of wood in the market, as well as the need to import the material, mainly from the neighbouring country Russia. (Finnish Forest Industries, 2017).

4.3.6 **Rating and Conclusion**

In line with the ReSOLVE framework created by the Ellen MacArthur Foundation, the following conclusions were drawn. Pluspuu Talot and its manufacturing company Ollikaisen Hirsirakenne cover the following four aspects of circular economy:

Regenerate Use of renewable and biodegradable materials, logs and wood, for their buildings.

Share Efficient design built to last. Logs are not permanently attached and easy to replace.

Optimise Simple jointing method, rapid building time, self-insulating logs and less waste in the production.

Loop Not yet discovered if aspects of remanufacturing, refurbishment, recycling are offered.

Virtualise No outspoken aspects of dematerialisation were found.

Exchange The use of new technologies such as non-settling logs and the CLT panels.

Pluspuu Talot achieved certificates from Tehty Suomessa (translated: Made in Finland), WWF Ystäväyritys 2017 (translated: WWF Friendly Company 2017) and is also a member of the Green Building Council Finland (Pluspuu, 2017a). Their manufacturing company Ollikaisen Hirsirakenne is awarded the Luotettava Kumppani (translated: Reliable Partner) and AAA highest credit rating by Bisnode (Ollikaisen Hirsirakenne, 2017a). However, both companies have neither LEED or BREEAM certificates at the moment and further information about future plans of achieving those certificated were not given.

4.3.6.1 **Conclusion**

Pluspuu Talot is a newly founded company that uses a local manufacturing company and as well as local products. They offer high quality, innovative products, that varies from small saunas up to fully suitable residences in a variety of options in order to meet the customer's demand.

Their line of products is all based on wood, a renewable material that offers characteristics such as insulation, ventilation and durability. The material is a natural choice for Pluspuu Talot and its manufacturing company Ollikaisen Hirsirakenne, as both companies are located in Finland, the European country with the highest percentage of forests.

Finland promotes energy efficiency and renewable energy sources, while also produces quality timber with a good reputation worldwide. The country promotes a building ethic that is reliable and comparable according to the EU Construction Products Regulation. Since there is a higher growth of the wood resources compared to the usage, Finland could enforce more incentives in order to boost the use of this renewable energy sources. After going through how possible legislation could affect the company, there was not found any particular one that would either promote or hinder Pluspuu Talot or neither its manufacturing company Ollikaisen Hirsirakenne. Still it remains unclear if Pluspuu Talot follows the Ecodesign Directive (2009/125/EC) and the Energy Labelling Directive (2010/30/EU).

Pluspuu Talot has some aspects of circularity, but since the lack of information and their unwillingness to answer questions, further statements about their actual circularity, their way of working and possible future development cannot be given at the moment.

4.4 Villa Asserbo

Villa Asserbo is a wooden residential house designed to be easy to produce, build, maintain and disassemble. The residence has been made from different segments, which all can be carried by just two persons. Each segment is created by a technique called 'Wood 3D printing', where a digital file can be uploaded into a CNC machine to create the different shaped parts. Combining all milled parts will create the segment, which is then assembled into a house using non-permanent methods.

Most materials are recyclable and energy efficient techniques are implemented to keep the environmental impact to a minimum. The cladding (outside wooden structure) is made of Nordic spruce and local veneer.

4.4.1 General information

Figure 45. Front Villa Asserbo (Eentileen, 2012)

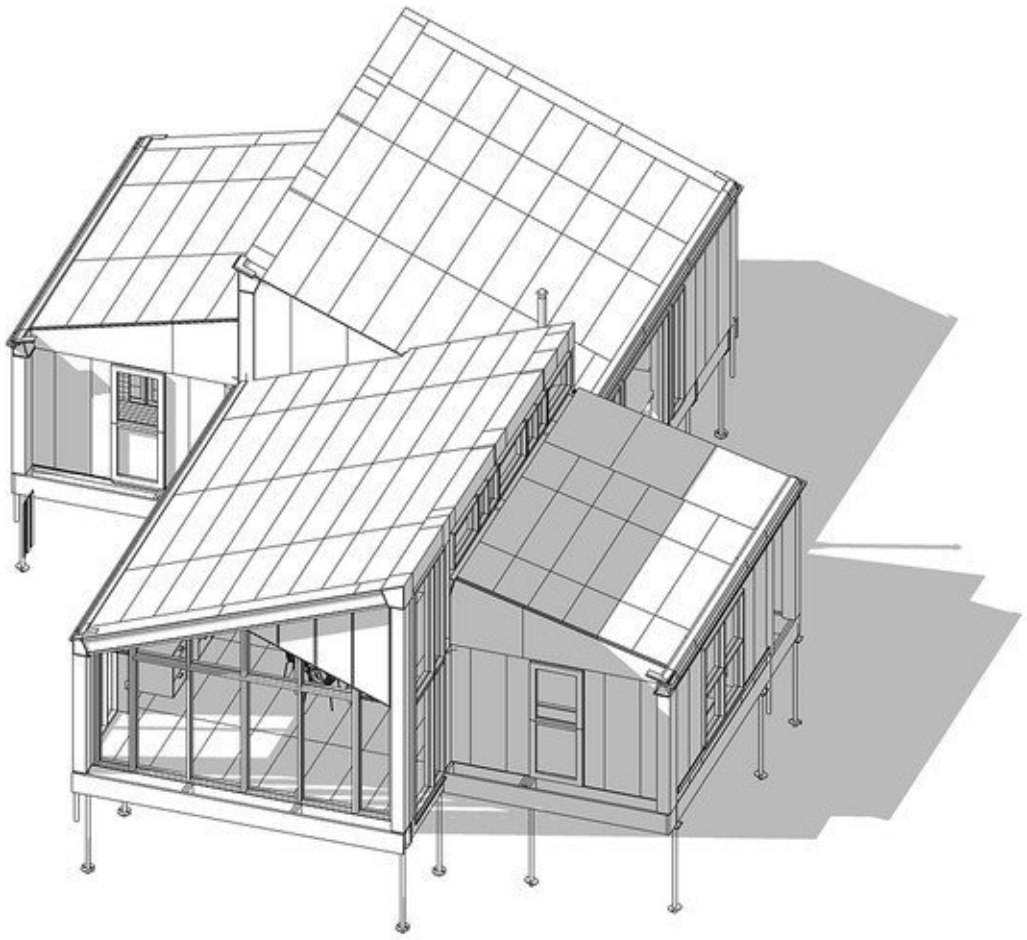


Figure 46. 3D model Villa Asserbo (Eentileen, 2012)

Location/ country:	Asserbo, Nordsjælland, Denmark
Construction year:	2011/ 2012
Architect(s):	Frederik Agdrup & Nicholas Bjørndal (Company: Eentileen, located in Kobenhavn, Denmark)
Manufacturer:	Facit Homes, located in London, Great Britain
Type of building:	Residential house
Area:	125 m^2
Tags (Resolve):	Regenerate, Optimise, Loop, Virtualise, Exchange

4.4.2 **Project goals**

The architects Nicholas Bjørndal and Frederik Agdrup, Facit homes and the customers had several goals for this project. The main goal is a house with the smallest environmental footprint as possible.

“We take the entire life cycle and all aspects of this into consideration – from the making of the house, to the habitation of the house and in the end the deconstruction and recycling of the house. this means our overall footprint is one of the lowest on the market.” stated by Nicholas Bjørndal to digital magazine Designboom (Designboom, 2013).

This should make it “the most sustainable house on the market,” according to Frederik Agdrup. (ASME, 2012).

The second main goal for this building was the capability to build the house with two persons and without heavy equipment.

“Another dogma for this project has been: no component of the construction is heavier than two men are able to carry it and the house can be built without the use of cranes or heavy machinery. This dogma does not only address the simplicity and innovative approach to designing for assembly, but gives way for several other perspectives on how to approach the global market. It is a highly adaptable system which is easily implemented in regions with limited resources. For example, improvement of housing conditions of 3rd world countries or recovery plans for regions hit by natural disasters.” stated by Frederik Agdrup to Designboom (Designboom, 2013).

Low energy consumption and the use of modular building components made from a 3D model with a CNC machine was also a goal which the builders achieved. The building is energy efficient, took six weeks to build and can be easily dismantled and recycled. Modularity in construction and buildings has great potential in transitioning to a circular economy, and this building could over time be a successful example.

4.4.3 **Supply chain**

Villa Asserbo is a small and compact house, which is designed to be built anywhere with a CNC machine nearby. Secondly, the building is designed to be 100 % recyclable through the use of sustainable materials such as wood, glass and steel. The aim is to have minimum impact on the environment when used and even when built.

This all results in a limited amount and size of supply chains. Also, since the villa is planned to be built on demand, big supply chains are not in place because of this low volume production.

The building uses several components/materials from manufacturers, such as WISA Plywood (Building material), Superwood (Cladding), Warmcell (Fibre isolation), Kronetag (Olivine roofing) and NKT fasteners (connections). All these materials are made to be recycled, but no recycle partners except for WISA plywood are known. WISA plywood is willing to take the waste wood leftover from production back, and recycle it to make new plywood (UPM, 2011).

More information about the specific materials used and new technologies can be found in the next chapter ‘Biological and technical cycles’.

4.4.4 **Biological and technical cycles**

Villa Asserbo has several interesting solutions to namely reduce its impact on the environment during building and usage. The noteworthy solutions are: modular segments made of 100 % recyclable wood, 100 % recycled fibre insulation, regenerative roof lining, and non-permanent foundation.

4.4.4.1 **Modular segments**

Figure 47. Modular segments and building process (Eentileen, 2012)

Villa Asserbo is fully digitally designed, with modular segments and building, as shown in Figure 47. Four types of segments are used, namely 'wall, roof, floor and header' types (ASME, 2012). These segments are created by using a CNC machine, which uses sliced 3D models to create G-code which then guides the machine. The CNC machine is fed multiple sheets sequentially to improve production speed.

This stacking of sheets can be interpreted as printing (adding layer after layer), which would make this process 3D wood printing. However, this process is not additive (adds material), but subtractive (removes material) due to milling. The amount of waste from milling is however at a minimum, through usage of the high precision CNC machine and the return policy on waste wood with the plywood supplier (UPM, 2011).

4.4.4.2 **Building material**

The goal for Villa Asserbo is to be 100 % recyclable. This is achieved by using wood as the main building material. The foundations, the segments and the cladding are all made of sustainable wood with the FSC certificate.

The main building material is WISA spruce plywood, shown in Figure 49, which besides a FSC certification also received a PEFC (sustainable foresting) certification (WISA plywood, 2017). The wood used for the cladding are the SW4 boards from the company Superwood (Superwood, 2017), shown in Figure 48. The company Superwood has received the EU environmental award for being one of Europe's most environmentally friendly companies (Superwood, 2017).

Figure 48. SW4 boards as cladding (Superwood, 2017)

Figure 49. WISA spruce plywood (Superwood, 2017)

4.4.4.3 **Insulation**

The insulation of the building is blown cellulose fibres from the company Warmcel, shown in Figure 50. These fibres are made from 100 % recycled newspapers. The newspapers are collected from offices, schools, overruns from printing companies and kerbside collections. The manufacturing process from newspaper to fibre uses very little energy which combined with the material choice gives Warmcel an extremely low GWP (Global warming potential) of 0,106 kg CO_2/kg . Average GWP for commonly used insulation is 1,2 kg CO_2/kg for mineral insulation and 3,0 for SPF (Spray Polyurethane Foam) (Buildinggreen, 2010). GWP means the overall influence of the insulation on the planet by comparing CO_2 produced by production of the material against the CO_2 savings from using it.

Figure 50. Warmcel insulation fibres (Warmcel, 2017)

4.4.4.4 **Roofing**

The roofing of the building is made out of the material Olivine (iron-magnesium silicate) provided by the company Kronetag. The DERBICOLOR Olivine roofing, shown in Figure 51 uses the material Olivine to neutralize CO_2 when it rains. The rain will bring the CO_2 in contact with the Olivine to create a residue made out of sand (silicon dioxide) and magnesium carbonate, which are both harmless to the environment (Derbigum, 2017).

Figure 51. DERBICOLOR FR Olivine roofing (Derbigum, 2017)

4.4.4.5 **Foundation**

The foundation of Villa Asserbo is made of 28 steel helical micro piles, installed by Facit homes. The screw piles are expected to be from the company ABC Anchors, since a similar project to Villa Asserbo, built in September 2012 by Facit Homes, was featured in Grand Designs (ABC anchors, 2012).

The used piles are presumably the 60R conical screw piles from ABC Anchors, shown in Figure 52, which allow for easy placement and removal. This means no permanent structures are required for a stable foundation of the villa.

Figure 52. 60R conical screw piles from ABC Anchors (ABC anchors, 2012)

4.4.5 **Influencing factors**

The following chapter describes several influencing factors in the execution of Villa Asserbo.

4.4.5.1 **Legislation**

The legislation for buildings may have an impact on the ease of implementation of CE. Therefore local, regional and national legislation will be researched for possible influencing factors.

The legislation in Denmark applies to both Villa Asserbo and De Fire Styrelser. Therefore, this chapter will be split up into general building legislations and a conclusion with the influences of these legislations on the building. The general building legislations will only be added in the Villa Asserbo best practice case.

General legislation

Denmark has the Danish building regulations (BR10, BR15 and BR20). BR10 first appeared in 2010, BR15 in 2015, BR20 will be enforced in 2020. The regulations target residential and commercial sectors, specifically energy consumption.

These building regulations aim to reduce total greenhouse gas emissions by 40 % compared to Denmark in 1990 (Federane, 2014). BR20 aims for a reduction of 75 % compared to 2006, and additionally, Denmark aims to have a 100 % renewable sourced energy and transport system by 2050 (StateofGreen, 2017). Every building regulation has specific requirements for maximum energy consumption and losses true transmission, conduction and radiation. These requirements can be seen in Figure 53.

	Class 2010	Class 2015	Class 2020
Maximum energy demand/year (residential) HFS in the building's heated floor space in m²	52.5 kWh/m2 + 1650 kWh/ HFS	30 kWh/m2 + 1000 kWh/ HFS	20 kWh/m^2
Maximum energy demand/year (non-residential)[1] HFS in building's heated floor space in m²	71.3 kWh/m² + 1650 kWh/ HFS	41 kWh/m² + 1000 kWh/ HFS	25 kWh/m^2
Max. air leakage/second (test pressure 50 Pa)	1.5 l/m2	1.0 l/m2	0.5 l/m2
Max. design transmission loss[2], single-storey	5 W/m²	4 W/m²	3.7 W/m²
Min. energy gain[3] through windows/glazed walls	-33 kWh/m²year	-17 kWh/m²year	0 kWh/m²year

[1] includes demand for lighting
[2] Average heat loss through 1m² of the non-transparent parts of the building envelope at 20°C inside temperature and -12 °C outside.
[3] Solar heat gain minus heat loss through 1 m² of window (facing south-east) during a standard Danish winter.

Figure 53. Requirements BR10, BR15 & BR20 (Federane, 2014)

Energy consumption for residential buildings will include (according to BR20): "heating, domestic hot water, ventilation, electricity for operating the building (fans, pumps, etc.) and potential penalty for overheating" (Wittchen & Kragh, 2016). Non-residential buildings will have a fixed value of 25 kWh per m² which also included lighting (Federane, 2014).

These regulations met certain difficulties during their implementations such as a lack of interest or a lack of knowledge from the targeted sectors. Also, the potential cost savings might be dwarfed by other potential cost savings within the building or company and therefore lack strong incentive for investment. (Federane, 2014). Statistics however show the reduction of energy consumption matching (delayed) the building regulations, shown in Figure 54.

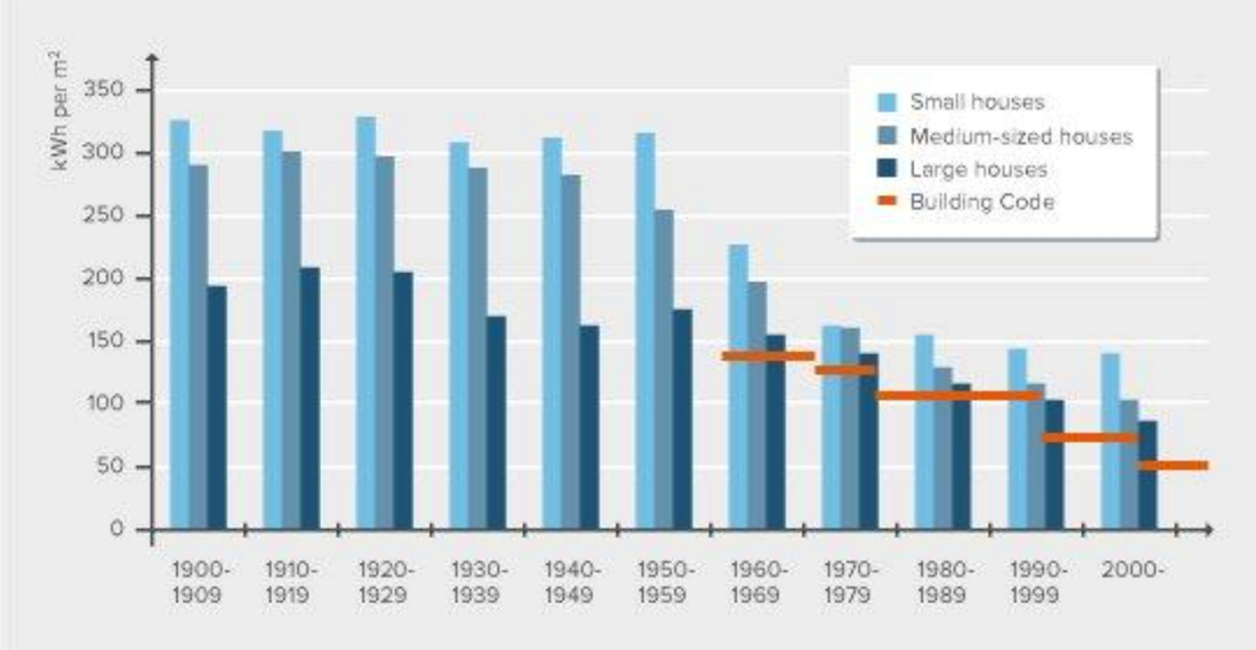


Figure 54. Energy consumption compared to building code requirements (IEA, 2008)

The building regulations include:

- proper usage of the building and its materials;
    - protection against collapses, pests and radon particle has to be implemented besides safety for loads and health;
- dimensioning structures to withstand normal static and dynamic loads;
- designing foundations safe enough to withstand frost and dynamic loads;
- selection of materials to resist conditions of the climate;
    - including moisture sensitive materials, to prevent mold;
    - using quality assurance procedure to guarantee optimal quality of the materials;
- usage of materials with moisture build up;
- building tents smaller than 50 m^2.

(Trafik-, Bygge- og Boligstyrelsen, 2017)

The building regulations contain a number of specific rules/guidelines for moisture/water control. Preventive measures must be applied concerning water damage to structural parts and possible health issues to occupant true condensation, outside water and moisture, groundwater, snow, melt water and general wet area's (bathroom, utility rooms and toilets). (Trafik-, Bygge- og Boligstyrelsen, 2017).

The EU also provides guidelines for designing, constructing and maintaining buildings, which are implemented into the building regulations. The most important norms for buildings in Denmark are:

- DS/EN 1990 Basis of structural constructions;
- DS/EN 1991 Densities, self-weight and imposed loads for buildings;
- DS/EN 1991-1-2 Fire load;
- DS/EN 1991-1-4 Wind load;
- DS/EN 1991-1-5 Thermal load;
- DS/EN 1991-1-7 Accidental actions;
- DS/EN 1995-1-1 General rules and rules for buildings;
- DS/EN 1995-1-2 Timber structures, fire design.
- DS/EN 1993-1 Steel structures
    - DS/EN 1993-1-1 Steel structures, general rules for buildings;
    - DS/EN 1993-1-2 Steel structures, fire dimensioning;
    - DS/EN 1993-1-3 Steel structures, additional rules for cold-formed elements and cladding;
    - DS/EN 1993-1-4 Steel structures, additional rules for stainless steel;
    - DS/EN 1993-1-5 Steel structures, plate construction;
    - DS/EN 1993-1-6 Steel structures, strength and stability of shell structures;
    - DS/EN 1993-1-7 Steel structures, strength and stability under transverse load;
    - DS/EN 1993-1-8 Steel structures, collections;
    - DS/EN 1993-1-9 Steel structures, fatigue;
    - DS/EN 1993-1-10 Steel structure, Material toughness and through-thickness properties.

(Trafik-, Bygge- og Boligstyrelsen, 2017)

No information on differences between regional, local and national legislation can be found. The tasks on regional and local level are enforcing, providing support and were possible adapting the regulations. This differs from national level, where the regulations are created and changed. (ECOtech, 2016).

The legislations in Denmark have several influences on Villa Asserbo. Firstly, building with wood is difficult in Denmark due to the regulations on moisture and water damage. Wood is more susceptible which means it is harder to meet the set requirements for moisture compared to more permanent materials such as steel, bricks and concrete.

Secondly, energy consumption regulations are consistently increasing. These regulations can work as a stimulant to improve the efficiency of a building. It can also increase the need for new and more efficient technological solutions, which might fit the current linear market model better than a circular one.

Lastly, the building needs to be designed for a minimum life span of 20+ years. The life span can be reached through durable materials or by maintenance. Material science shows that highly efficient materials are more expensive and in general have a shorter life span with the same amount of maintenance. Circular economy entails upkeep of the efficiency of a building through maintenance and refurbishment, which will be harder and more expensive when these materials need to be designed for optimal efficiency and set life span. Therefore, a medium will have to be found in the materials' lifespan and the efficiency, which is not optimal.

4.4.5.2 **Geographical influences**

Villa Asserbo is located in Asserbo, Nordsjælland in Denmark. Nordsjælland is one of the three big islands, along with Funen and Vendsyssel-thy in Denmark. Nordsjælland is positioned in the east part of Denmark, close to Sweden.

4.4.5.2.1 Physical geography

Physical geography contains information about the natural environment. This includes among other things: oceanography, hydrology, geomorphology, climatology and biography (Wiki, 2017). This chapter will contain the most important factors for buildings, namely the climate and the typography.

Climate

The Nordic countries cover around 3,5 million km^2 and have a very large variety in climates. Denmark has, with its relative southern location, a moderate climate. This climate is also caused due to the high number of waterbodies around Denmark. Denmark is enclosed by the Atlantic Ocean in the west and the Baltic Sea in the east. The Atlantic Ocean with its Gulf Stream brings warm ocean currents from the coast of Florida towards the West Nordic countries.

This results in mild winters and cool summers, with temperatures between -5°C and +30°C. Consequently, little snow cover during winters and relative cool summer are common. This reduces the need for specific building requirements, such as snow retention and guard systems or UV protection windows and high airflow cooling systems. This neutral climate with little temperature fluctuation allows for a highly insulated building where cooling and heating can be kept to a minimum.

Typography

The land in Denmark is in general flat. This makes it easy for building and transport as well as cultivation of the ground. 11 % of the Denmark's area is covered by forest for a total of 4860 km^2, with 69 % of this located on the mainland of Denmark and the remaining 31 % on the islands. Near Asserbo, in the Nordsjælland, is the Gribskov forest located with an area of 55.00 km^2 (Wiki, 2017). Asserbo is located less then 5 km away from the Danish straits, which creates a slightly salty environment (30 parts per 1000) which has to be taken into account when building (Britannica, 1998).

4.4.5.2.2 Human geography

Human geography contains information about the human environment, with includes several aspects such as human, political, cultural, social and economic ones. The most important aspects for building are the economic, development and transportation geography.

Economy

The economy of Denmark shows a 1,2 % growth each year, with an unemployment rate of 6,3 % (heritage, 2017). This places Denmark 14 in the EU rank list for GDP (gross domestic product) (International montary fund, 2016). Denmark has one of the lowest poverty rates in EU in 2014 with a ratio of 0,05 on a population of 5,6 million (OECD, 2014). The average income per working inhabitant is € 40,000, which places Denmark among the top 5 of the highest incomes in the EU (Wiki, 2015). Denmark can therefore be considered a well-developed and prosperous country. Consequently, this cannot be considered a negative influence on investments into circular economy.

Transportation

Denmark is a country with a good transportation system, where most parts of the country can be easily reached. Denmark has been promoting the usage of bicycles, public transport and walking over the usage of a car, which has resulted in a low rate of car usage of 29 % in 2015 (State of green, 2015). Thus, Denmark can be considered to have an advanced and clean mobility and which has little to no effect on the building process of this building.

4.4.6 Rating and conclusion

The building is rated using the ReSOLVE framework, from the Ellen MacArthur Foundation, to conclude which aspects of CE are covered in this building.

Regenerate One of main goals for Villa Asserbo was having a small footprint on its environment. This has been achieved through the use of recyclable materials, such as FSC certified wood, steel removable screw piles as foundation and olivine roofing.

Share Villa Asserbo has used, like most buildings, maintenance to prolong its lifespan and maintain its efficiency. The modular design allows for (slightly) easier upgradability compared to conventional buildings.

Optimise Waste of materials during the construction process and low energy consumption are achieved by accurate building through the use of a high precision CNC machine.

Loop Most of the building materials in Villa Asserbo are meant to be recycled and re-used in either a similar building or down-cycled into other uses.

Virtualise The building plans for Villa Asserbo are fully digital, which removes the need for physical plans and documents.

Exchange The new production technology in this building is the 3D wood printing, which uses a CNC machine to precisely mill all sections for the modular segments and can be combined with on-site production.

Villa Asserbo was set out to become an environmentally friendly building where every facet of the building has been optimised. Impact during production has been reduced through the use of 3D wood printing with an on-site CNC machine. The modular design allows for little waste and removes the need for heavy equipment. The modular building segments also allow for efficient and easily adjustable and upgradable buildings, which can also be disassembled easier.

The screw pile foundation removed the need for a solid permanent foundation and makes it possible reduce the environmental impact after the building has been dismantled. All building materials are recyclable which further reduces its overall impact on the environment.

Villa Asserbo is the first commercial modular 3D wood printed building in the world, and shows the possibilities from this promising concept. This concept of a 3D wood printed building allows for more modular and customizable designs, while 3D printing with other materials opens even more possibilities. Supply chain and re-use sharing is not applied to this building, which could be an opportunity to make this building even more suited for a circular economy.

More detailed research has also shown the influences from geography and legislations on the building. Denmark has a very favourable environment and climate to build this specific building, and is economically in a good position to move forward to a more circular economy. The legislations in place both harm and stimulate building with new materials, since the moisture prevention laws are strict and make building with wood difficult. Efficiency regulations do stimulate/ force investments into more efficient buildings. No information could be found on official sustainability ratings.

4.5 De Fire Styrelser

'De Fire Styrelser', official name being Nexus CPH, is built to be the hub for the Danish traffic council, Danish road directorate, Rail Net Denmark and the DEA (Danish Energy Agency). The building is designed to be flexible, future-proof and provide a healthy working environment.

Besides offering working space for the before mentioned authorities, there are also green walkways, a café, a restaurant, a service centre and a conference and education centre in the building. Light and an abundance of glass allow for a warm and comfortable environment improving the experience for its occupants.

(Arkitema, 2014).

4.5.1 General information

Figure 55. Exterior 'De Fire Styrelser' (Arkitema, 2014)

Figure 56. Interior 'De Fire Styrelser' (Arkitema, 2014)

Figure 57. Progress building (A.Enggaard, 2015)

Name:	Nexus CPH
Location/ country:	Kalvebod Brygge, Copenhagen, Nordsjælland, Denmark.
Construction Year:	2014
Architect:	Arkitema Architects, located in Copenhagen, Denmark
Manufacturer:	MOE, located in Copenhagen, Denmark
Contractor:	Caverion, headquarters located in Helsinki, Finland
Type of building:	Office
Area:	43.000 m^2
Tags (Resolve):	Share, Optimise, Exchange

4.5.2 **Project goals**

De Fire Styrelser was commissioned by the Danish property agency with the one of the requirements being: a new office building as a PPP (Private Public Partnership) project (Bygningsstyrelsen, 2017).

This form of cooperation includes design, construction, operation, maintenance and financing as tasks for the contractor (Wiki, 2017). Efficiency of the building in a PPP project is a main priority for the contractor, because a higher efficiency equals the opportunity for higher profits. This leads to the usage of more durable and energy efficient materials, compared to traditional buildings. Therefore, initial costs will be higher and should be earned back over the complete lifecycle of the building. This leads to: investments into efficiency improving solutions, flexible design and easier to maintain solutions.

Another requirement for the building was to provide a healthy working environment, flexible enough to change to the needs of its occupants and the possibility to be easily upgraded in the future. Energy efficiency was another goal to keep running costs and environmental impact as low as possible. An impressive design would also allow it to be a visual marker when entering or leaving Copenhagen, given its location near one of the mayor entrance roads of the city in Kalvebod Brygge.

The selection of the contractor was based on the lowest possible offered price, which met all set requirements and meets as many optional requirements as possible. The building is currently being constructed, so besides the proposed plans little to no additional information is available. These plans however indicate that most requirements will be met.

4.5.3 Supply chain

The supply chain for De Fire Styrelser is designed as a PPP project. The user will have an agreement with the contractor for a set price for usage of the building. This form of contracts is relatively new, and information is scarce regarding the PPP agreement for this building. However, known is the certain risk the contractor takes by agreeing to a PPP contract. Therefore, an extensive SWOT analysis is useful to outline the threats within the project, for example pre-contact risks, buildings risks (building site, design, construction and commissioning risk), financial risks, operating risks, user based risks, legislative risks and building specific risks (AusAID, 2009).

The contractor for the De Fire Styrelser is the company Caverion (former YIT and ABB electric), which specializes in designing, installing and servicing of energy efficiency technical solutions for buildings, infrastructure, industrial plants, marine and offshore. Caverion provides electrical, plumbing, ventilation, cooling, security and automation installations (Dagensbyggeri, 2015). The agreement to build and maintain the technical installations is for 25 years, with sustainable solutions being the main focus to have the lowest possible LCC (Total Lifecycle Cost) for the building (Dagensbyggeri, 2015).

Subcontracting is the responsibility of the contractor, which includes the architectural firm Arkitema for designing the building and engineering firm MOE.

4.5.4 Biological and technical cycles

The technical and biological cycle of a product encloses every step from production to disassembly. The eventual goal is a biological cycle where the material is harvested, manufactured into a product, being used for as long as possible and then returned to the biosphere with minimum damage. The technical cycle should provide solutions which prolong the life of a product to the maximum and reduces damage from usage to its environment.

De Fire Styrelser focuses predominantly on durability, flexibility and efficiency, due to the PPP contract which is explained in the chapter Project goals. This focus is clearly visible in the construction method of the building. The materials are also planned to be recycled after deconstruction, to reduce environmental impact and costs (KEA, 2016).

The building is constructed to have load bearing facades, several supporting concrete cores, stairs and elevators to support the floors and roof. This allows for an open workspace due to the lack of vertical supports. It also allows for easy upgradability of the building, since the floor is not load bearing.

The floors and the roof are made of hollow 400 mm thick pre-stressed slabs, shown in Figure 58, which are loosely positioned in between the facades, merging points of the wings of the buildings and cores. This allows for slight movement to counter heat influences and movement within the structure. (DEPA, 2015).

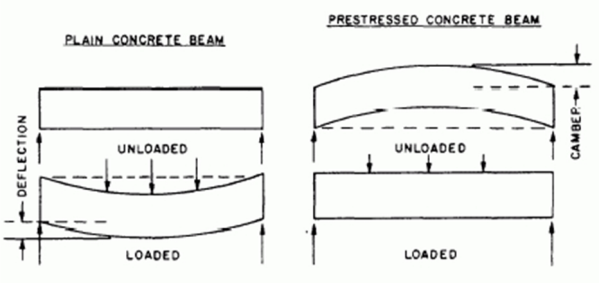


Figure 58. Non-stressed vs Pre-stressed slab (Wellsconcrete, 2017)

Efficiency is increased through the use of solar panels, which lowers the total energy consumption of the building (Nordicpropertynews, 2016). The windows are made of wood, aluminium and composite to offer a renewable, low maintenance and well insulated solutions. Other possible solutions (inclusion of solutions cannot be proven, since the building is still in construction) are rainwater collection, low energy consuming light sources and a green roof (Molio, 2015). The building meets the Danish BR20 regulations, and can therefore be classified as a low energy building (Bygningsstyrelsen, 2017).

The last noteworthy feature of the building is the inclusion of smart technical installations from Caverion, which uses digital and automated solutions. These solutions provide an efficient and optimized installation for both consumption and durability.

4.5.5 **Influencing factors**

The following chapter describes the influencing factors in the execution of De Fire Styrelser.

4.5.5.1 **Legislation**

The legislation for this building may have an impact on the ease of implementation of CE. Therefore local, regional and national legislation will be researched for possible influencing

factors. This specific building is located in Copenhagen, Nordsjælland, Denmark, similar to Villa Asserbo. The general legislation of Denmark can be found in chapter Villa Asserbo 'Legislation'.

The legislations in Denmark have several influences on De Fire Styrelser. One of them is the energy consumption regulations proposed in the building regulations. These regulations can both work as a stimulant or a deterrent, since the building needs to be updated to meet the new regulations every five years. De Fire Styrelser was set out to meet the BR20 regulations, and is therefore very efficient.

A second influence is the large number of guidelines for designing steel structures in buildings. Added to this are extra rules for occupant safety, fire safety, technical installation requirements and minimum strength requirements which all heavily influence the building process of an office building in general. These regulations could impair circular solutions, which could make it a deterrent.

Lastly, a building is designed with a certain lifespan in mind, which can be achieved through durable materials and/ or maintenance. The balance between costs, durability and efficiency can be proven to be difficult. It either requires large amounts of technology and resources or compromises to achieve the set life span at maximum efficiency as circular economy (Optimise) would entail.

4.5.5.2 **Geographical influences**

De Fire Styrelser is located in Copenhagen, in Denmark. This consequently means the influences from geography will be the same as for Villa Asserbo.

4.5.6 **Conclusion and ratings**

The building is rated using the ReSOLVE framework, from the Ellen MacArthur Foundation, to conclude which aspects of CE are covered.

Regenerate De Fire Styrelser makes use of solar panels, incorporates a park in the building and has green roofs.

Share The building has been designed to be upgraded and flexible though the use of loadbearing facades and supporting cores which allows for open workspaces and removable floors.

Optimise Efficiency is one of the main focus points due to the PPP (Public Private Partnership) contract. This leads to low-energy technical installations with digital controlling for maximum efficiency.

Loop Most of the building materials are meant to be recycled, to regain a large amount of the initial investment back after deconstruction.

Virtualise This building has no new specific virtualize aspects. (The building is designed and tested digitally for energy usage and different loads. This practice is however commonly used in new buildings.

Exchange PPP agreements are uncommon, but have a great potential to create a circular business model.

De Fire Styrelser was designed with the PPP agreement in mind. This means the use of efficient systems and materials to reduce the LCC as much as possible, since the responsibility for the functioning of the entire building will be for the contractor Caverion. The lower LCC outweigh the higher initial costs, which means the PPP agreement acted as a stimulant to investments in energy efficient systems, such as solar panels, energy efficient windows and rainwater collection. The building complies to the building regulations BR20 and can therefore be considered a low-energy building.

Flexibility and upgradability are also important aspects of this building, since they prolong the effective life of the building and allow for higher occupation rates. The load-bearing facades and supporting cores allow for open workspaces and relatively easy to replace/ move floors. These open workspaces should allow for a more healthy and inspiring working atmosphere.

More detailed research has also shown the influences from geography and legislations on the building. Denmark has a very mild environment and climate which makes it easy to build, combined with its good economical position allows Denmark to move forward to a more circular economy. The building is one of many circular projects from the government and initiatives to create a more sustainable environment in Denmark. The Danish legislations both harm and stimulate building with new materials, where efficiency regulations stimulate/ force investments into more efficient solutions and buildings. No information could be found on official sustainability ratings.

4.6 Park 20|20

Park 20|20 C.V. is a business park (Figure 59) located in Hoofddorp, close to Amsterdam Schiphol International Airport, in the Netherlands. “It is the first fully operational cradle to cradle work environment” according to park 2020 (Park 20|20, 2010), developed by Delta Development Group, VolkerWessels and Reggeborgh Groep (Park 20|20, 2010). The business park incorporates different circular solutions such as buildings that are designed for disassembly, the use of solar panels, heat and cold storage, wind orientation and ventilation, a “closed loop” water-management system on site, green roofs and nature sites. The main focus of this project, besides its cradle to cradle aspect, is the human well-being of its occupants. It aims to be an “inspirational environment that stimulates the creativity and effectiveness of employees by creating safe and healthy places for work and recreation.” (William McDonough + Partners, 2010).

Al buildings are BREEAM or LEED certificated as can be seen in Figure 60, which also shows the EPC value of some building. The EPC value describes the energy consumption per square meter of a building per year in kW / m^2. (Hebbes, 2017)

A project called ‘Valley’, developed by the same groups as Park 20|20, has started nearby with the goal of becoming “the first circular business development hub in the world” (Valley, 2015).

4.6.1 General information

Figure 59. Park 20|20 (William McDonough + Partners, 2010)

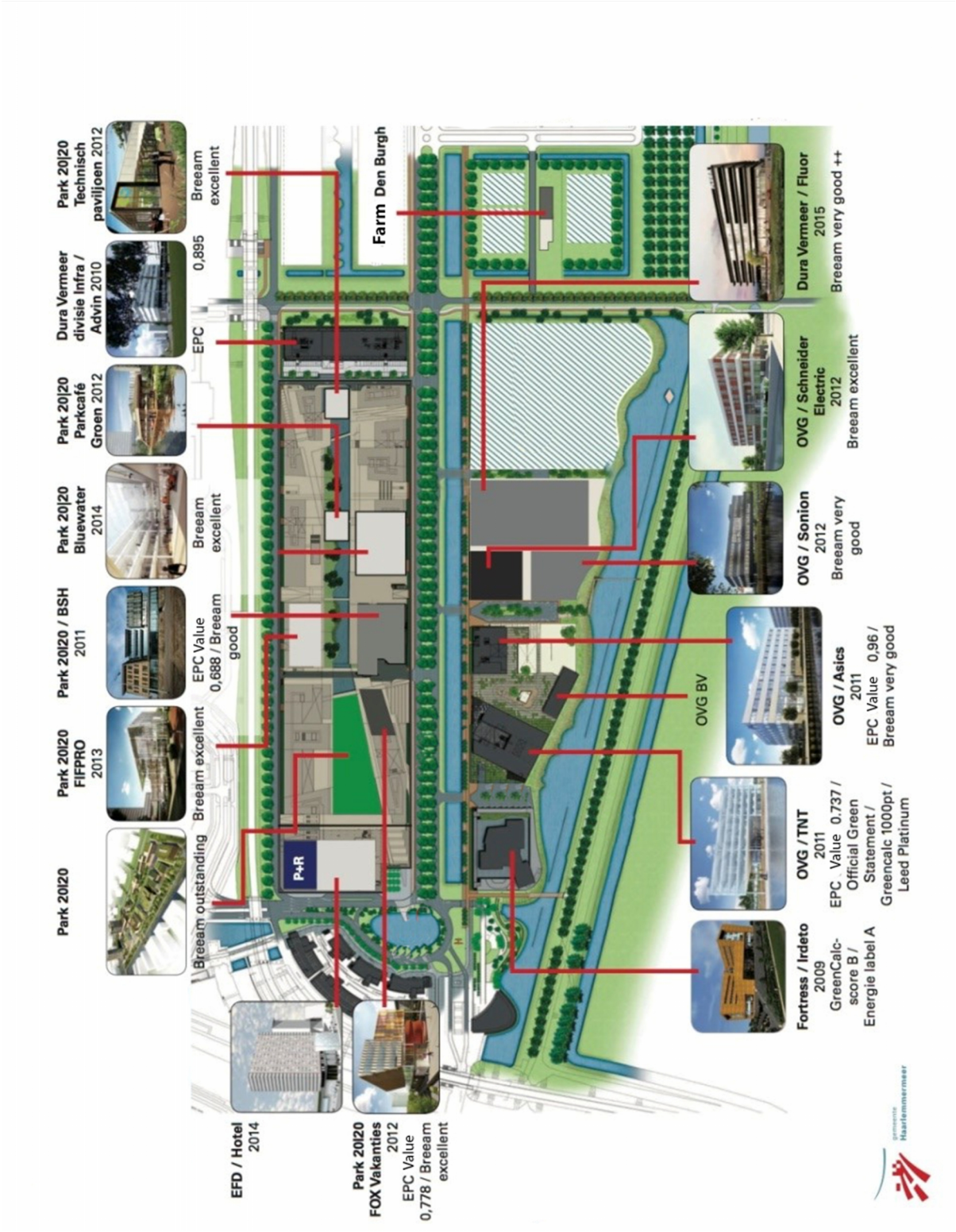


Figure 60. Buildings in Park 20|20 and their certificates (Van Der Meer, 2015)

Name:	Park 20|20 C.V.
Location:	Hoofddorp, Netherlands
Construction year:	Started 2009. Expected to be completed in 2017
Client:	Delta Development Group
Master planning:	William McDonough + Partners
Landscape architect:	Nelson Byrd Woltz
Project executors:	VolkerWessels
	Reggeborgh Group
	Delta Development Group
Type of building:	Office Building
Area:	114.000 m^2
ReSOLVE tags:	Regenerate, Share, Optimise, Loop, Virtualise, Exchange
Link:	http://www.park2020.com/

4.6.2 **Project goals**

The developers of Park 20|20 are aiming to become the first fully Cradle to Cradle (C2C) Business Park in the Netherlands (William McDonough + Partners, 2010). Apart from that, they wish to design a work space that encourages employees' creativity and performance, leading to increased productivity and less absence. Their method to become C2C is by leasing products and returning them after use, which is an effective economic model to lower the purchase value of a building and to implement the latest innovations. (Park 20|20, 2010) The goals of Park 20|20 include increasing the surrounding area's economic viability, attracting and retaining workers, supporting connectivity with nearby communities and reducing the region's traffic congestion by transit-oriented development.

To support environmental sustainability, the developers aim to increase biodiversity and regional natural connectivity, use renewable and passive energy strategies, eliminate waste, and extend the lifetime and residual value of buildings. (Asla, 2010) The C2C concept aids many of these goals by making designs for disassembly, material passports, using biodegradable materials, and reusing and recycling materials. (William McDonough + Partners, 2010)

As the developers of Park 20|20 want to stay on top of latest sustainable developments, they cooperate with other organizations, NGOs and universities in an innovation platform. The goals of this platform are to further increase renewable energy use, save more water by increased cleaning and filtration, and increase the amount of materials that can be recycled or reused. (William McDonough + Partners, 2010).

4.6.3 **Supply chain**

Park 20|20 was founded by three partners: Delta Development Group, VolkerWessels and Reggeborgh Group. This collaboration has previously proved successful in the re-development of the former Fokker industrial facility into the sustainable Fokker Logistics Park located in Schiphol, Netherlands. (William McDonough + Partners, 2010)

The architects responsible for the masterplan of Park 20|20 are William McDonough + Partners, together with the Dutch architectural firm N3O. William McDonough is the author of the book 'Cradle to Cradle: remaking the way we make things'. (Park 20|20, 2010).

Site and architectural design of Phase I commenced in 2009 and is utilizing C2C protocol for material specification. Construction of the first building began March 2010. (Asla, 2010)

Delta Development Group

Delta Development Group (Figure 61) is an independent, internationally operating property developer. Since 2012, Delta's office is located at Park 20|20. Delta is a pioneer in the field of sustainable and Cradle to Cradle developments. The company has invested a lot of energy and time in knowledge-gathering, sharing and innovation through research and various other collaborations.

Delta has practical examples in their portfolio, such as feasible housing, offices and logistics business premises that point profitable business cases. The company also has a vision on quality of living and working. (Duurzaamgebouwd, 2017).

Figure 61. Delta Development Group (Park 20|20, 2010)

VolkerWessels

VolkerWessels (Figure 62) is a Dutch concern with around 120 companies and 15.000 employees. They are active in three market sectors: construction & real estate, infrastructure & energy & telecom. They develop, design, build, finance, manage, operate and maintain for their stakeholders: clients, financiers, employees, suppliers and society in a broad sense. It is a company that utilizes opportunities and introduces sustainable innovations.

Figure 62. VolkersWessels (Park 20|20, 2010)

Reggeborgh

Reggeborgh (Figure 63) is a private investment company based in Rijssen, which invests mainly in construction, real estate, fiberglass, financial services and energy.

Property investments are based in the Netherlands, Germany and Canada. Reggeborgh is involved in the entire property value chain: finance, purchase, development, construction, investment, asset management and property management.

Figure 63. Reggeborgh (Park 20|20, 2010)

William McDonough + Partners

Originally from the United States, William McDonough (Figure 64) is an internationally recognized author, architect and designer, who specializes in sustainable development and the circular economy. He is the founder of the architecture and planning firm William McDonough + Partners, the principal designer of Park 20|20. Together with Michael Braungart he co-founded MBDC, a C2C consulting firm, and other non-profit organization that allow further cradle to cradle thinking, such as GreenBlue and the Cradle to Cradle Products Innovation Institute.

Figure 64. William McDonough + Partners (William McDonough + Partners , 2017)

Municipality of Haarlemmermeer

The master planning process involved consultation with municipality planners (Figure 65) to ensure that Park 20|20 respected the regional and municipal master plans. Community interests were represented in the review and approval process, including policy and technical review by appropriate Aldermen and the City Council. Park 20|20 master plan received unanimous approval by the City Council of Beukenhorst in June 2009.

(William McDonough + Partners, 2010).

Figure 65. Gemeente Haarlemmermeer (Gemeente Haarlemmermeer, 2017)

Material suppliers

Finding C2C material suppliers was not easy, as there were very few suppliers that had C2C-certified materials available. After asking 72 suppliers to provide products close to being C2C materials, they found 41 suppliers that either had C2C-certified materials or were confirmed to supply adequate alternatives where no C2C materials existed (Scott, 2014). With these suppliers, several long-term relationships and contracts were developed, to allow for product leasing arrangements. This way, suppliers are encouraged to take responsibilities for their materials, and to return nutrients to their appropriate cycles. (William McDonough + Partners, 2010).

Contractors

Different organizations were involved in the success of Park 20|20.

- **Arizona State University**: Investigated the impact of the workplace on employee productivity.
- **TU Delft**: Provided solutions for the processing of biological waste in the park and the treatment of grey water.
- **Ellen MacArthur Foundation**: Information on the application of the circular economy in the urban area.
- **Dutch Green Building Council**: Certification of buildings.
- **C2C Products Innovation Institute**: Provided training courses to stimulate certification of Cradle to Cradle products.

  (Park 20|20, 2010).

4.6.4 **Biological and technical cycles**

The following paragraphs will outline achievements that are realised in Park 20|20 concerning the integration of circular economy in their buildings as well as other relevant achievements.

4.6.4.1 **Cradle to Cradle**

The materials used in Park 20|20 are as much C2C-certified as possible. For a material to be C2C-certified, it must meet strict standards regarding environmental friendliness, health for users, reusability, technical and biological cycles, and the honesty of the production process (Park 20|20, 2010). Biodegradable materials such as food, fibre and wood are used. Technical materials are reusable in another life such as metals, glass and plastics (William McDonough + Partners, 2010). The amount of certified products applied at Park 20|20 increases every year through research and innovation (Park 20|20, 2010).

An example of C2C design in buildings would be parts of the building that are seen as "technical nutrients" rather than ultimately a waste product. These technical nutrients can be reused after they have fulfilled their current purpose, which greatly increases the value of said product. For example, a steel beam in a building is still in usable conditions 15 years. (Scott, 2014).

All buildings of Park 20|20 were equipped with window panes from AGC, the only C2C glass manufacturer in Europe, which reduced the average cost (per unit) of furnishing (C2C-Centre, 2017)

Figure 66 shows the C2C materials used in the buildings of at ark 20|20.

Xero-Flor®
Moss Sedum
(zilver gecertificeerd)

Accoya® Wood
(goud gecertificeerd)

RHEINZINK®
Cladding
(zilver gecertificeerd)

Alcoa, Inc.
(zilver gecertificeerd)

AGC Glass
(zilver gecertificeerd)

Royal Mosa
Floor and Wall
Tiles
(zilver gecertificeerd)

Daas Baksteen
Zeddam BV
ClickBrick®
(goud gecertificeerd)

Espacio Solar
DEPLOSUN®
Glass Top Sun Tube
(zilver gecertificeerd)

Derbigum® DERBIPURE
White Roofing
(basis gecertificeerd)

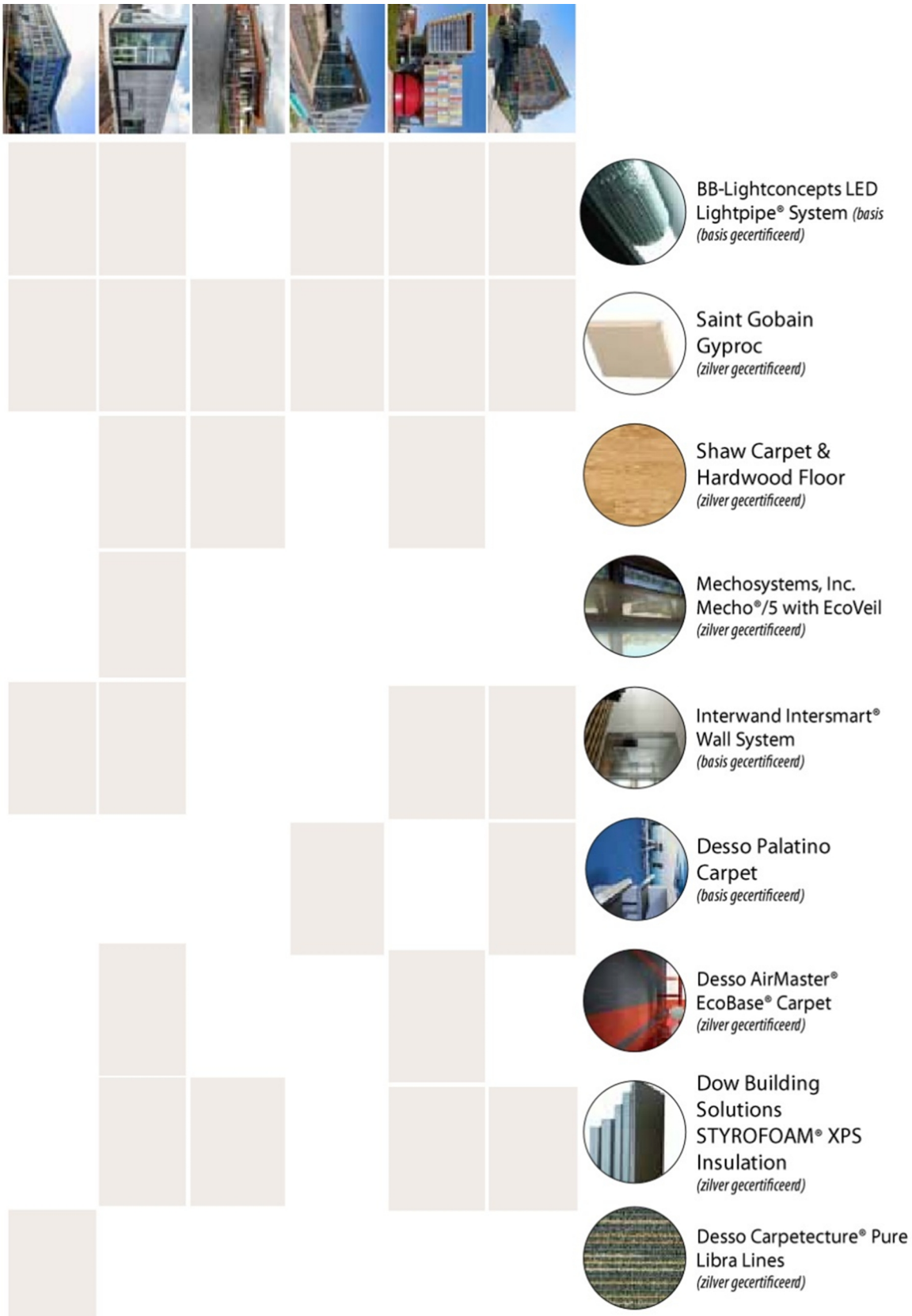


Figure 66. Buildings and C2C materials used at Park 20|20 (C2C-Centre, 2017)

4.6.4.2 **Design for disassembly**

As stated before, disassembly is an important part of the circular economy and therefore of Park 20|20. The buildings are designed to be easily disassembled or reconfigured, which allows for innovation. For example, if an innovative technology to save more heat energy would be developed that involved changing windows, these could easily be replaced in the buildings at Park 20|20. This applies to nearly all parts of the buildings, which allow the buildings to keep their value over time and preventing them from becoming outdated. In this way Park 20|20 adequately considers future technological innovations in its current design. (Scott, 2014) Detailed plans are kept describing the exact materials used and where they were placed. The design also included reducing the weight of buildings, to allow for easier replacement and effective reuse of products in other production processes or as new raw material (C2C-Centre, 2017).

4.6.4.3 **Solar energy**

In Park 20|20, solar energy is used as part of the solution to become fully sustainably powered. Green roofs equipped with PV (PhotoVoltaic) (Figure 67) arrays provide the community with a renewable carbon-free energy source. The plants used on the roofs reduce surface temperatures.

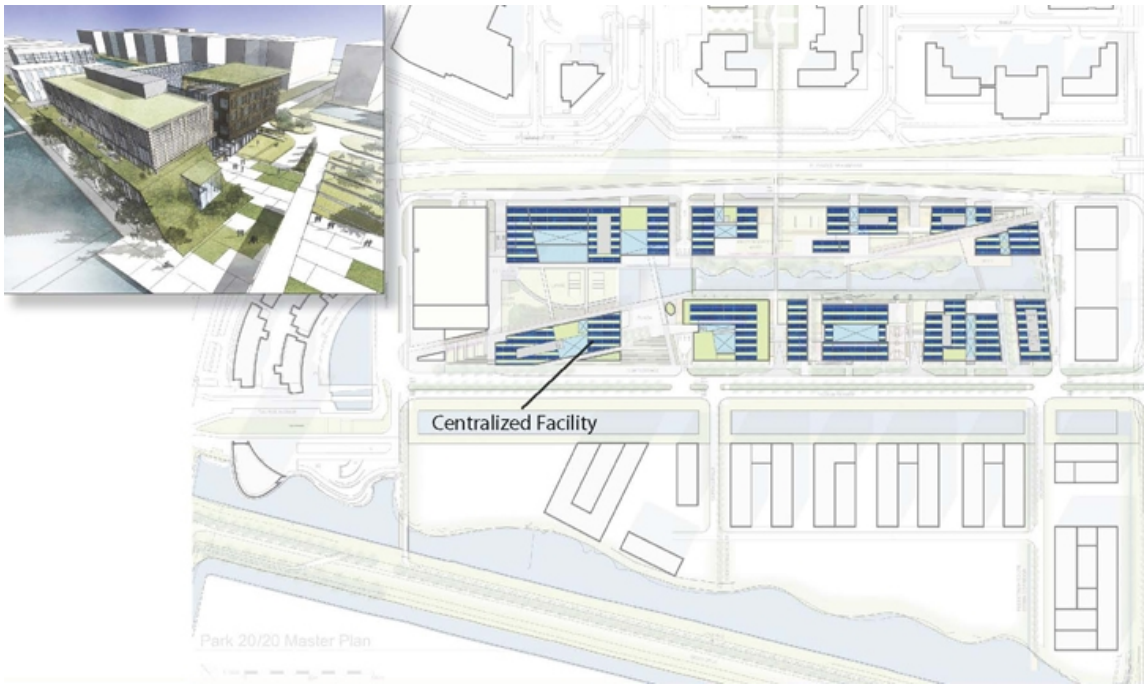


Figure 67. Map of photovoltaic arrays surface in Park 20|20 (Asla, 2010)

For optimal building placement, a solar path diagram was made (Figure 68), which maps the path of the sun through the day and year to determine optimal solar orientation. This enabled the developers to angle buildings in a direction that maximized sun exposure during winter and shade during summer (Asla, 2010). To ensure optimal daylight use for the green roofs and the buildings' interiors, size and mass of the buildings were adjusted accordingly. Also, by installing monitoring systems transparency of energy consumption patterns was created, which allows for the possibility of further energy saving (William McDonough + Partners, 2010).

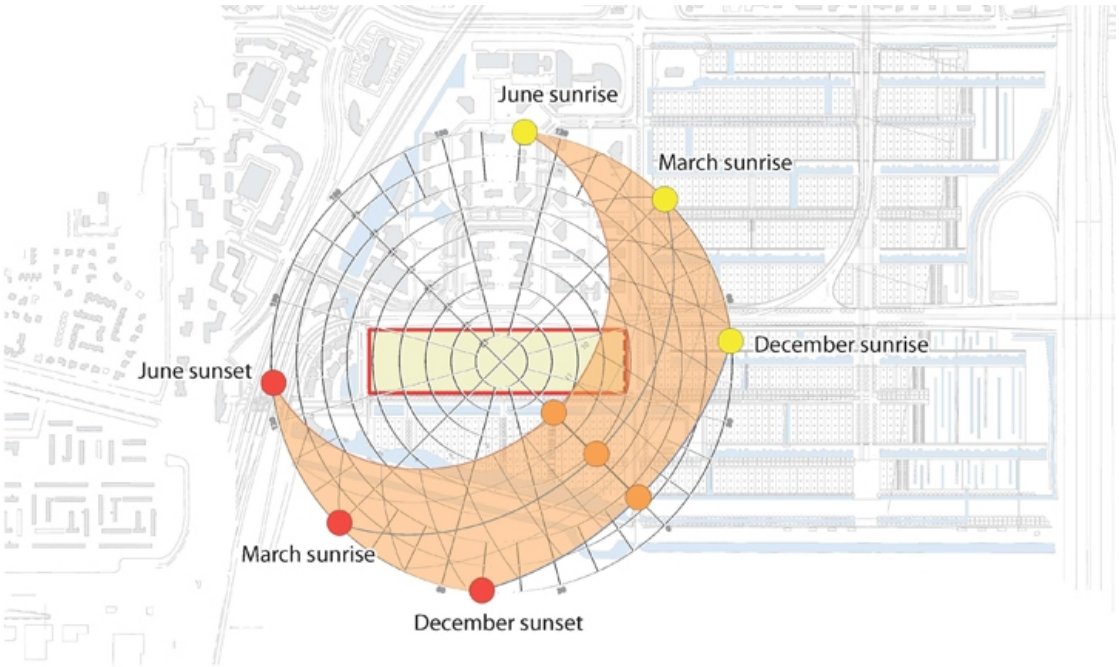


Figure 68. Solar path diagram (Asla, 2010)

4.6.4.4 **Hot and cold storage**

To regulate the temperature Park 20|20 uses geothermal heat pumps. During the summer, cold water stored underground is used to cool the building through a loop of pipes, which is piped back into the storage once it has become too warm. During the winter the process is reversed, as warm water is used to heat the building, returning cold to the basin. (Singhal, 2014).

4.6.4.5 **Water purification**

At its core, Park 20|20 uses a 'closed loop' water-management system to treat and reuse wastewater (Figure 69). To accomplish this, a building's wastewater is directed to a central treatment facility where it is purified with helophyte filters and then re-circulated to buildings for use in toilet flushing. Heat generated in the process is used to create hot water for the area's hotel. The solar-powered water treatment facility reduces waste and water usage by 90 %. (C2C-Centre, 2017).

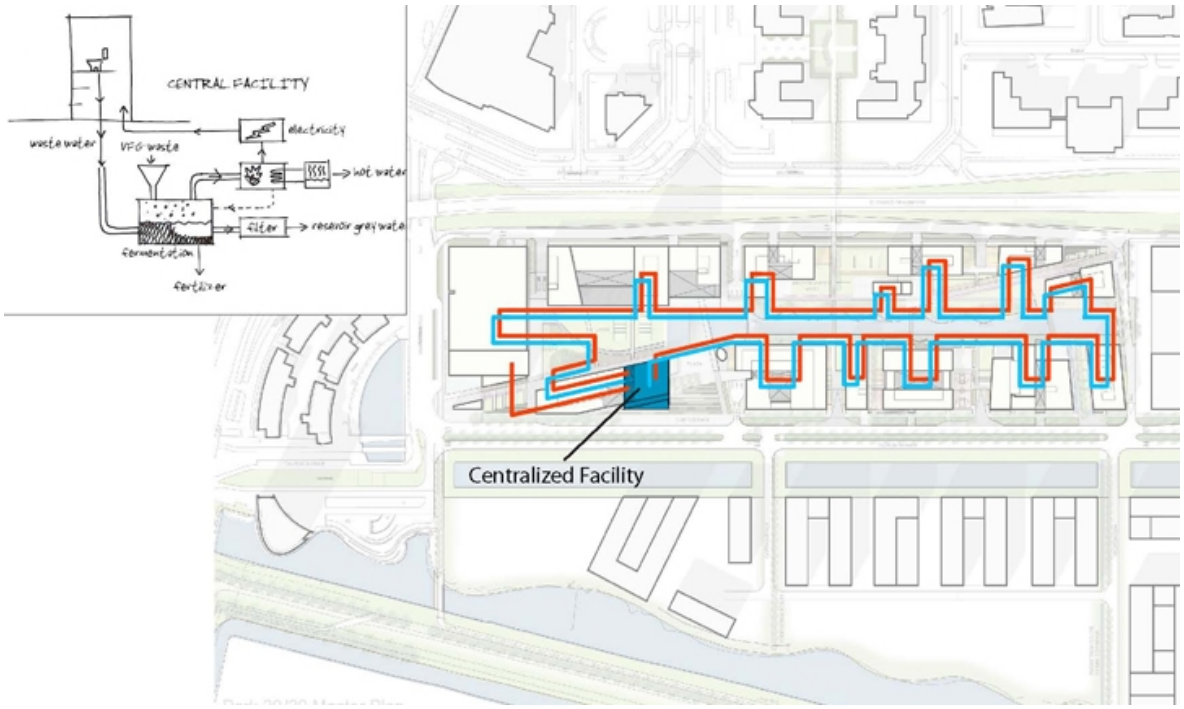


Figure 69. Waste water, heat and power system (Asla, 2010)

Green roofs absorb rainfall and increase biodiversity. Runoff and overflow are directed to on-site storage (Figure 70).

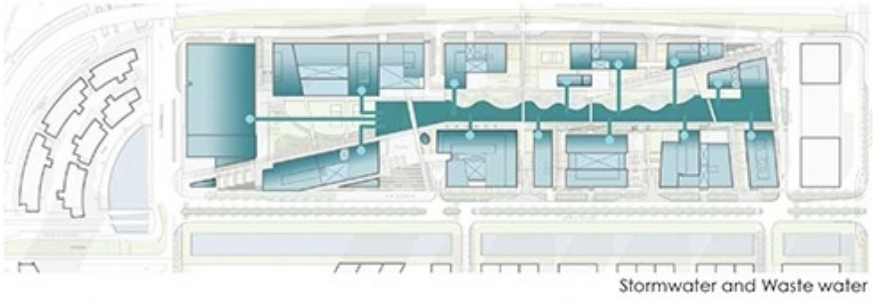


Figure 70. Storm water and wastewater (Asla, 2010)

The wastewater treatment is part of Park 20|20 agenda of waste-free design, which is in line with the C2C principles. This agenda also includes the capturing of energy and soil amendments, and eliminating sewage discharge.

(William McDonough + Partners, 2010) (Asla, 2010)

4.6.4.6 **Wind orientation**

Wind is used as a passive energy reduction strategy. A wind rose diagram was made to determine the wind speeds on-site for building ventilation strategies (Figure 71), and to determine the speed and direction of winds in winter for optimal protection strategies. This reduces energy demand and provides fresh air for human well-being. (Asla, 2010).

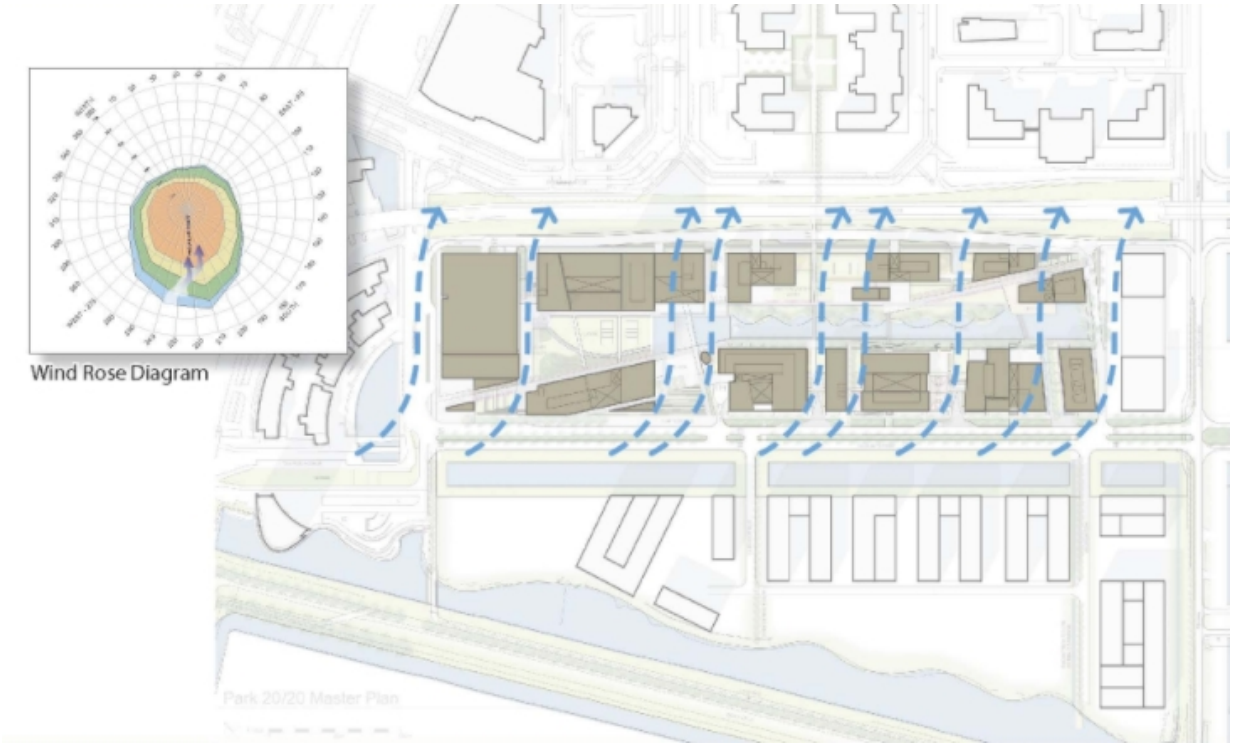


Figure 71. Wind and Ventilation (Asla, 2010)

4.6.4.7 **Regeneration of the environment**

To increase biodiversity and create a healthy ecological environment, Park 20|20 has constructed an environmental plan that aims to establish clean and healthy water flows, improve air quality, increase photosynthetic productivity, build healthy soils in greater quantities than before development, and increase connectivity between ecological landscapes (Figure 72).

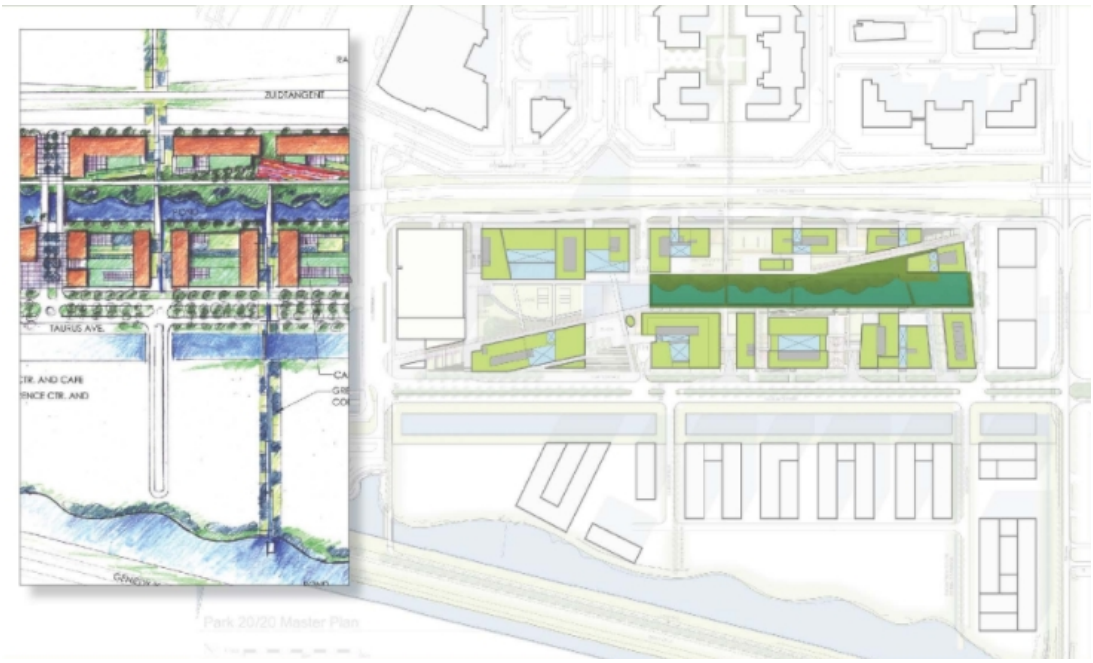


Figure 72. Ecology and biodiversity (Asla, 2010)

The landscape plan combines the municipality's design of rational, quadrated streetscape planning with informal and diverse greenery in the internal canal garden, but also ensures the planning of Park 20|20 is respectful of regional 'cultural landscape' and the template of the 'polder grammatical'. The plan's introduction of diverse plant palettes creates biologically robust gardens, and connects these interior gardens with the regional natural environment through landscape corridors. It also creates additional green areas on roofs and parking decks. Altogether, the addition of these green environments increases photosynthesis, insulate buildings, stores carbon dioxide, produces oxygen, builds soil and biomass, and filters air and water. Furthermore, flowering plants have a positive effect on human well-being, and the on-site wetlands and gardens allow birds to nest, rest and feed. (Asla, 2010) Part of the green vegetation is a butterfly garden, a bee garden and a vegetable garden for urban farming (Figure 73).

Figure 73. Urban garden Park 20|20 (Park 20|20, 2017)

As the Netherlands have a unique canal system that includes flooding and water level stabilization, it had to be made sure that the landscape plan of Park 20|20 did not drastically alter the regional aquatic environment, which is why polder water management was studied. (William McDonough + Partners, 2010).

4.6.4.8 **Human well-being**

The architecture of Park 20|20 is people-oriented and aims to support its occupants' well-being by creating elegant, well-lit interiors that ensure a good connection between employees and available daylight. The buildings of glass and steel with integrated greenery, modern installation techniques and high-quality finishes also supports creativity and inspiration and is aimed to be user-friendly. Apart from this fresh, clean air should be available to everyone, to increase comfort, productivity and health. On top of this, inhabitants are protected from harmful exterior elements such as noise, pollution, mould and infestations of any kind. Thanks to the present interior gardens, the environment encourages relationships between nature and man-made communities. The materials used present no negative effects on either the environment or humans, and are therefore safe to use indefinitely. All this is part of Park 20|20's belief that a good business park can be beneficial to human well-being in many ways, while still promoting environmental health and sustainability.

(Park 20|20, 2010) (William McDonough + Partners, 2010).

4.6.5 **Economic viability**

Delta is engaged in the development of models for valuation and construction to make C2C buildings economically attractive. Some of the aspects that contribute to financial success are:

- **Quality of the buildings**: helps the buildings to be sold quickly to at a higher price (from € 135 per m^2 for € 210 per m^2). The Bosch Siemens Home Appliance Group office and product showroom was sold in 2011 with a 23 % return.
- **Increase in productivity**: around 5 % is measured after a one-year internal review of the Bosch Siemens building showing. This results in a major saving for tenants.
- **Financial lease**: of materials for buildings in which the material suppliers remain owners. The results in lower upfront cost due to payment for use instead of ownership.
- **Involvement of building engineers**: early in the design process reduced the construction cost by about 20 %.
- **Reduced average cost for grey water recycling**: by sharing the cost of grey water purification over several units.
- **Site-wide heating & cooling**: results in lower cost of mechanical installations for each building.
- **Site-wide capacity to use e.g. solar panels**: reduces initial cost for the hardware.

Costly testing and conducting an efficient supply chain was a barrier in realising profitable C2C buildings. However, this only needs to be done once.

(Scott, 2014) (C2C-Centre, 2017)

4.6.6 **Influencing factors**

The following chapter describes several influencing factors in the execution of park 20|20.

4.6.6.1 **Legislations**

Legislation in general hindered the execution of the project, due to resentment of municipalities to change legislations (Van Der Meer, 2015) and leasing agreements of building materials which impede with project ownership legislation (Scott, 2014).

4.6.6.2 **Know-how**

Regarding the know-how of the involved parties, a couple of influencing factors can be stated:

- The good understanding of the economic, social and environmental advantages of C2C encourages the stakeholders.
- The concept of C2C is perceived as abstract which hindered the understanding of it.
- The project schedule was extended due to the need for target reconstruction, costs caused by the financial crisis, and the time-consuming search for right material suppliers and C2C material innovation processes.
- Stakeholders of C2C building do not yet always have the same expert knowledge as non C2C stakeholders.
- Information on required stakeholders for C2C buildings was not always available.
- Effective communication between stakeholders of C2C buildings stimulates the implementation.
- Training for suppliers and users were organized at Park 20|20, which stimulates cooperation and network processes towards C2C building.

(Van Der Meer, 2015)

4.6.6.3 **Stakeholders and supply chain**

According to the thesis of Van Der Meer, the following factors were determined about the supply chain and among stakeholders that influenced the project:

- Beforehand it was not clear whether the project would be successful. This lack of thrust in the project hindered its development.
- The municipality did not approve the infrastructure planning of Park 20|20 in the beginning.
- Stakeholders did not feel comfortable to work with new partners in the beginning.
- The cooperation of national architects with a foreign specialist in C2C design stimulated the project.
- The collaboration of different parties such as engineers, developers, contractors, municipality, users, suppliers and architects had a positive influence on the project.
- The integration of the building sector in the design process resulted in a turbulent process in the beginning.
- Learning and innovation has been an important aspect in the process where C2C materials where not always available.
- The buildings sector is not always motivated to rethink their way of working.

(Van Der Meer, 2015).

4.6.7 **Rating and conclusion**

Park 20|20 has high ambitions on circularity through its C2C design approach. Using sustainable materials, advances installation techniques, air purification, ergonomic and appealing design, daylight and green elements, a healthy and inspiring work environment is created. The buildings protect the users from elements such as noise, mould and infestations.

According to the ReSOLVE framework, Park 20|20 covers the following aspects of CE:

Regenerate	Green roof, water flows, nature sides with species diversity and optimized linkage of site landscape are used to increase and regenerate regional ecosystems. The embedded nature sequesters carbon, makes oxygen, builds soil and absorbs, filters air and water.
Share	The buildings are designed for disassemble to allow for reconfiguration and reuse the materials, increasing the residue value.
Optimise	Water waste is reduced by 90 % through the use of a “closed loop” water-management system.
Loop	For the construction of the buildings C2C materials were used. However not all materials meet the standard since the supply of Cradle to Cradle materials is not yet sufficient.
Exchange	Renewable energy and energy efficiency is achieved through the use of photovoltaic arrays, heat and cold storage, as well as wind orientation for ventilation.

Influencing factors such as changes needed in regulations and laws required for C2C building were hindering the adoption of CE. Regarding the know-how of the parties involved it can be concluded that the concept of C2C was perceived as abstract, which hindered the understanding. There has also been a lack of knowledge, both in expertise and the knowledge about the required stakeholders. However, good training stimulated cooperation and network processes towards C2C building. The fact that stakeholders felt uncomfortable working with new partnerships combined with the building sector being traditional and conservative, discouraged companies to rethink their practices in terms of C2C. Park 20|20 covers buildings with different levels of BREEAM certificates, from very good to excellent as can be seen in Figure 60.

4.7 Bionorica Headquarter

Bionorica AG (Aktiengesellschaft, in English: stock corporation) is a German company situated in southern Bavaria. It was founded 85 years ago (in 1933) and by now it has developed to "one of the leading global manufacturers of herbal medicines" (Bionorica SE, 2017). The new headquarter in Neumarkt, Germany was built in 2007 combining innovative energy technologies and intelligent materials. The company itself states about the building: "The new company headquarters is one of the most sustainable office buildings in Europe and thus an expression of the company philosophy being put into practice. […] [It] represents a milestone in construction with reference to ecological effectiveness, environmental friendliness and health compatibility for the employees" (Bionorica SE, 2017).

Figure 74. Bionorica SE (Bionorica SE, 2017)

4.7.1 General information

Figure 75. Bionorica Headquarter (Bionorica SE, 2017)

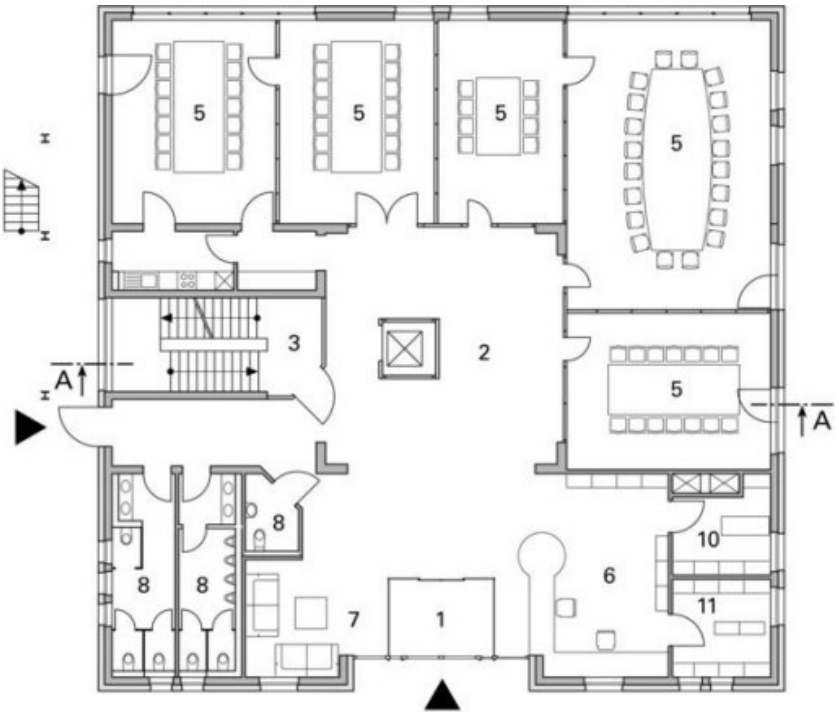


Figure 76. Bionorica Headquarter - Ground plan of first floor (bba, 2008)

Name:	Bionorica Headquarter
Location:	Neumarkt, Germany
Construction year:	2007
Architect:	Wolfgang Brummer (company: Brummer und Retzer, located in Amberg, Germany)
Manufacturing company:	See chapter 'Biological and technical cycles'
Type of building:	Office Building
Area:	Approximately 480 m^2
Tags:	Regenerate, Optimise, Loop, Virtualise, Exchange
Link:	http://www.c2c-centre.com/project/bionorica

4.7.2 **Project goals**

Located in Germany, Bionorica AG is a leading global manufacturer of herbal medicines. They therefore have energy demanding manufacturing processes and extensive clinical and pharmaceutical studies. Energy saving, and energy production was one focus, but the overall aim was a building that contributes to the environment. It had to be in harmony with nature as sustainability is a main part of the company's philosophy. The new headquarter had to express this in practice.

The aim was not to build another low energy house or a building that focuses only on one aspect of sustainability. "The construction and the materials used for this purpose were to cause as little burden on the environment as possible" (C2C centre, 2017).

To reach this goal special toxic free concrete, air filtering colours, recyclable textiles and dismantable furniture were used. (For more information about the technical solutions, see chapter 'Biological and technical cycles')

4.7.3 **Supply chain**

The building is meant to be completely recyclable. Therefore, special materials and products were used to build the headquarter. Outstanding are the carpets and windows which are only leased and will be returned to the supplier after a specific time (see Figure 77).

The furniture is designed for disassembly and recyclable to high percentage. Even the textiles used are meant to go back in a loop and be part of a new product again. For all non-recyclable materials Bionorica has a take-back guarantee. (Braungart, Cradle to Cradle Design, 2012)

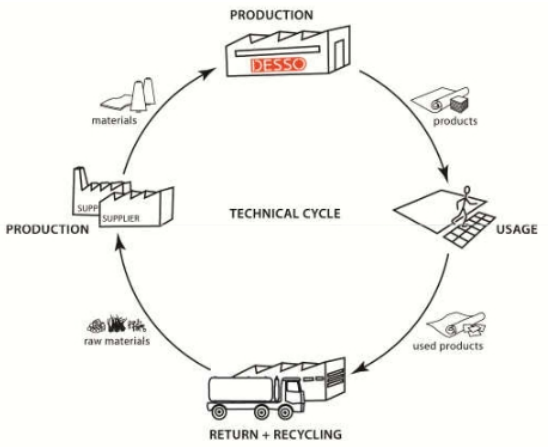


Figure 77. Example: supply chain carpets (Braungart, Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe, 2014)

4.7.3.1 **Summary of companies involved**

Figure 78 shows some companies that were involved in the project and supplied cradle to cradle or environment friendly products. A more detailed list of companies and their contribution to the building is given in Table 6.

.

Figure 78. Manufacturing companies involved (Braungart, Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe, 2014)

Table 6. List of companies involved

Company	Contribution	Company logo
Art aqua	Water walls and green walls	**Figure 79. Art aqua (Art Aqua, 2017)**
Backhausen	Recyclable interior textiles	**Figure 80. Backhausen (Backhausen, 2017)**
Desso	Dust control flooring	**Figure 81. Desso (DESSO, 2017)**
Elektro Lück	Lighting design	**Figure 82. Elektro Lück (Elektro Lück, 2017)**
EPEA	Ecological material evaluation	**Figure 83. EPEA (EPEA, 2017)**

Farmbauer	Heating, sanitation and ventilation	**Figure 84. Farmbauer (Farmbauer, 2017)**
Grammer Solar	Contributions to solar roof	**Figure 85. Grammer Solar (Grammer Solar, 2017)**
Heidelberg Cement	Defined concrete additives	**Figure 86. Heidelberg Cement (Steelguru, 2017)**
Herman Miller	Air and skin-safe furniture	**Figure 87. Herman Miller (Herman Miller, 2017)**
Korsche Metallbau GmbH + Co. KG	Façade construction	**Figure 88. Korsche Metallbau (Korsche Metallbau, 2017)**
MSCN - Martin Stanscheit Corporate Navigation	CI (corporate identity) consultancy	**Figure 89. MSCN (MSCN, 2017)**

Schüco	Photovoltaic windows and skylights	**Figure 90. Schüco (Schüco International KG, 2017)**
Xeroflor	Interior and exterior vegetation	**Figure 91. Xero flor (Xero flor, 2017)**
ZAE Bavaria	Thermal building simulation	**Figure 92. ZAE Bavaria (ZAE Bayern, 2017)**

4.7.3.2 **Construction planning**

The Bionorica Headquarter was planned by a cooperation of several companies. "A thermal building simulation was carried out by the Centre for Applied Energy Research in Bavaria (ZAE), and plant engineering was also tested" (ZAE Bayern, 2017). Also, special about the project is "that the entire energy technology was not divided up into the individual specialist planners. Ventilation, heating, refrigeration, electrical and solar technology were grouped under a single bracket and then divided into individual departments" (bba, 2008).

4.7.4 **Biological and technical cycles**

Figure 93 shows some examples of special cradle to cradle principles realized in the Bionorica Headquarter. In the following chapter the biological and technical cycles of products and materials used for the building are explained. The chapter is divided into several subchapters according to the areas (e.g. 'construction base', 'inside', 'outside') of the building.

Figure 93. Added value (C2C BIZZ, 2014)

4.7.4.1 **Construction base**

The Bionorica headquarter is built of materials whose production and use do not pollute nature. The building is PVC (Polyvinyl chloride) free. The steel does not contain any rare non-ferrous metals. The processed concrete of Heidelberg Cement is free of nitrogen oxides and organic hydrocarbons. The concrete additives do not contain heavy metals and halogen compounds. The cement was made without using substitute fuels to ensure low natural radioactivity (bba, 2008). The nitrogen pollution in the air is even reduced by the so called 'TioCem': nitric oxide from the ambient air is converted into nitrate (NO_3^-) which is washed as a nutrient in the soil when it rains (see Figure 94). (Braungart, Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe, 2014)

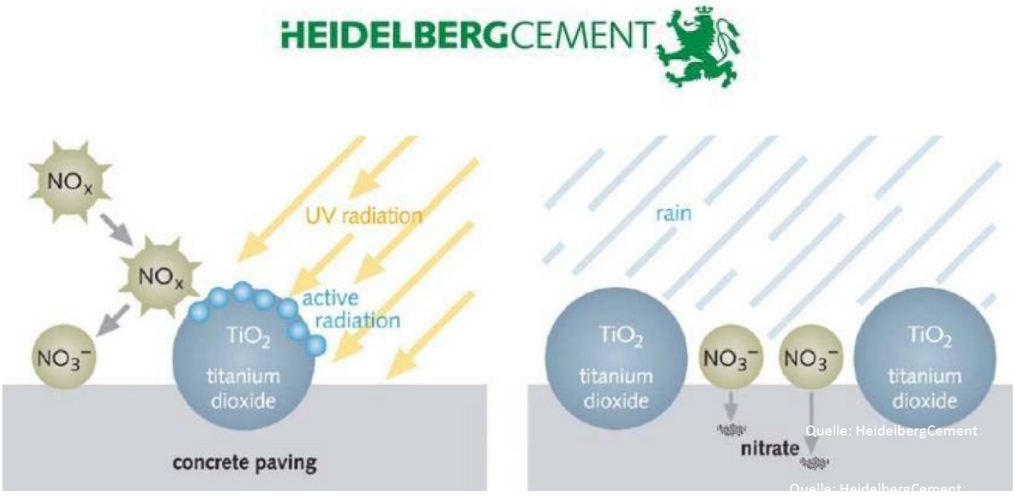


Figure 94. Heidelberg Cement - 'TioCem' (Braungart, Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe, 2014)

4.7.4.2 Outdoor

Solar modules

The building has a carbon-neutral energy supply and produces more energy than it consumes throughout the year. The surplus is fed into the social electricity grid. (Tay, 2010) This is achieved with solar energy: The four-storey building has a slightly inclined, flat roof of approximately 480 m^2 built of Photovoltaic (PV) modules. These individual formable PV modules can be used in all areas of the building envelope. The ProSol PV modules are also used on the southeast façade (see Figure 95) generating electricity both from the inside and the outside. (bba, 2008)

Figure 95. Solar modules (Schüco, 2017)

Windows

The windows are delivered by the German company Schüco. They are triple glazed (see Figure 96) with concealed fitting providing high thermal insulation properties. (Fensterplatz, 2007) Special about these widows is that they are leased for 25 years and will be returned to Schüco to make new windows. (Tay, 2010)

The remaining facade was insulated on the outside with 20 cm mineral foam boards providing high energy savings. (bba, 2008)

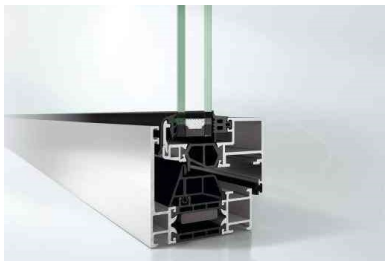


Figure 96. Schüco window (Schüco International KG, 2017)

Green façade

Bionorica Headquarter has a green façade made by Xeroflor, a German green roof supplier. There are several advantages the green facades provide to the building: First the plants enrich the air with oxygen and reduce CO_2 content as well as dusts and gases from the air. Green facades also store water and therefore relieve the public sewage system. Additionally, they reduce noise by reflection and partial absorption and provide thermal insulation as well as protection of the facades skin from external damage. The overall concept and system of layers in shown in Figure 97. (Xero flor, 2017)

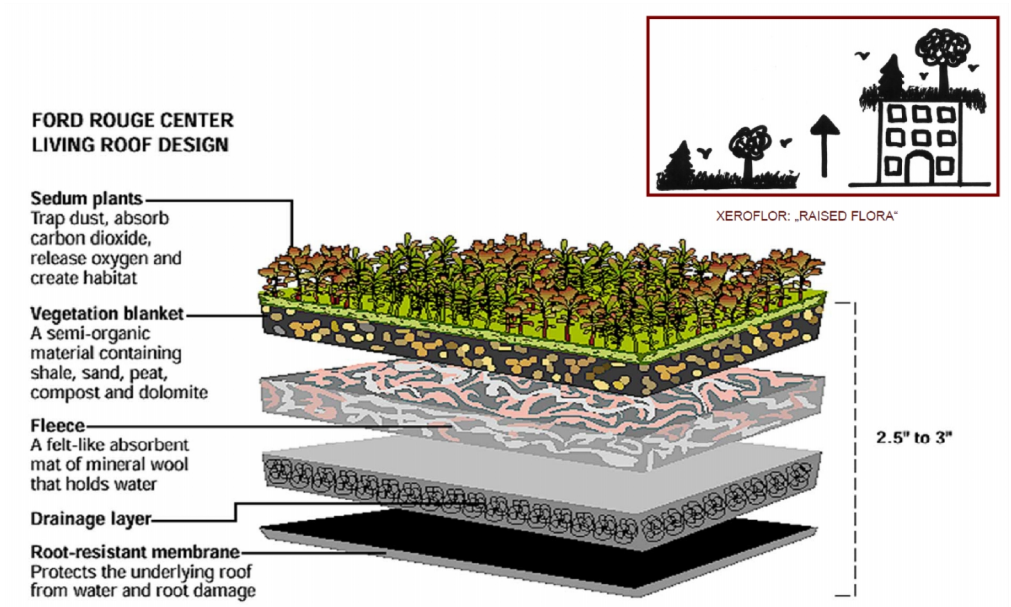


Figure 97. Xeroflor 'Raised flora' (Braungart, Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe, 2014)

4.7.4.3 **Indoor**

Leased carpets

The German Cradle to Cradle certified company Desso delivered dust control flooring (carpets) to the Bionorica Headquarter. Special about these carpets is first that they are only leased meaning that Desso takes back the used carpets and recycles them again. The healthy closed loop system based on Cradle to Cradle principles which Desso calls 'ClosedLoopCarpet' is also unique. The company hereby focuses on the most effective methods to separate materials. The yarn and other fibres from the backing are separated, producing

> "two main material streams which can be recycled. After an additional purification stage, the yarn (with the required purity) is returned to the yarn manufacturer for the production of new yarn. In the entire process, some virgin material is needed to compensate for losses and process inefficiency. Today's bitumen backing is recycled as a valuable raw material for the road and roofing industry. All non-recyclable fractions will be used as secondary fuel in the cement industry." (Desso, 2017)

Special about Desso carpets is also the quality. The urban indoor air quality is in general three to eight times worse compared to outdoor air due to off-gassing of chemicals from indoor fittings. Desso carpets, in contrast, have "fibres that actually improve air quality, instead of off-gassing VOCs (volatile organic compounds) and other toxic compounds" (Tay, 2010).

To make sure the carpets are of the best possible quality, every supplier needs to undergo a 'Material Health Assessment of products and material ingredients'. For this, a product declaration needs to be filled in by the supplier being the basis for a third-party material health-assessment by EPEA (Environmental Protection Encouragement Agency, a scientific research and consulting institute). If the product assessment is graded positive the material can be purchased. (Desso, 2017)

Water walls and green walls

The company Art Aqua delivered indoor water walls and green walls to the Bionorica Headquarter. They regulate the humidity level in rooms, eliminate pollutants in the air and thus help to create a health and performance-enhancing indoor climate. (Art Aqua, 2017)

Figure 98 shows an example of a green and water object installation in a business office.

Figure 98. Indoor green and water object installation (Art Aqua, 2017)

Recyclable furniture

The office furniture meets the requirements of C2C (cradle to cradle). For example, the MIRRA chair of the German office furniture supplier Herman Miller is used. The materials used have largely a green chemistry composition and most of the parts are recyclable. The chair is overall PVC free and designed for rapid disassembly (see Figure 99). (Rossi, Charon, Wing, & Ewell, 2006)

Figure 99. C2C MIRRA chair by Herman Miller (Braungart, Cradle to Cradle Design, 2012)

Recyclable textiles

The Austrian company Backhausen provides furniture and decorative fabrics based on C2C principles. The company offers a return guarantee for all their products. The textile line called 'Returnity' is environmentally friendly produced using 100 % recyclable fabric (see Figure 100). At the end of the products' lifecycle, the fabric is taken back to be useful in infinite ways in new products. (Perkins, 2012)

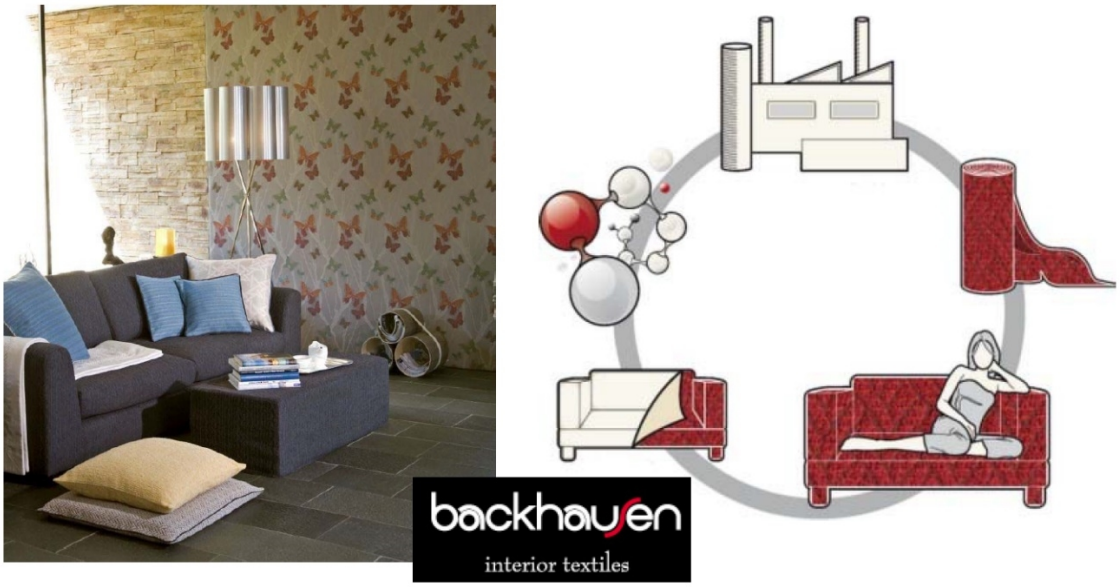


Figure 100. Backhausen 'Returnity' (Braungart, Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe, 2014)

4.7.4.4 Others

Colour

The protection coating is harmless to the groundwater. (Handelsblatt, 2017) The room colours do not cause harmful odour and actively clean the air. (Greenbuilding, 2009)

Ventilation

"The building makes use of plant-based air filters and high performing insulating materials that also improve the air inside the building." (Tay, 2010)

4.7.5 **Influencing factors**

The following chapter describes several influencing factors in the execution of Bionorica Headquarter.

4.7.5.1 **Law and incentives**

Germany has annual construction and demolition waste (including road construction) of 209,5 million tonnes (2014). That means over half of the overall annual waste produced in Germany (401 million tonnes in 2014) is caused by the construction industry. Still Germany has a recycling rate of roughly 90 % of mineral building waste. (ALBA Group, 2017)

The recycling law in Germany which was implemented in 1994 defines the waste disposal according to the polluter pays principle. It is based on the principle that waste is to be avoided first and secondly materially or energetically used. Meaning only if the non-usability is proven an environmentally friendly disposal can take place. (Mettke, 1995) Usually the implementation is predominantly via the commission of private waste disposal companies. 40 % of construction and demolition waste is used to fill former mining facilities. Just under 10 % is processed into the recycle of building materials for the use in deep building measures. (BDE, 2016)

In 2017 a new law called 'Mantelverordnung' came into effect. It regulates the production of mineral replacement building materials from construction and demolition waste. Furthermore, it states which materials may be used to fill excavations or opencast mines and for which materials other recover or disposal opportunities must be found. (BMUB, 2017)

4.7.5.2 **Geographical influences**

The Bionorica Headquarter is located in southern Germany. In general, the country has relatively large deposits of brown coal, potash and rock salt as well as stones and earths for the building industry. These resources are mainly situated in northern Germany. (Geotechnologien, 2017) Having currently enough resources available might be a reason for the poor percentage of circular economy buildings in Germany. Nevertheless, the country has attempts of being environmental friendly, as the high recycling quote of mineral building waste by roughly 90 %,

mentioned in the previous chapter. Apart from recycling, Germany also focuses on solar energy. In 2014 half of the needed energy was produced by solar panels. (WirtschaftsWoche, 2014)

Energy production and energy saving are therefore a main aspect in the building industry nowadays in Germany. In 2015 there have been built over 100.000 new low energy houses. Compared to 2010 the figure doubled. (Hermelink, 2016)

To minimize the power consumption special energy saving windows, walls and thermal insulation are used. To produce energy, solar panels on houses are a current trend in Germany. Apart from that there are also some construction trends concerning the interior design. First the flexibility of rooms is a main issue of clients meaning that rooms are kept open with less weight-bearing walls to make adaptions in the future. Secondly there is real wood flooring used instead of laminate floor which might contain harmful substances. This trend of avoiding harmful materials also applies to the wall paint as natural lime plaster instead of wallpaper is used. In general, the choice of materials is made with focus on durability, health promotion and sustainability. (Bauhaus Portal, 2017)

4.7.5.3 **Know-how**

The Bionorica Headquarter was designed by Wolfgang Brummer from the company Brummer and Retzer in Amberg, Germany. He had no special knowledge about cradle to cradle but learned about the topic very fast. (Greenbuilding, 2009)

The project was accompanied by several C2C-specialists, e.g. the EPEA (Environmental Protection Encouragement Agency, a scientific research and consulting institute) which also made the analyses of the used materials. (EPEA, 2017)

4.7.6 **Rating and Conclusion**

According to the ReSOLVE framework by the Ellen MacArthur Foundation, the building covers the following aspects of circular economy:

Regenerate	The Bionorica Headquarter produces its own renewable energy partly via PV modules on the roof and façade. The materials used are to be recyclable and for those materials that are non-recyclable a take-back guarantee from the supplier is offered.
Share	The lifetime of certain products, e. g. office furniture, is prolonged as they are built modular and parts can be exchanged easily.
Optimise	Several products used in the building have been optimised by other parties, e. g. the office chair MIRRA that is meant to be disassembled or the green façade that makes the outer wall useful in terms of insulation.
Loop	Most of the products implemented in the building are meant to be recycled and used again, e. g. carpets, furniture and textiles that are returned to the supplier who makes new products out of them.
Virtualise	A thermal building simulation was carried out and plant engineering was also tested.
Exchange	New services as the leasing model for windows or carpets are implemented.

The Bionorica Headquarter considers and implements several circular economy aspects. The whole building was to be as harmless to nature as possible. It is meant to be recyclable and the materials that cannot be recycled are taken back by the supplier. The building is PVC free, the cement is free of nitrogen oxides and organic hydrocarbons as well as the steel used does not contain any rare non-ferrous metals. The roof and part of the façade is made of PV modules producing energy for the building. For better thermal insulation, green façades have been installed which additionally enrich the air with oxygen and reduce CO_2 content as well as dusts and gases from the air. The windows as well as the carpets are leased and returned to the supplier at the end of their lifetime for being recycled and used in new products again. Office furniture, e. g. the MIRRA chair meet the requirements of a C2C products with focus on

dismantling. The same applies to the textiles which are environmentally friendly produced and 100 % recyclable fabric. Indoor water walls and green walls regulate the humidity in rooms, eliminate pollutants in the air and thus help to create a health and performance-enhancing indoor climate.

For the project, many different companies needed to work together, release information about materials and optimize their products and manufacturing processes. Even if the building is one amongst a very small number of CE buildings in Germany, the Bionorica Headquarter is a milestone in cradle to cradle inspired buildings.

5 Business idea

Developing an own business idea in the field of circular economy is the second part of this EPS project. The idea does not have to be situated in the field of the construction industry, but is meant to be innovative based on 'out of the box' thinking.

5.1 Business idea brainstorming

To generate several ideas a brainstorm session was held, looking into existing business ideas as well as regional and European problems related to circular economy. Figure 101 shows the outcome in the form of a mind map.

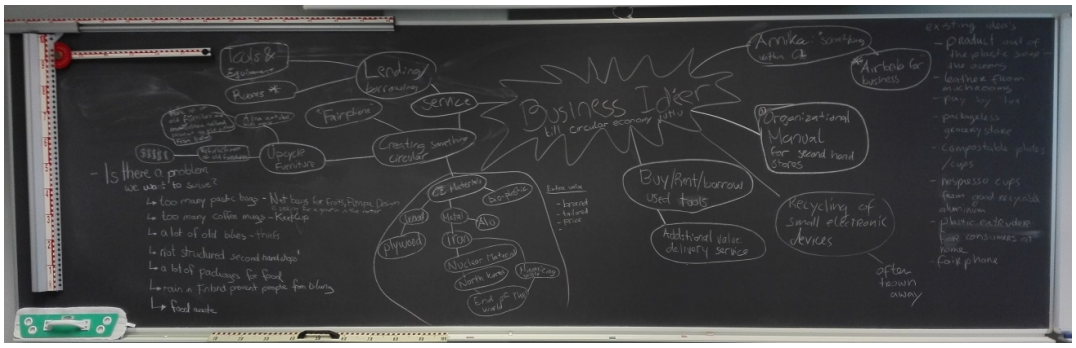


Figure 101. Business idea - Mind Map

To conclude the brainstorm session, four ideas were considered the most promising and rated by each member voting their first, second and third choice, see Table 7 for outcome.

Table 7. Business ideas

No.	Description	Rating
1	Decrease of packages in supermarkets	8
2	Upcycling products e.g. furniture	8
3	'Airbnb' for buildings/offices and integration of virtual environments for discussion over distance	4
4	Organisational manual for second-hand stores to promote sales	3

After carrying out the rating, business idea number one 'Decrease of packages in supermarkets' was chosen for further research, even if the final voting was equal to business idea number two.

The conclusion fell in favour of business idea number one because of the positive input by the team coach Stefan Pellfolk.

5.2 Decrease of packages in supermarkets

The chosen operation area is quite large and there are several opportunities to lower the number of packages used in supermarkets. To find out how to decrease package consumption, a look at the supply chain of supermarkets makes visible where those packages appear and therefor where they can be cut. Figure 102 shows a general supply chain of supermarkets where the manufacturer receives the ingredients for the product from a raw material supplier. Distributors than carry the products to the wholesalers who take the items to the retailers (in this case: the supermarkets). Finally end users (in this case: customers) come into the shop and buy the products.

Figure 102. Supply chain of supermarkets (Google pictures, 2017)

After choosing the business idea for further research, the following step was to perform a new brainstorm on how to evolve the chosen example into a more defined business idea.

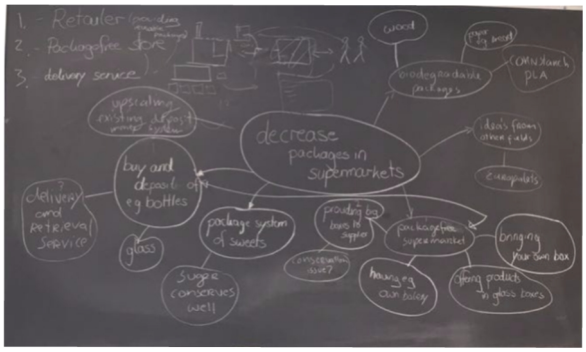


Figure 103. Result of the second brainstorm session

The outcome, as seen in Figure 103, were three promising ideas to be further developed:

1. **Reusable package producer**: Creating a standardized reusable package solution to producers/ manufacturers and retailers.
2. **Package-free store**: A store that receives big shipments of goods, bunkers up and offers the customers products served in their own bags, bottles and containers.
3. **Delivery service**: Grocery delivery service using reusable boxes and bottles that are traded with a deposit fee.

5.2.1 Business idea No. 1: Reusable package producer

This business idea aims to create a company that will produce a reusable package solution, trying to make a standardization on the market.

5.2.1.1 Description

The company will offer reusable package solutions to producers/ manufacturers and retailers, for usage by the final customer. Manufacturers and retailers will not buy the products but rent them, like Euro pallets. This will be discussed later on under the heading 'Package systems'. Customers can return products to a recycle station as the ones in Finland for the deposit-refund 'pantti' system. The goal would be to create a standardization of packaging on the market.

5.2.1.2 Sale options

The company could offer one or several of the following sales options:

Reusable package solutions: Made of durable eco-friendly or recyclable materials, e.g. glass container (see Figure 104).

Packages are rented by the companies in a network of users, being paid by the final customer trough a deposit-refund system. The package sizes can be both small for end users as well as bigger options for the transit of goods between manufacturers and retailers.

Figure 104. Glass container (Pexels, n.d.)

Delivery and retrieval service of the reusable package solutions: This service is to not burden manufacturers and retailers with additional workload, and therefor make the reusable package solutions more attractive.

5.2.1.3 Package system

The idea behind the reusable package solution has taken inspiration from these current existing systems:

Euro pallet: Reusable and durable eco-friendly pallets, handled by EPAL (European Pallet Association), that are available on demand for renting and simplifying the logistic progress. It improves the handling process and reduces the storage costs as well as the initial investment through outsourcing of expense, labour and maintenance (European Pallet Association, n.d.).

Deposit-based 'pantti' system: Used in Finland for beverage packages, enabling for an efficient collection and a good incentive for recycling through a deposit fee paid upon return at the reverse vending machines. This service is handled by the Finnish company Palpa. Recycle rates in Finland are among the highest in the world: in 2016 recycle rates were 96 % for cans, 92 % for plastic bottles and 88 % for glass bottles (Palpa, 2017).

5.2.1.4 **Supply chain**

The reusable package solution works as following between the users in the supply chain (see Figure 105):

1. **Package producer:** is responsible for the production costs, as well as cleaning of the packages and stocking upon retrieval from the retailers.
2. **Manufacturers, retailers:** rents the packages from the producer and is therefore viable without a noticeable initial investment. Through adding a deposit sum to the price of the product on sale, the finance behind the renting of the reusable packages becomes profitable. They also prepare the packages for retrieval by the package producer.
3. **Customer:** receives the deposit from the retailer upon retrieval and is therefore incentivized to recycle the reusable packages.

Figure 105. Example of the supply chain (Google pictures, 2017)

5.2.1.5 **Competitors**

As for now, there are no examples found of companies that would directly be associated with this business idea. Apart from the already mentioned ones by EPAL and Palpa in the chapter 'Package system', one further noticeable example was found that offers a product with certain similarities:

The Finnish company RePack offers a recycled, returnable and reusable packaging service, aimed for at companies that run a webstore. The users are constantly growing, and the solution is currently implemented by a number of Finnish, German and Dutch companies. The reusable package solution is shown in Figure 106.

Figure 106. The reusable package (RePack, n.d.)

The customers get reward points upon returning the empty package, that has a free return label on the inside. The returned packages, offered in three main sizes to fit most products, are then cleaned, inspected and redistributed by RePack. Packages that do not meet the inspection requirements are recycled into new products.

Implementing the solution is made easy for the companies through a 'plug and play' software, and the customers are not forced to use RePack, but can choose to do so at the checkout. As customers are the ones paying for RePack, companies offering this service have a guaranteed return on the investment (RePack, n.d.).

5.2.1.6 **SWOT-analysis**

The SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is divided into the business analysis, looking at the strengths and weaknesses of the company itself, and the environmental analysis, defining opportunities and threats which are determined by the market.

5.2.1.6.1 Business analysis

Table 8 shows the business analysis. The package producing company has the strength of having a durable, sustainable product that incentivize recycling through an initial deposit sum. Manufacturing companies and retailers could find it an interesting solution as the standardization of packaging sizes and outsourcing of the additional steps would favour the whole supply chain. As a new business, the company will have to do a substantial initial investment as well as lobbying as a first step. There might be a struggle in meeting the possible high demand. Additionally, the customers might show unwillingness to pay a higher price for the products and store the used reusable containers at home instead of bringing them back to the retailer.

Strengths	**Weaknesses**
• Reduced plastic usage • Active recycling through deposit return • Outsourced steps of the business procedure, less risks • High durability of the reusable packages • No initial investment by the target group • Standardization of the package sizes, more effective transportation and storage • No additional processes for cleaning and stocking by manufacturers and retailers	• Production might not meet the possible high demand • Initial investment by the producer will be very high • Reusable boxes take space at customers home before returned, may be inconvenient due to their size • High deposit fees may not be paid by the customer • Manufacturers and retailers might be unwilling to change the existing layout

Table 8. Business analysis: reusable package producer

5.2.1.6.2 Environmental analysis

Table 9 shows the environmental analysis. The package producing company has the advantage that the market for environmental friendly and sustainable products is growing. A product with this high recycling rate, that helps to lower the plastic waste and carbon emissions, could be very much appreciated. The only downside so far is that the simplicity and lower purchase price of the basic plastic packages might be in favour throughout the supply chain.

Opportunities	Threats
• Demand by the market for sustainable, eco-friendly products • High rate of recycle, less plastic waste • More effective transports lower the carbon footprint	• Lower cost of the basic plastic packaging might be favourable

Table 9. Environmental analysis: reusable package producer

5.2.1.7 **Conclusion**

Summing up the conclusions from the business and environmental analysis, there are four different strategies for the business model of a reusable package producer. Table 10 shows the SWOT-analysis.

- **Strategy: 'expand'**: The opportunity-strength strategy is to meet the demand of eco-friendly and sustainable quality products, through promotion of the economic aspects in the marketing campaigns.
- **Strategy: 'secure'**: The threat-strength strategy is to make a broad, trustworthy research that informs both all the actors, from manufacturers to final users, why the transition to a reusable package solution is needed and why it is worth to consider it.
- **Strategy: 'catch up'**: The opportunity-weakness strategy focuses on performing an accurate initial research to make the planned budget match as much as possible, in order to lower possible economic threats and correspond the demand. Also, a successful lobbying campaign would give product a successful release into the market.
- **Strategy: 'avoid'**: The threat-weakness strategy is to focus on a finished 'plug-in' solution that clearly highlights the positive attributes brought, while giving the safety of being a reliable business partner that can provide what it promises.

		Environmental analysis	
		Opportunities	**Threats**
Business analysis	**Strengths**	*Strategy: expand* • Meet the demand of eco-friendly and sustainable quality products • Promote the economic aspects occurring throughout the whole supply chain	*Strategy: secure* • Perform a broad, trustworthy research informing why the transition is needed and why it is worth it
	Weaknesses	*Strategy: catch up* • Accurate initial research to to lower possible economic threats and correspond the demand	*Strategy: avoid* • Offering a 'plug-in' solution • Being a reliable business partner

	• A successful lobbying campaign would give a positive receival

Table 10. SWOT-analysis: reusable package producer

5.2.2 Business idea No. 2: Package-free store

The second business idea is a package-free store. In other words, it is a grocery store that is plastic free. Figure 107 shows one possible store design.

Figure 107. Package-free store (Goethe, 2017)

5.2.2.1 Description

The overall concept of this store is that all products offered are unpackaged and the customer can buy any amount of a certain product. There are several sale options for different products as well as various package systems to carry the shopping.

5.2.2.2 **Sale options**

Dispensers, e.g. for cereals, flour, pasta, rice, nuts

By means of dispenser, the customer fills the desired amount of a certain product in a brought along box or a rented box from the store. The dispensers are made of glass, wood and stainless steel (see Figure 108).

Figure 108. Dispenser (Utopia, 2017)

Filled glass bottles, e.g. for milk, yoghurt

Liquid products such as milk and yoghurt will be offered in glass bottles. These bottles have a deposit system, so people will bring back empty bottles as an exchange for new ones (see Figure 109).

Figure 109. Filled glass bottles (Google pictures, 2017)

Loose products, e.g. fruit, vegetables

Fruits and vegetables will be offered as lose products. There are stored in wooden boxes (see Figure 110).

Figure 110. Loose products (Muenchner Kindl, 2017)

Counter, e.g. for sausages, cheese, bread

At a counter, customer can buy products like sausages and cheese but also bread (see Figure 111).

Figure 111. Counter (Koeln Deutz, 2017)

5.2.2.3 Package systems

Customers have three different options on how to carry their shopping:

Bring-along boxes

First, customers can bring their own boxes, (Figure 113), which are weighted empty first and a second time after they have been filled with a product. Thus, the difference between the two weights is the amount of a certain product the customer needs to pay for, see Figure 112.

Figure 113. Bring-along boxes (Store shops, 2017)

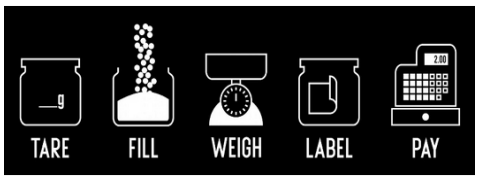


Figure 112. Weighting (Best practice business, 2017)

Supermarket boxes

Secondly, the customer has the opportunity to rent a box from the store. These boxes are made of environmentally friendly and plastic free materials, e.g. glass (see Figure 114) and traded under a deposit system. These boxes are treated the same way as customers own boxes when it comes to weighting (see Figure 112).

Figure 114. Supermarket box (Utopia, 2017)

Paper bags

A third option for customers to carry their products are paper bags that are 100 % recyclable (see Figure 115).

Figure 115. Paper bags (Google pictures, 2017)

5.2.2.4 **Supply Chain**

To secure that during transportation the products are not stored in plastic containers the overall aim of the store is to interact directly with the manufacturers. For example, as shown in Figure 116, the empty dispensers are sent to the manufacturer (1), get filled and are offered directly back to the shop (2). The same applies to the liquid products. The empty glass bottles or mugs are filled with e.g. milk or yoghurt and offered right to the customer. Products which are offered at the counter such as sausages and cheese need to be transported to the shop without getting packed into plastic. Closed glass boxes are one possibility for it. Lose products like fruits and vegetables can be transported in reusable cardboard packages.

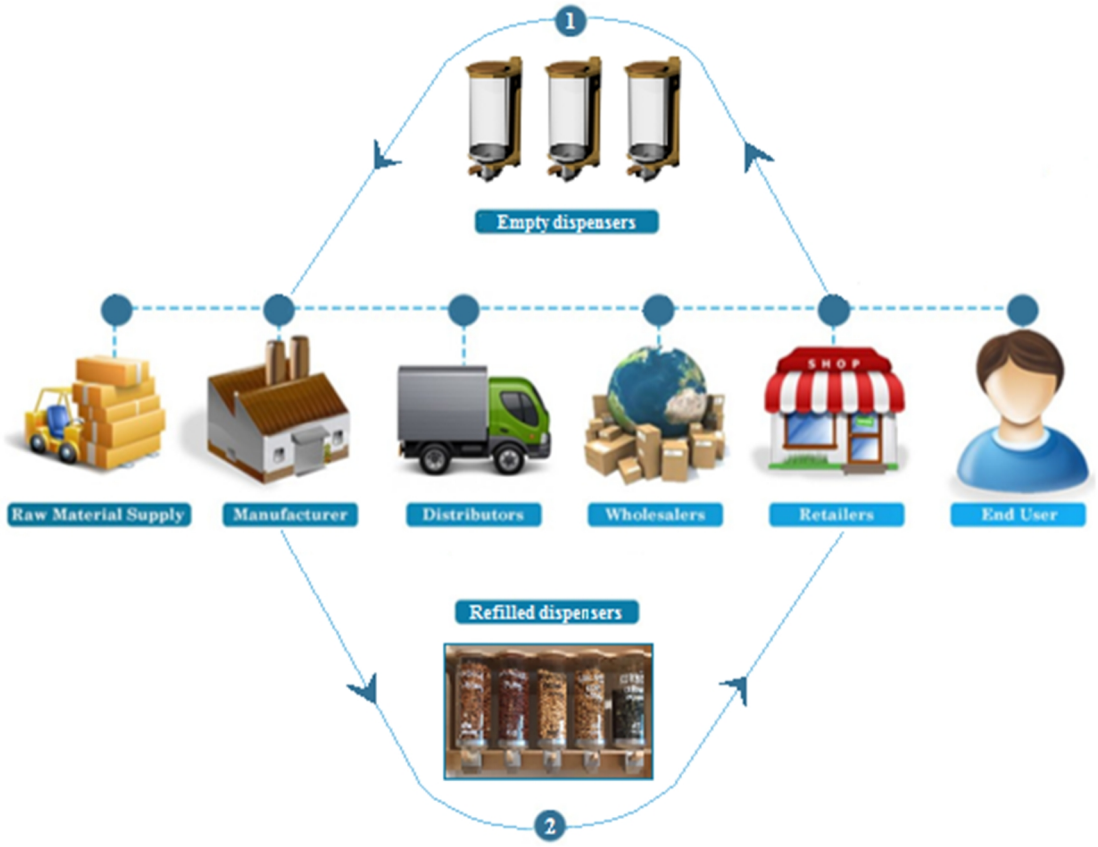


Figure 116. Example of the supply chain (Google pictures, 2017)

5.2.2.5 **Competitors**

The trend of packaging-free stores is spreading all over Europe, with most stores found in Germany, and for the moment none in Finland. There are a couple of stores in Sweden, Denmark and Norway, so it will probably not take long until the first package-free store opens in Finland.

On www.bepakt.com, a website promoting zero-waste index, one can find a map over most of the current European packaging-free stores (see Figure 117) (Bepakt, 2017). The figure shows a map of 2015, while a more disordered but updated version is available online.

Figure 117. Map of packaging-free stores in Europe (Bepakt, 2017)

5.2.2.6 **SWOT-analysis**

In the same way, as in business idea No. 1, the SWOT-analysis is divided into the business analysis looking at the strengths and weaknesses of the store itself and the environmental analysis defining opportunities and threats which are determined by the market.

5.2.2.6.1 Business analysis

Table 11 shows the business analysis. The package free stores are characterized by being plastic-free, offering regional products that can be bought in any desired amount and therefore using less packaging materials. On the other hand, the products are relatively expensive and there is only a limited number of different products available as the supermarket interacts directly with every regional supplier. Being package free the products have a shorter durability and customers need to bring time to fill the boxes. Furthermore, the boxes take space at the customers home and bringing an own box to the supermarket may be inconvenient. As the supermarket also offers boxes to borrow a separate process for cleaning and handling these packages needs to be installed.

Strengths	**Weaknesses**
• Plastic-free stores • Regional products • People can take the amount they want to have • Less material usage and therefore less expenses for packaging	• Limited number of products • Higher prices • Shorter durability of products • Filling the own box is time consuming • Reusable boxes take space at customers home • Having to bring an own box to the supermarket may be inconvenient • New/Additional processes for cleaning and handling of the stores own boxes

Table 11. Business analysis – package free supermarket

5.2.2.6.2 Environmental analysis

Table 12 shows the environmental analysis. The business model can benefit from the ongoing eco-trend meaning that more and more people think about and look for their environmental footprint as well as from the EU's aim to reduce plastic. Threats to the packages free stores are expensive logistics with the regional suppliers, competitors in the field of package free grocery and big supermarket chains that offer low-cost products.

Opportunities	Threats
• Eco-trend: more and more people look for their environmental footprint • EU's aim to reduce plastic	• Logistics with suppliers/ manufacturers • Competitors in the field of package free grocery • Competitors in the field of low-cost supermarkets that offer cheap products

Table 12. Environmental analysis – package free supermarket

5.2.2.7 Conclusion

As a result, there are four different strategies for the business model of a package-free supermarket. Table 13 shows the SWOT-analysis.

- **Strategy: 'expand'**: The opportunity-strength strategy is to emphasize the ecological aspect in marketing campaigns, so people see the uniqueness and the positive impact on the nature. Additionally, grant funds from the EU can be applied for.
- **Strategy: 'secure'**: The threat-strength strategy has to focus on good relationships to the local suppliers to make the supply chain as efficient as possible. As a result, prices for the products can be kept low.

- **Strategy: 'catch up'**: The opportunity-weakness strategy focuses on the unique-selling points as being environmental friendly and buying only the amount needed of a product. Furthermore, the shopping must be as customer friendly as possible.
- **Strategy: 'avoid'**: The threat-weakness strategy is to focus on a market niche rather than trying to compete with big supermarket chains offering low-cost products.

		Environmental analysis	
		Opportunities	**Threats**
Business analysis	**Strengths**	*Strategy: expand* • Emphasize the ecological aspect in marketing campaigns • Try to get grant funds from the EU	*Strategy: secure* • Focus on good relationships to local supplier • Make the supply chain as efficient as possible
	Weaknesses	*Strategy: catch up* • Focus on unique-selling points: environmental friendly and buying only the amount needed of a product • Make shopping as customer friendly as possible	*Strategy: avoid* • Focus on market niche • Do not try to compete with big supermarket chains

Table 13. SWOT-analysis: package free supermarket

5.2.3 **Business idea No. 3: Delivery service**

The third business in is a delivery and retrieval service using reusable boxes. This means that the company does the shopping.

5.2.3.1 **Description**

Customers order their products in the desired amount online. The company will than collect these items from the wholesalers (not from the supermarkets as there all products are already packaged), put it in reusable packages and deliver it to the end user. At the same time with the delivery, the used packages from former orders will be picked up at the customers place and cleaned to 'shop' with them again.

The material wrapping the ordered products need to be reusable or biodegradable.

Reusable boxes

These boxes are made of environmentally friendly and plastic free materials, e.g. glass (see Figure 118) and traded under a deposit system. Customers can return them when receiving a delivery. The boxes will be cleaned and reused.

Figure 118. Supermarket box (Utopia, 2017)

Packing material

There is only post-consumer packing material (see Figure 119) used for bringing the products to the customers. Everything is 100 % recyclable and 100 % compostable.

Figure 119. Packing material (Package free shop, 2017)

5.2.3.2 **Supply chain**

The supply chain for this business idea is shown in Figure 120. Starting from the customer (1) who orders the desired products online, the company 'delivery service' (2) hires people or employs workers (3) to do the shopping (4). The products are put into reusable boxes and delivered to the customer (5). At the same time with receiving a delivery the customer has the opportunity to give the empty boxes from former orders back (6). The reusable boxes are owned by the company 'delivery service' and traded within a deposit system. Before reusing the boxes, they are cleaned, which is also in charge of the company.

The traditional retailer will be skipped with this business idea as the products are received from the wholesalers.

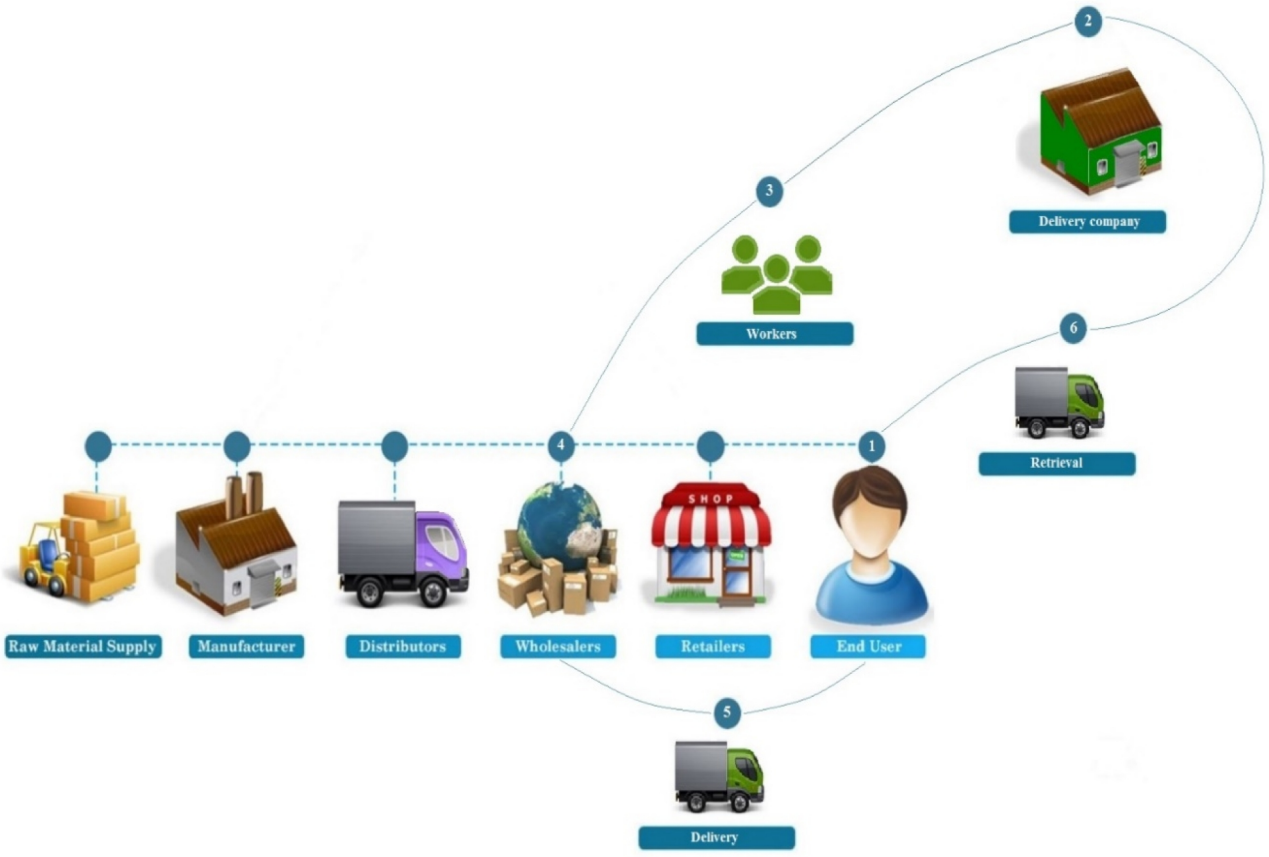


Figure 120. Business idea - delivery service (Google pictures, 2017)

5.2.3.3 Competitors

This business idea has at the moment no found competitors that provide the service of both delivery and retrieval. The closest one is the online grocery shopping, a booming trend implemented by several retailers throughout Europe, as well as various food delivery companies starting up their business on the market (Murray, 2017). Food delivery is still quite niched but in the future, there might be a widespread system similar to Amazon Prime Air, a concept that uses a drone for fast deliveries of various goods in as little as 30 minutes (Amazon, 2017).

According to the data and analysis website The Nordic Web "The Nordics already has a competitive online grocery market" (Murray, 2017). The biggest current example in Finland is run by Kesko Corporation, a merge of Finnish wholesalers dating back to the 1940's, that offers online grocery shopping on their K-Market, K-Supermarket and K-Citymarket through the platform www.k-ruokakauppa.fi. The customers have the possibility to order at home and pick up the already packed goods at the store or to get home delivery when available, depending on the location.

5.2.3.4 SWOT-analysis

In the same way, as in business idea No. 1 and No. 2 the SWOT-analysis is divided into the business analysis looking at the strengths and weaknesses of the company itself and the environmental analysis defining opportunities and threats which are determined by the market.

5.2.3.4.1 Business analysis

Table 14 shows the business analysis. One major strength of the business model 'delivery service' is the convenience for customers. Getting the shopping delivered and not having to go

to the supermarket on their own is a great advantage considering for example time. Plus, people can order the amount of a certain product needed. Additionally, there is a trend nowadays toward online-shopping. Nearly every shop offers a web-shop including a delivery system.

On the other hand, a shorter durability of products need to be accepted. As well as the boxes taking space at the customers home. The company 'delivery service' itself has to establish a process for cleaning and handing the reusable boxes. Furthermore, higher prices are estimated as the transportation costs as well as the cleaning process of boxes costs money.

Strengths	Weaknesses
• Getting shopping delivered is convenient for the customer • People can order the amount they want to have • Online-shopping trend	• Shorter durability of products • Reusable boxes take space at customers home • New/ Additional processes for cleaning and handling of reusable boxes • Transportation costs for delivery service • Higher prices

Table 14. Business analysis: delivery service

5.2.3.4.2 Environmental analysis

Table 15 shows the environmental analysis. The EU's aim to reduce plastic can be considered as an opportunity as well as the eco-trend meaning more and more people look for their environmental footprint.

In contrast, there are competitors in the field of grocery delivery. What also needs to be taken into account is that the delivery within cities is more efficient than having to drive to the countryside.

Opportunities	Threats

• Eco-trend: more and more people look for their environmental footprint • EU's aim to reduce plastic	• Competitors in the field of grocery delivery • Delivery within cities is more efficient than having to drive to the countryside

Table 15. Environmental analysis: delivery service

5.2.3.5 **Conclusion**

Table 16 shows the combined result of the SWOT-analysis. The conclusion is overall similar to the one for business idea No. 2 'Package-free store', with the only difference in the strategy 'avoid': the delivery service company needs to focus on the whole market rather than a certain niche. The four different strategies are once again the following:

- **Strategy: 'expand'**: The opportunity-strength strategy is to emphasize the ecological aspect in marketing campaigns, so people see the uniqueness and the positive impact on the nature. Additionally, grant funds from the EU can be applied for.
- **Strategy: 'secure'**: The threat-strength strategy has to focus on making the transportation as well as the deposit system and cleaning of boxes as efficient as possible. As a result, prices for the products can be kept low.
- **Strategy: 'catch up'**: The opportunity-weakness strategy focuses on the unique-selling points as being environmental friendly and buying only the amount needed of a product. Furthermore, the shopping must be as customer friendly as possible.
- **Strategy: 'avoid'**: The threat-weakness strategy is to focus on the whole market rather than trying to compete with already existing niched delivery providers.

		Environmental analysis	
		Opportunities	**Threats**
Business	**Strengths**	*Strategy: expand* • Emphasize the convenience	*Strategy: secure* • Make the transportation as efficient as possible

	Weaknesses	• Emphasize the ecological aspect in marketing campaigns • Try to get grant funds from the EU *Strategy: catch up* • Focus on unique-selling points: environmental friendly and buying only the amount needed of a product	• Make the deposit system of boxes and the cleaning as efficient as possible *Strategy: avoid* • Focusing on whole market

Table 16. SWOT-analysis: delivery service

6 Conclusion

To conclude this research project made for the EPS at Novia UAS, here follows a summary of the deep research topics, the business idea and thoughts on future research in CE within the field of construction industry. The topics were divided into three different subchapters to make the chapter easier to read.

We reckon this research will give the R&D department at Novia UAS tools and knowledge to further implement CE in the Ostrobothnia region. With a list of examples containing companies, projects and buildings that match on several circular aspects, as well as deeper research on six of them, we delivered to our project customer a base for their upcoming research, that can used to find matches with similar examples in the Ostrobothnia region. This we believe will help incentivize the conversion from the current linear system to a circular one.

6.1 Best practice cases

The topics for the best practice cases were chosen from over 120 buildings that matched search terms based on the ReSOLVE framework by the Ellen McArthur Foundation. It is sometimes hard to find information about buildings, especially in English, where thoughts of CE laid specifically behind the project. Especially in Eastern European countries we concluded that there is a lack of advanced circular incentives in the building industry, as the examples were few and hard to find compared to eastern and northern Europe.

In the future, we will probably see a further growth in companies using wood as their primary building material, as it is a renewable and durable material. The conclusion can be drawn from the case of Pluspuu Talot, Finch Buildings, Villa Asserbo and several others listed on our website, that more companies will start implementing different ideas in the usage of wood as a first step into circular economy, as we likely will see companies that specifically handle recycling, upcycling and refurbishment of wooden products back to the market.

Cases as the one of the Bionorica Headquarter are futuristic and interesting. The technologies of these so called ‘plus buildings’, which produce more energy than they actually consume, as well as leasing parts of the materials used, might become part of the ‘everyday life’ in a near future. This means design to recycle the building materials as in the case of Bionorica Headquarter, Villa Asserbo and Park 20|20**.**

3D-printing is taking a leap forward in the development, as seen in Villa Asserbo and from companies listed on our website, more and more are taking up the challenge of trying to make the first widespread mass-produced 3D-printed house. The choice of material is quite broad, using options between concrete, wood and various synthetic materials. Even so, the technology has yet to be refined.

Based on the examples, we believe that flexibility, upgradability and durability will be a central thought during the designing phase of future buildings. These might be implemented not only on more outspoken buildings like De Fire Styrelser, Park 20|20 and Bionorica Headquarter, but also on small-scale projects like the ones offered by Finch Buildings or, maybe in the future more outspokenly, by Pluspuu Talot.

As a central thought in CE is the reusability, beside the implementation of the before mentioned thoughts, the implementation of reusability in the design will be applied more in future buildings. This can already be seen in the planning of Villa Asserbo, Finch Buildings, Bionorica Headquarter and Park 20|20**.**

From a legislation point of view, one can notice that laws written for the linear system can stand in the way of CE initiatives, as in the case of Park 20|20. The CE 'know-how' among the stakeholders in the supply chain is not always existing, which can interfere with the implementation of CE. Also, the motivation to rethink the way of working by the stakeholders is not always a fact, since it requires effort and money to be performed. The circular buildings available today, provided by pioneers in the field, together with the scarcity of materials and the ongoing growth of the world population, will help and stimulate both companies and governments in their operations towards the implementation of CE.

Finch Buildings

Finch Buildings produces modular buildings assembled from separate modules, mainly made out of FSC-certified wood. 90 % of all materials used in the modules are suitable for reuse. The company behind the buildings aims for a high flexibility through an adjustable living area surface, adjustable interiors as well as simplified transport and relocation of the modules. According to the manufacturers, the total cost of ownership for a module is lower than the one of a competitive alternative over a lifespan of 15 years. Also, the buildings are meant to last for over a century if well maintained, and are designed to be highly energy-efficient. However, clients still often seem to opt for non-circular alternatives when it comes to the actual purchase.

This building was chosen because of its combination of modularity, the use of wood and its durability. For more information, see chapter 4.2 'Finch Buildings'.

Finding information about the building was not difficult, since there were several commercial reports available. However, detailed technical information as well as the barriers and enablers experienced by the company were not easily found. Our opinion is that in the future this kind of modular, flexible and sustainable buildings might have a significant breakthrough on the market if a successful marketing campaign is performed.

Pluspuu Talot

Pluspuu Talot is a studio founded in late 2009 in Helsinki, Finland. As their main product, they offer architectural services with house packages, consisting of carefully designed log houses in various shapes, making them customizable according to the customer's needs. Their line of products is all based on wood, that compared to other traditional building material is renewable and combines characteristics such as insulation, ventilation and durability. Pluspuu Talot uses the manufacturing company Ollikaisen Hirsirakenne for the construction of the buildings. As the project customer from Novia's R&D department showed interest in the circularity and the supply chain of the company, the decision was made to further research in the matter. For more information, see chapter 4.3 'Pluspuu Talot'.

Finding information about the company, their way of building and different technologies was not hard, as their website was packed with useful information. What was lacking was information about the actual circularity in a loop after sales, as in refurbishment plans and reuse of the materials, and the company didn't give any additional insight in the question. In the future we will likely see the company adding a refurbishment plan and maybe the implementation of recycled materials.

Villa Asserbo

Villa Asserbo is a '3D wood printed' house, located in Asserbo, Denmark. The focus of this project was to have the smallest possible environmental footprint for a building, in aspects such as designing, building, usage and deconstruction. The villa was build out of modular segments, made with a portable CNC-machine. The machine milled multiple digitally designed sections in quick succession, out of sustainable plywood boards. The modular segments are small and light enough to be carried by two persons, which makes heavy equipment redundant and on site building possible. The project was chosen because of its focus on circularity both in the technical and biological cycle. It also uses wood from the

Nordic wood industry, and ample information was initially available.For more information, see chapter 4.4 ‘Villa Asserbo’.

Villa Asserbo is positioned in a suitable environment, both physically as well as economically. Denmark stimulates sustainable and energy efficient projects, with only the moist/ water control legislations impeding construction with wood. Information about the building was hard to find as it is a ‘one of a kind’, but the technology used was interesting, so we are surprised it did not receive more attention.

De Fire Styrelser

De Fire Styrelser, also called Nexus CPH on technical terms, is a hub for four Danish government boards located in Copenhagen, Denmark. The building is designed as a PPP (Private Public Partnership-project) meaning the responsibility of the building is for the builder, also called the contractor. The customer pays a fixed price for using the building, which stimulates the investment into efficient and durable systems and technologies from the contractor. The building is designed to be flexible, upgradable and durable. The building was chosen because of its form of agreement, which changes the common ‘owning a property’ to a leased construction and is one of the requirements for a circular economy. For more information, see chapter 4.5 ‘De Fire Styrelser’.

Denmark has a favourable geography, both physical as well as economically. The legislations stimulate energy efficient buildings, which helped making this building comply to the Danish 2020 energy requirements. We found the project to be what circular economy is about, and predict this kind of building agreements to be game changers in the future building industry.

Park 20|20

Park 20|20 is the first fully operational cradle to cradle work environment, with multiple buildings on an area of 114.000 m². The main focus, besides being cradle to cradle, is the well-being of its inhabitants. The business park incorporates different circular solutions such as buildings that are designed for disassembly, the use of solar panels, a 'closed loop' water-management system, green roofs and green walls. The business park was chosen for its use of C2C materials and the large scale of the project. For more information, see chapter 4.6 ‘Park 20|20’.

There was a lot of information on Park 20|20 available, however like in the case of Finch Buildings, detailed technical information was not available online. Park 20|20 was not available to consult for further information due to other priorities at the moment. We reckon the park will be successful, while its technical solutions will hopefully spread to less high-end projects.

Bionorica Headquarter

The Bionorica Headquarter is situated in Neumarkt, Germany, and is a building planned to be fully recyclable. Special about the building is the supply chain, as the materials that cannot be recycled, like windows and carpets, are taken back by the supplier through a leasing agreement. What is also outstanding are the technical solutions implemented in this building as it is PVC-free. The roof and part of the façade are made out of solar modules, which produce more energy that the building actually consumes. For better thermal insulation, green façades have been installed enriching the air with oxygen and reducing carbon dioxide content. The building was chosen for the implemented technical solutions as well as its circular supply chain. For more information, see chapter 4.7 ‘Bionorica Headquarter’.

There was a lot of information available on the internet, mainly on German websites. Since the building is already ten years old, it was a milestone in CE-inspired buildings by that time. In general, Germany does not specifically promote circular economy in the construction industry, but supported the use of solar modules in house building. We hope more of this kind of buildings will be designed in the future, while at the same time we find it strange that leasing of the materials and parts has not yet made a leap forward into the commercial housing market.

6.2 Business idea: Decrease of packages in supermarkets

Several brainstorm sessions were held in order to come up with a novel idea that would match the aspects of CE. The chosen operation area was decreasing the package usage in supermarkets, which is remarkably large and withholds several opportunities. Therefore, three promising ideas in this field were developed.

Starting from scratch and without any particular area restricting the research for a business idea, it took some time to make the final decision of which field to further develop our idea. Additionally, when voting for the idea to choose there was no alternative with a clear advantage, since all the four initial alternatives had quite similar standings. As the field of research was chosen, the progression proceeded with ease and no problems were encountered during the process of finalizing the task. We noticed some kind of similar initiatives were already developed, presented in the chapter 'Competitor analysis' for each of the three ideas, but apart from the package-free stores the competition in the areas is yet at an initial phase of development. In the future, we firmly believe that initiatives like the ones by us presented will be game changers that will revolutionize the market and the way we handle our everyday life.

Idea No. 1: Reusable package producer

This business idea aims to create a company that will produce a reusable package solution, trying to make it a standardization on the market. The company will offer the reusable package solutions to manufacturers and retailers, for usage by the final customer. Manufacturers and retailers will not buy the products but rent them, like the system behind the Euro pallets by EPAL. The boxes can be returned to a recycle station, as the ones seen in Finland for the deposit-refund 'pantti' system by PALPA. For more information, see chapter 5.2.1 'Business idea No. 1: Reusable package producer'.

Idea No. 2: Package-free store

The second business idea aims to establish a package-free store, which is a grocery store that is plastic free. The overall concept of this store is that all products offered are unpackaged, and the customer can buy any amount of a certain product. There are several sale options for different products, as well as various package systems to carry the shopping. To ensure that during transportation the products are not stored in non-reusable plastic containers, the overall aim of the store is also to interact directly with the manufacturers. For more information, see chapter 5.2.2 'Business idea No. 2: Package-free store'.

Idea No. 3: Delivery service

The third business idea aims to create a company that offers a delivery and retrieval service using a reusable or biodegradable material for wrapping the orders. The

customer orders a desired quantity of the products online and the company then collects these items from the wholesalers, where the products are still to be packaged, putting them in reusable packages and performing a delivery to the end user. At the time of the delivery, the used packages from former orders will be retrieved and brought back to be cleaned and reused. For more information, see chapter 5.2.3 'Business idea No. 3: Delivery service'.

6.3 Future research

For further research by the R&D team of Novia UAS, or by anyone performing such a task in the field of CE in the construction industry, here are some thoughts and recommendations on the topic presented. For the research process of existing CE buildings, projects or companies we highly recommend knowledge of the local language, as information and sources are significantly easier to find. Online information is sometimes lacking, so by contacting involved parties one can find out information not available before, as well as saving precious time and resources.

Several documents that handle specifically about CE in the construction industry where found online and can be useful for further research. One specific document highlights several CE-examples in the building environment and key principles, which are based on the ReSOLVE framework by the Ellen MacArthur Foundation. The title is "Circular economy in the built environment" made year 2016 by ARUP, a global independent company of specialists. The link is the following:

https://www.arup.com/publications/research/section/circular-economy-in-the-built-environment

Building up clear guidelines and a structure is recommended, in order to make the research topics better comparable, highlighting their differences, pros and cons. Using guidelines and a structure also helps being time effective, having a clear aim on what to look for.

We hope that the information in this document helped taking society one step closer from linear to a circular, sustainable economy.

7 Reflection

This chapter contains the reflection of the team on the project. Here matters such as planning, individual roles and personal experiences are expressed and elaborated.

7.1 Schedule and time follow up

The project planning and the earned value analysis were two important tools for time management to keep track of the progress and if necessary to make adjustments. As Figure 4 shows the hours worked on the project, the created value is more or less equal in between the different group members. Noticeable is the fact that Jonathan did not participate in the English and Swedish classes, thus his total amount of hours is minor compared to the rest of the team.

Due to previous experience in research projects a good sense of time needed for each task was available, this resulted in an accurate time management. Regarding the project planning, shown in Figure 2, the tasks were defined too superficial at the beginning which resulted in a lack of progress overview. These tasks have been divided in smaller subtasks to easier keep track of the progress. Just before the midterm report, compiling the report and presentation took more time than expected which resulted in a backlog in the deep research and business idea. By increasing the workload, we managed to get back on schedule.

7.2 Belbin test

In the beginning of the semester a Belbin test was performed to investigate the expected role of each group member within the team. The result showed the lack of a high score in ‘team worker’ within the group, which could lead to a lag of synergy as well as redundant and uncoordinated work. This partly appeared when the group members were working separately. Corrective measures were taken such as meetings for reviewing and group discussions about the further project development.

Thijs Bod: *Finisher, Shaper and Monitor*

Thijs was not recognised to have one dominant Belbin-role in the project. Normally, the 'Finisher' is the most dominant role, but due to writing and reading not being one of his core talents, the Finisher was less dominant. During the project and as a chairman, his less dominant roles of 'Coordinator' and 'Implementer' were more on the foreground, as well as 'Resource Investigator' and 'Plant' by collection information and generating ideas during the research phase of the project.

Killian Durieux: *Monitor, Plant and Shaper*

As a 'Monitor' Killian was able to make impartial and strategic judgments during the whole decision-making process. However, sometimes he could appear as dispassionate. During the final phase, the 'Finisher' was his dominant role in correcting spelling, grammar and by actively contributing to finding a right structure for the report.

Jonathan Greco: *Resource investigator, Plant and Shaper.*

The roles of 'Resource Investigator' and 'Plant' enabled Jonathan to be creative in the project and generated multiple ideas during project, for example during the creation of the business idea. As the 'Plant' role he lost sometimes track of structure and deadlines, but during the final phase of the project he gave a significant contribution in the review process.

Alina Reuter: *Coordinator, Shaper and Implementer.*

The rules of being a strong 'Coordinator' and 'Implementer´ were noticeable during the whole project. Alina kept track of the time management and delegated work appropriately. In delegating she also took a lot of work for her own. Her 'Shaper' role ensured that the team kept moving forward and did not lose focus, as she was convinced of her ability to finish the project successfully. The role of 'Shaper' could sometimes collide with the role of 'Plant' from the other group members.

7.3 General

To improve the teamwork a review moment has been performed after the midterm report. All the members have reviewed each other on the following aspects: technical contribution

(quality and quantity), willingness to build on each other's ideas, team process, leadership, positive attitude and initiative. A discussion has been held afterwards to clarify the feedback.

7.3.1 **Thijs**

The research topic has been of special interest to me, however reading and writing are not my core talents, so there were some collisions between my interests and my talents. In English, report writing and in project management I gained new knowledge and skills, since 'thesis' writing, including the use of formal English, are partly new to me. My design skills were useful in the visual parts of the project such as video editing, logo and presentation making. Some of the feedback I received from the midterm review moment is the tendency to investigate and bring forward more information than needed. In the second half of the semester I worked on sticking more to the project goals and being selective in what to present. As a team in communication we sometimes encountered some obstacles when working on different formats for the report and having to align them afterwards. Regarding the supervision in the project, I would like to receive more constructive criticism and involvement.

Group evaluation:
Thijs put great effort throughout the project and was willing to take over tasks. He wrote parts of the CE introduction, made deep researches about the 'Finch buildings' and 'Park 20/20', created the logo and edited the video. Thijs was struggling from time to time with English grammar which had to be corrected through the peer reviews. As chairmen in the second half of the semester he was criticised for long meetings but improved this in the end. Overall Thijs was motivated and willing to work. He did a great contribution to the project.

7.3.2 **Killian**

The research topic was not my first pick. I wanted to participate in an EPS project, mainly for working in an international environment with people from different countries and studies. I did hope to participate in a "Green"/sustainable technology based project, and the circular economy came the closest to this topic. It was also a chance for me to experience a research project, to see if this type of work would suit me. However, I felt I did not receive the same fulfilment from this project as I normally get from e.g. designing and building a technical

product. This could be due to the relative lack of technical content or the deliverables of a research project. Nonetheless, staying here has been an amazing experience where I learned a lot about staying, alone, in a foreign country.

Group evaluation:

Killian has a great curiosity. Regarding the project, he was a huge contribution questioning and reflecting the work of others critically. That was helpful especially for this research topic. At the beginning of the project he was criticised for his negative appearing attitude. He was responsible for the Belbin documentation at the beginning, WBS, report structure, contributed in the introduction to the CI and deep researches of 'Villa Asserbo' and 'De Fire Styrelser'. Additionally, he put significant effort in reviewing the work of others and compiling the reports, as well as being secretary for the first part of the semester. Overall Killian strongly increased his performance during the semester and is mainly involved in the success of the project.

7.3.3 **Jonathan**

Between the different projects available this semester, this was the one I was most interested in, as well as the one most suitable according to my study background, so I'm happy I was chosen for it. I did this report as a part of my bachelor thesis, which was a good way to gather material and prepare for my thesis, but dividing my time between the two things resulted to be more complicated than I first thought. I struggled in the beginning, but got better as soon as I found the rhythm and prioritized finishing the report over the thesis. Quality and quantity wise, I reckon myself have given a good contribution to the project, while an area that could be improved is quicker delivery time for the different assignments, as I sometime got stuck on details and struggled to finish some of the assignments.

Group evaluation:

Jonathan is the only research investigator in the group according to the Belbin results. This could be seen during the research task, since this is where interest might be lost after the initial phase. He struggled sometimes in the beginning with time management and distraction and

was therefore criticised, but this got significantly improved over the remaining time of the project. He contributed with the CI introduction, the best practice case 'Pluspuu Talot', the business idea and the conclusion chapter. Additionally, he reviewed large parts of the deep researches. Overall Jonathan increased his performance during the project and acted as the secretary for the second part of the semester. His effort contributed, as the other members, to the success of the project.

7.3.4 **Alina**

The research topic was my first choice and I am glad about the opportunity to work on it. As I was not used to team working in a big context like this, I sometimes might have put the other team members under stress. Probably this is due to the fact that I am focused on deadlines and on the will to finish the task until then. I appreciated being the chairmen for the first half of the semester. I experienced and learned a lot through this. I expected some critical thoughts and input to improve.

Group evaluation:

Alina is a dedicated and hard worker. She coordinates tasks and looks to it that they are done in time. She putted a lot of effort in the website for the project and the project management part, including time management. She also worked on the deep research of the Bionorica Headquarter, on the business idea and acted as the chairlady in the first part of the semester. Alina is sometimes criticised for being an individual worker, resulting in a loss of benefits that team work can offer. She was praised for her skill to make decisions and did a great contribution to the project.

8 Bibliography

A.Enggaard, 2015. *kontorhus-paa-kalvebod-brygge.* [Online]
Available at: http://www.enggaard.dk/aktuelle_projekter/kontorhus-paa-kalvebod-brygge

ABC anchors, 2012. *facit-homes.* [Online]
Available at: http://www.abcanchors.co.uk/tag/facit-homes/

Abidin, N., Yusof, N. & Othman, A., 2013. Enablers and challenges of a sustainable housing industry in Malaysia. *Construction Innovation,* 12(1), pp. 10-25.

ALBA Group, 2017. *Recycling in Deutschland.* [Online]
Available at: https://www.alba.info/unternehmen/presse/pressemappe/zahlen-und-fakten-zur-kreislaufwirtschaft-in-deutschland.html
[Accessed 29 10 2017].

Amazon, 2017. *Amazon: Amazon Prime Air.* [Online]
Available at: https://www.amazon.com/Amazon-Prime-Air/b?node=8037720011
[Accessed 24 11 2017].

Arkitema, 2014. *nexus-cph-kalvebod-brygge.* [Online]
Available at: https://arkitema.com/da/arkitektur/erhverv/nexus-cph-kalvebod-brygge

Art Aqua, 2017. *Art Aqua.* [Online]
Available at: http://www.artaqua.de/unternehmen/aktuelles/details/news/wasserwand-und-gruene-wand-fuer-bionorica.html
[Accessed 29 10 2017].

Asla, 2010. *Park 20/20: A Cradle to Cradle Inspired Masterplan.* [Online]
Available at: https://www.asla.org/2010awards/612.html
[Accessed 13 11 2017].

ASME, 2012. *printing-houses.* [Online]
Available at: https://www.asme.org/engineering-topics/articles/construction-and-building/printing-houses

ASME, 2012. *printing-houses.* [Online]
Available at: https://www.asme.org/engineering-topics/articles/construction-and-building/printing-houses

AusAID, 2009. *Structuring public-private partnerships (PPPs),* s.l.: NEDA.

Backhausen, 2017. *Backhausen.* [Online]
Available at: http://www.backhausen.com/unternehmen/tradition/
[Accessed 28 10 2017].

Bankvall, L., Bygballe, L. E., Dubois, A. & Jahre, M., n.d. *Interdependence in supply chains and projects in construction, Supply Chain Managament: An International Journal.* s.l.:s.n.

Bauhaus Portal, 2017. *Aktuelle Bautrends in Deutschland.* [Online]
Available at: https://www.hausbau-portal.net/aktuelles-aus-der-baubranche/hausbau-kataloge/aktuelle-bautrends-in-deutschland-841.html
[Accessed 31 10 2017].

bba, 2008. *Neubau eines Verwaltungsgebäudes in Neumarkt - Ganzheitlich betrachtet.* [Online]
Available at: https://www.bba-online.de/fachartikel/energie/ganzheitlich-betrachtet/#slider-intro-1
[Accessed 28 10 2017].

BDE, 2016. *Branchenbild der deutschen Kreislaufwirtschaft - Kompetetn, Leistungsstark, Zukunftsorientiert.* Berlin: s.n.

Beckers, F., 2016. *Kreislaufwirtschaft im Baubereich - Wo sind wir? Welche sind die nächsten Schritte?.* Aachen: s.n.

Bepakt, 2017. *Bepakt: Map of Packaging-Free Supermarkets.* [Online]
Available at: http://bepakt.com/packaging-free-supermarkets/maps/
[Accessed 23 11 2017].

Best practice business, 2017. *Best practice business.* [Online]
Available at: http://www.best-practice-business.de/handel-unverpackte-lebensmittel/
[Accessed 05 11 2017].

Bionorica SE, 2017. *Bionorica.* [Online]
Available at: http://english.bionorica.de/
[Accessed 28 10 2017].

Bionorica SE, 2017. *Bionorica - At a glance.* [Online]
Available at: http://english.bionorica.de/en/company/at-a-glance.html
[Accessed 28 10 2017].

Bionorica SE, 2017. *Bionorica - Company history.* [Online]
Available at: http://english.bionorica.de/en/company/our-history.html
[Accessed 28 10 2017].

BMUB, 2017. *Neu Regeln für mineralische Abfälle und Bodenschutz.* [Online]
Available at: https://www.bmub.bund.de/pressemitteilung/hendricks-tragfaehige-loesung-fuer-umgang-mit-bauabfaellen/
[Accessed 30 10 2017].

Braungart, P. D. M., 2012. *Cradle to Cradle Design.* Brussels: s.n.

Braungart, P. D. M., 2014. *Ein Leben im Überfluss und ohne Abfall - das Prinzip der Nährstoffkreisläufe.* Berlin: s.n.

Britannica, 1998. *Kattegat.* [Online]
Available at: https://www.britannica.com/place/Kattegat

Buildinggreen, 2010. *avoiding-global-warming-impact-insulation.* [Online]
Available at: https://www.buildinggreen.com/news-article/avoiding-global-warming-impact-insulation

Bygningsstyrelsen, 2017. *kalvebod-brygge-opp.* [Online]
Available at:
https://www.bygst.dk/(X(1)S(vw0celqx3ihkqayxqvwhig2z))/projekter/kalvebod-brygge-opp/?AspxAutoDetectCookieSupport=1

Bygningsstyrelsen, 2017. *projekter/kalvebod-brygge-opp.* [Online]
Available at:
https://www.bygst.dk/(X(1)S(vw0celqx3ihkqayxqvwhig2z))/projekter/kalvebod-brygge-opp/?AspxAutoDetectCookieSupport=1

C2C BIZZ, 2014. *C2C BIZZ – Guide to Cradle to Cradle (C2C) inspired Business Sites.* Luxembourg: s.n.

C2C centre, 2017. *C2C centre - Bionorica.* [Online]
Available at: http://www.c2c-centre.com/project/bionorica
[Accessed 29 10 2017].

C2C-Centre, 2017. *Park 20|20.* [Online]
Available at: http://www.c2c-centre.com/project/park-2020
[Accessed 13 December 2017].

Circulair Nederland, 2016. *Alliander – Energie voor circulair.* [Online]
Available at: https://www.circulairondernemen.nl/oplossingen/alliander-energie-voor-circulair
[Accessed 6 10 2017].

Construction History Society, 2014. *What is construction history?.* [Online]
Available at: http://www.constructionhistory.co.uk/about-construction-history-society/construction-history/

Dagensbyggeri, 2015. *87553-caverion-forventer-stigende-opp-omsaetning.* [Online]
Available at: http://www.dagensbyggeri.dk/artikel/87553-caverion-forventer-stigende-opp-omsaetning

Dagensbyggeri, 2015. *87553-caverion-forventer-stigende-opp-omsaetning.* [Online]
Available at: http://www.dagensbyggeri.dk/artikel/87553-caverion-forventer-stigende-opp-omsaetning

De Architect, 2017. *Finch Buildings.* [Online]
Available at: http://www.dearchitect.nl/projecten/finch-buildings
[Accessed 11 11 2017].

De Groot Vroomshoop, 2017. [Online]
Available at: http://degrootvroomshoop.nl/
[Accessed 2017 11 10].

De Mors BV, 2017. [Online]
Available at: http://www.demors.nl/
[Accessed 2017 11 10].

DEPA, 2015. *Publikation%20om%20Cirkulær%20Økonomi.pdf.* [Online]
Available at:
https://byg.di.dk/SiteCollectionDocuments/Arrangementer%20og%20nyhedsdocs/Publikation%20om%20Cirkulær%20Økonomi.pdf

Derbigum, 2017. *co2-absorbant-roofing.* [Online]
Available at: https://www.derbigum.com/en/waterproofing/co2-absorbant-roofing

Designboom, 2013. *entileen-demonstrates-how-to-print-a-home/.* [Online]
Available at: https://www.designboom.com/architecture/entileen-demonstrates-how-to-print-a-home/

DESSO, 2017. *DESSO.* [Online]
Available at: http://www.desso.com/media/66951/desso_consumer_logo_rgb_190_x_165.jpg
[Accessed 28 10 2017].

Desso, 2017. *Desso - Cradle to Cradle.* [Online]
Available at: http://www.desso.com/c2c-corporate-responsibility/cradle-to-cradle/
[Accessed 28 10 2017].

Desso, 2017. *Desso - Suppliers.* [Online]
Available at: http://www.desso.com/c2c-corporate-responsibility/suppliers/
[Accessed 28 10 2017].

Duurzaamgebouwd, 2017. *Delta Development Group.* [Online]
Available at: https://www.duurzaamgebouwd.nl/partners/c/delta-development-group
[Accessed 13 December 2017].

ECOtech, 2016. *WEC-case-study-Energy-Building-Codes.* [Online]
Available at: https://wec-policies.enerdata.net/Documents/cases-studies/WEC-case-study-Energy-Building-Codes.pdf

Eentileen, 2012. *print-house-42.jpg?1441895399.* [Online]
Available at:

https://images.adsttc.com/media/images/55f1/93ed/99e9/ba68/b100/007c/slideshow/print-house-42.jpg?1441895399

Eentileen, 2012. *villa-asserbo/12.* [Online]
Available at: http://eentileen.dk/projekt/villa-asserbo/12

Elektro Lück, 2017. *Elektro Lück.* [Online]
Available at: http://www.elektrolueck.de/
[Accessed 31 10 2017].

Ellen MacArthur Foundation, 2015. *Delivering the circular economy. A toolkit for policymakers.,* s.l.: ELLEN MACARTHUR FOUNDATION.

Ellen Macarthur Foundation, 2015. *TOWARDS A CIRCULAR ECONOMY: BUSINESS RATIONALE FOR AN ACCELERATED TRANSITION,* s.l.: Ellen MacArthur Foundation.

Ellen Macarthur Foundation, 2017. *Circular Economy Overview.* [Online]
Available at: https://www.ellenmacarthurfoundation.org/circular-economy/overview/characteristics
[Accessed 20 09 2017].

EPEA, 2017. *EPEA - The Cradle of Cradle to Cradle.* [Online]
Available at: http://www.epea-hamburg.org/de
[Accessed 31 10 2017].

EPSON, 2016. *Umweltschutz im Büro: Epson stellt Papier-Recycling- und Produktionsmaschine auf der CeBIT 2017 vor.* [Online]
Available at: https://www.epson.de/insights/article/umweltschutz-im-buro-epson-stellt-papier-recycling-und-produktionsmaschine-auf-der-cebit-2017-vor
[Accessed 23 09 2017].

EPSON, 2017. *PaperLab.* [Online]
Available at: http://global.epson.com/innovation/paperlab/
[Accessed 23 09 2017].

European Commission, 2017. *Circular economy.* [Online]
Available at: https://ec.europa.eu/growth/industry/sustainability/circular-economy_de
[Accessed 20 09 2017].

European Environmet Agency, 2016. *Circular economy to have considerable benefits, but challenges remain.* [Online]
Available at: https://www.eea.europa.eu/highlights/circular-economy-to-have-considerable
[Accessed 28 9 2017].

European Green Office, 2011. *Existing Labels and Certifications.* [Online]
Available at: http://www.eugreenoffice.eu/existing_labels_and_certifications_1

European Union, 2017. *BOTNIA-ATLANTICA.* [Online]
Available at: https://www.botnia-atlantica.eu/frontpage/
[Accessed 28 9 2017].

Farmbauer, 2017. *Ingenieurbüro Farmbauer.* [Online]
Available at: http://www.ib-farmbauer.de/
[Accessed 31 10 2017].

Federane, 2014. *Case_Study_Danish_Building_Code_Final.* [Online]
Available at: http://www.fedarene.org/wp-content/uploads/2016/03/Case_Study_Danish_Building_Code_final.pdf

Fensterplatz, 2007. *Die Bionorica Firmenzentrale.* [Online]
Available at: http://www.fensterplatz.de/fenster/fenster.nsf/MainPage?OpenFrameset&Frame=Mainframe&Src=/fenster/fenster.nsf/0/2F2E2EAB8F18B83CC125731B0038B106%3FOpenDocument
[Accessed 28 10 2017].

Finch Buildings, 2016. *Productfolder winter 2016,* s.l.: Finch Buildings B.V..

Finch Buildings, 2017. [Online]
Available at: http://www.finchbuildings.com/
[Accessed 10 11 2017].

Finch Buildings, 2017. *Leiden opent eerste Finch Building.* [Online]
Available at: http://www.finchbuildings.com/leiden-primeur/
[Accessed 10 11 2017].

Finch Buildings, 2017. *Product brochure September 2017,* s.l.: Finch Buildings B.V.

Finnish Forest Association, 2016a. *Finnish Forest Association: Finnish forest resources.* [Online]
Available at: https://www.smy.fi/en/forest-fi/forest-facts/finnish-forests-resources/
[Accessed 08 11 2017].

Finnish Forest Association, 2016b. *Finnish Forest Association: Forest ownership.* [Online]
Available at: https://www.smy.fi/en/forest-fi/forest-facts/finnish-forests-owned-by-finns/
[Accessed 08 11 2017].

Finnish Forest Industries, 2017. *Finnish Forest Industries: Demand for domestic wood.* [Online]
Available at: https://www.forestindustries.fi/in-focus/forests-and-wood-supply/demand-for-domestic-wood/
[Accessed 14 11 2017].

Fonecta, 2017. *Finder: Pluspuu Talostudio.* [Online]
Available at:
https://www.finder.fi/Talopaketteja/Pluspuu+Talostudio/Helsinki/yhteystiedot/2275285
[Accessed 06 11 2017].

Geotechnologien, 2017. *Die Rohstoffsituation in Deutschland.* [Online]
Available at: http://www.wertvolle-erde.de/rohstoffe-ressourcen-reserven/die-rohstoffsituation-in-deutschland
[Accessed 30 10 2017].

Goethe, 2017. *Goethe.* [Online]
Available at: https://www.goethe.de/resources/files/jpg447/81.jpg
[Accessed 03 11 2017].

Goldapple, L., 2016. *Atlas of the Future - Let there be (intelligent) light.* [Online]
Available at: https://atlasofthefuture.org/project/pay-per-lux/
[Accessed 23 09 2017].

Google pictures, 2017. *Google pictures.* [Online]
Available at: https://www.google.fi/search?client=firefox-b-ab&dcr=0&biw=766&bih=715&tbm=isch&sa=1&ei=FHz8WYfNMYPZwALA9K2wAw&q=milch+joghurt+glas+k%C3%BChlschrank&oq=milch+joghurt+glas+k%C3%BChlschrank&gs_l=psy-ab.3...69769.72021.0.72229.12.11.0.0.0.0.212.1132.0j6j1.7.
[Accessed 03 11 2017].

Google pictures, 2017. *Google pictures.* [Online]
Available at: https://www.google.fi/search?client=firefox-b-ab&dcr=0&tbm=isch&q=supply+chain+packages+less+store&spell=1&sa=X&ved=0ahUKEwjuzcaGvKLXAhUCblAKHYtECKsQBQgiKAA&biw=1536&bih=732&dpr=1.25#imgrc=7fCk_l3KJAExxM:
[Accessed 04 11 2017].

Google pictures, 2017. *Google pictures.* [Online]
Available at: https://image.freepik.com/fotos-kostenlos/brown-recycelbar-papiertuten-brown-recycelbar-papiertuten_1205-478.jpg
[Accessed 04 11 2017].

Goverment of the Netherlands, 2016. *A circular economy in the Netherlands by 2050,* s.l.: The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs.

Government of the Netherlands, 2017. *From a linear to a circular economy.* [Online]
Available at: https://www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy
[Accessed 20 09 2017].

Grammer Solar, 2017. *Grammer Solar.* [Online]
Available at: http://www.grammer-solar.com/de/unternehmen/partner.html
[Accessed 28 10 2017].

Greenbuilding, 2009. *Ohne schlechtes Gewissen konsumieren,* s.l.: s.n.

GROUPE RENAULT, 2017. *Competitive circular economy.* [Online]
Available at: https://group.renault.com/en/commitments/environment/competitive-circular-economy/
[Accessed 23 09 2017].

Handelsblatt, 2017. *Cradle to Cradle - Ewiger Kreislauf.* [Online]
Available at: http://www.handelsblatt.com/technik/energie-umwelt/cradle-to-cradle-ewiger-kreislauf-seite-2/2963612-2.html
[Accessed 29 10 2017].

Hartmann, P. M., 2017. *Resources waste and circular economy.* Erlangen: s.n.

Hebbes, 2017. *5 tips om de EPC-waarde van je huis te doen dalen.* [Online]
Available at: http://www.hebbes.be/artikel/5-tips-om-de-epc-waarde-van-je-huis-te-doen-dalen

heritage, 2017. *denmark.* [Online]
Available at: http://www.heritage.org/index/country/denmark

Herman Miller, 2017. *Herman Miller.* [Online]
Available at: https://www.hermanmiller.co.uk/design-resources.html
[Accessed 28 10 2017].

Hermelink, D. A. H., 2016. *Treibt die Energieeffizenz die Baukosten in die Höhe.* Berlin: s.n.

Het Groene Brein, 2017. *How is a circular economy different from a linear economy?.* [Online]
Available at: https://kenniskaarten.hetgroenebrein.nl/en/knowledge-map-circular-economy/difference-circular-linear-economy/
[Accessed 9 29 2017].

IEA, 2008. *Energy Efficiency Requirements in Building Codes, Energy efficiency policies for new buildings,* Paris: International Energy Agency.

IMSA Amsterdam for Circle Economy, 2013. *Unleashing the Power of Circular Economy,* s.l.: s.n.

International montary fund, 2016. *GDP per country.* [Online]
Available at:
http://www.imf.org/external/pubs/ft/weo/2016/02/weodata/weorept.aspx?pr.x=22&pr.y=6&sy=2010&ey=2016&scsm=1&ssd

JUST Creative, 2009. *What makes a good logo?.* [Online]
Available at: http://justcreative.com/2009/07/27/what-makes-a-good-logo/
[Accessed 16 10 2017].

KEA, 2016.
Katrine%20Gulddahl_7ARK_specialerapport_Cirkulært%20Byggeri.pdf?sequence=1&isAllowed=y. [Online]
Available at:
https://opgaver.kea.dk/bitstream/handle/20.500.11869/62/Katrine%20Gulddahl_7ARK_specialerapport_Cirkulært%20Byggeri.pdf?sequence=1&isAllowed=y

Koeln Deutz, 2017. *Koeln Deutz.* [Online]
Available at: https://www.koeln-deutz.de/images/kunden/483_IMG_5248.JPG
[Accessed 03 11 2017].

Korsche Metallbau, 2017. *Korsche Metallbau.* [Online]
Available at: http://www.metallbau-korsche.de/
[Accessed 31 10 2017].

Lacy, P., 2015. *The Circular Economy. Great Idea, But Can It Work?.* [Online]
Available at: https://www.forbes.com/sites/valleyvoices/2015/01/20/the-circular-economy-great-idea-but-can-it-work/#2ee93bc22e28
[Accessed 28 9 2017].

Loohuis, 2017. [Online]
Available at: http://www.loohuisgroep.nl/
[Accessed 2017 11 10].

Lutter, S., Giljum, S. & Randles, M., 2016. *Regionale Kreislaufwirtschaft - Inputpapier für die Implementierung von RESET2020,* Wien: Forschungsgruppe "Nachhaltige Ressourcennutzung", Institute for Ecological Economics, Wirtschaftsuniversität Wien (WU).

Melymbrose, J., 2016. *7 Tips on What Information to Put on Your Business Card.* [Online]
Available at: https://business.tutsplus.com/articles/7-tips-on-what-information-to-put-on-your-business-card--cms-25194
[Accessed 16 10 2017].

Mettke, A., 1995. *Wiederverwendung von Bauelemten des Fertigteilbaus.* Taunusstein: s.n.

Ministry of the Environment, 2016. *Ministry of the Environment: Legislation on building products.* [Online]
Available at: http://www.ym.fi/en-US/Land_use_and_building/Legislation_and_instructions/Legislation_on_building_products
[Accessed 13 11 2017].

Ministry of the Environment, 2017b. *Ministry of the Environment: The National Building Code of Finland.* [Online]
Available at: http://www.ym.fi/en-

US/Land use and building/Legislation and instructions/The National Building Code of Finl and
[Accessed 13 11 2017].

Ministry of the Environment, 2017c. *Ministry of the Environment: Legislation on the energy efficiency of buildings.* [Online]
Available at: http://www.ym.fi/en-US/Land use and building/Legislation and instructions/Legislation on the energy efficiency of buildings
[Accessed 13 11 2017].

Molio, 2015. *ugens-projekt-nexus-cph.* [Online]
Available at: https://molio.dk/bygnet/nyhed/article/ugens-projekt-nexus-cph/

Motlagh, J. N., 2009. *SlideShare.* [Online]
Available at: https://de.slideshare.net/jmotlagh/project-requirements-what-are-they-and-how-do-you-know-you
[Accessed 20 09 2017].

MSCN, 2017. *MSCN.* [Online]
Available at: http://www.mscn-gmbh.de/
[Accessed 31 10 2017].

Muenchner Kindl, 2017. *Muenchner Kindl.* [Online]
Available at: http://das-muenchner-kindl.de/wp-content/uploads/SAM_2847.jpg
[Accessed 03 11 2017].

Murray, N., 2017. *The Nordic Web: The Nordic online grocery market landscape.* [Online]
Available at: https://thenordicweb.com/the-nordic-online-grocery-market-landscape/
[Accessed 24 11 2017].

Net Balance Foundation, 2017. *Substainable Construction.* [Online]
Available at: http://www.supplychainschool.org.au/themes/sustainable-construction.aspx

Nordicpropertynews, 2016. *first-sod-of-60000-sqm-office-building-on-kalvebod-brygge.* [Online]

Available at: https://nordicpropertynews.com/article/547/first-sod-of-60000-sqm-office-building-on-kalvebod-brygge

Nylund, R. & Ehrs, M., 2017. *Course Book for EPS Autumn Semester 2017,* Vaasa: s.n.

OECD, 2014. *poverty-rate.* [Online]
Available at: https://data.oecd.org/inequality/poverty-rate.htm

Ollikaisen Hirsirakenne, 2017a. *Ollikainen: Incredibly ecological.* [Online]
Available at: http://ohr.fi/en/rakentajalle/ymparisto/
[Accessed 07 22 2017].

Ollikaisen Hirsirakenne, 2017b. *Ollikainen: Superior quality and special proprieties.* [Online]
Available at: http://ohr.fi/en/rakentajalle/hirsi-rakennusmateriaalina/
[Accessed 07 11 2017].

Package free shop, 2017. *Package free shop.* [Online]
Available at: https://packagefreeshop.com/pages/how-we-pack
[Accessed 05 11 2017].

Park 20|20, 2010. *Opweg naar een Cradle to Cradle park 20|20,* s.l.: Park 20|20.

Park 20|20, 2017. *PARK 20|20 ONTHULT TIJDELIJKE INVULLING MET NATUUR, MOESTUIN EN SPORT.* [Online]
Available at:
http://www.park2020.com/nl/nieuws/56/park_20%7C20_onthult_tijdelijke_invulling_met_natuur,_moestuin_en_sport/
[Accessed 13 December 2017].

Pellfolk, S. & Glader, A., 2017. *CIRCULAR ECONOMY,* Vaasa: s.n.

Perkins, L., 2012. *Backhausen Weaves Innovation with New C2C Certified Fabric.* [Online]
Available at: http://www.c2ccertified.org/news/article/backhausen
[Accessed 28 10 2017].

Pluspuu, 2017a. *Pluspuu: Pluspuu.* [Online]
Available at: http://www.pluspuu.fi/en/pluspuu/
[Accessed 06 11 2017].

Pluspuu, 2017c. *Pluspuu: Modern Log Houses.* [Online]
Available at: http://www.pluspuu.fi/en/
[Accessed 07 11 2017].

Pluspuu, 2017d. *Pluspuu: Log house structures.* [Online]
Available at: http://www.pluspuu.fi/en/rakenteet/
[Accessed 07 11 2017].

RePack, n.d.. *RePack: Once you RePack, you always come back.* [Online]
Available at: https://www.originalrepack.com/service/
[Accessed 23 11 2017].

Rossi, M., Charon, S., Wing, G. & Ewell, J., 2006. *Design for the Next Generation - Incorporating Cradle-to-Cradle Design into Herman Miller Products,* Medford: Massachusetts Institue of Technology and Yale University.

Schüco International KG, 2017. *Schüco.* [Online]
Available at: https://www.schueco.com/web2/teamworknet-de
[Accessed 28 10 2017].

Schüco, 2017. *Bionorica AG - The phytoneering company,* s.l.: s.n.

Scott, L., 2014. *Park 20|20, Amsterdam: Born to Be Recycled.* [Online]
Available at: https://urbanland.uli.org/sustainability/park-2020-amsterdam-born-recycled/
[Accessed 13 December 2017].

Singhal, S., 2014. *B/S/H/ Inspiration House, Park 20|20 in Hoofddorp, The Netherlands by William McDonough + Partners.* [Online]
Available at: https://www10.aeccafe.com/blogs/arch-showcase/2014/05/13/bsh-inspiration-house-park-2020-in-hoofddorp-the-netherlands-by-william-mcdonough-partners/
[Accessed 13 December 2017].

State of green, 2015. *copenhagen-no-2-in-europe-for-air-quality.* [Online]
Available at: https://stateofgreen.com/en/profiles/state-of-green/news/copenhagen-no-2-in-europe-for-air-quality

StateofGreen, 2017. *intelligent-energy.* [Online]
Available at: https://stateofgreen.com/en/sectors/intelligent-energy

Statista, 2017a. *Statista: Annual turnover of the construction industry in Finland from 2010 to 2014.* [Online]
Available at: https://www.statista.com/statistics/432309/turnover-of-the-construction-industry-in-finland/
[Accessed 21 11 2017].

Statista, 2017b. *Statista: Annual turnover of the building construction industry in Finland from 2010 to 2014.* [Online]
Available at: https://www.statista.com/statistics/433147/turnover-building-construction-industry-finland/
[Accessed 21 11 2017].

Statista, 2017c. *Statista: Total number of employees in the construction industry in Finland from 2010 to 2014.* [Online]
Available at: https://www.statista.com/statistics/432470/number-employees-construction-industry-finland/
[Accessed 21 11 2017].

Statista, 2017d. *Statista: Total number of employees in the building construction industry in Finland from 2010 to 2014.* [Online]
Available at: https://www.statista.com/statistics/433312/number-employees-building-construction-industry-finland/
[Accessed 21 11 2017].

Steelguru, 2017. *Steelguru.* [Online]
Available at: http://steelguru.com/uploads/news/heidelberg-cement-india-infrastructure-development-cement-infra-news-india-infra-sector-india_14933.png
[Accessed 28 10 2017].

Store shops, 2017. *Store shops.* [Online]
Available at: https://www.stores-shops.de/typo3temp/pics/e7f74c32c4.jpg
[Accessed 05 11 2017].

Stuchtey, D. M. R., 2016. *Circular Economy: Werte schöpfen, Kreisläufe schließen.* [Online]
Available at: https://www.mckinsey.de/files/20160125_circular_economy_germany.pdf
[Accessed 23 09 2017].

Superwood, 2017. *det-digitale-hus--asserbo.* [Online]
Available at: http://www.superwood.dk/referencer/enfamilie-boliger/det-digitale-hus--asserbo

Superwood, 2017. *miljoe-og-baeredygtighed.* [Online]
Available at: http://www.superwood.dk/fordele-fakta/fakta/miljoe-og-baeredygtighed

Tay, E., 2010. *Green Future Solutions - Michael Braungart Shares Cradle to Cradle Principles at the Asia Sustainable Packaging Summit 2010.* [Online]
Available at: http://www.greenfuture.sg/2010/11/08/michael-braungart-shares-cradle-to-cradle-principles-at-the-asia-sustainable-packaging-summit-2010/
[Accessed 23 10 2017].

The Guardian , 2017. *Circular economy isn't a magical fix for our environmental woes.* [Online]
Available at: https://www.theguardian.com/sustainable-business/2017/jul/14/circular-economy-not-magical-fix-environmental-woes-global-corporations
[Accessed 1 10 2017].

Trafik-, Bygge- og Boligstyrelsen, 2017. *BR15.* [Online]
Available at: http://bygningsreglementet.dk/br15_03_id67/0/42

UPM, 2011. *house-made-of-upms-wisa-spruce-plywood-by-danish-architets-provides-a-new-model-for-sustainable-building.* [Online]
Available at: http://www.wisaplywood.com/Applications/References/Pages/house-made-of-upms-wisa-spruce-plywood-by-danish-architets-provides-a-new-model-for-sustainable-building.aspx

UPM, 2011. *house-made-of-upms-wisa-spruce-plywood-by-danish-architets-provides-a-new-model-for-sustainable-building.* [Online]
Available at: http://www.wisaplywood.com/Applications/References/Pages/house-made-of-upms-wisa-spruce-plywood-by-danish-architets-provides-a-new-model-for-sustainable-building.aspx

Utopia, 2017. *Utopia.* [Online]
Available at: https://utopia.de/app/uploads/2016/04/Plastikfrei-Laeden-p-Unverpackt-Kiel-Berit-Ladewig-1280x600jpg-640x300.jpg
[Accessed 03 11 2017].

Utopia, 2017. *Utopia.* [Online]
Available at: https://utopia.de/app/uploads/2016/05/brotdose-glas-z-manufactum-160520.jpg
[Accessed 04 11 2017].

Valley, 2015. *Amsterdamse metropoolregio krijgt met 'Valley' de eerste circulaire business development hub ter wereld.* [Online]
Available at: https://www.circularvalley.com/kopie-van-news
[Accessed 30 11 2017].

Van Der Meer, L., 2015. *BARRIERS AND DRIVERS IN COMMERCIAL DISTRICT,* s.l.: University Utrecht.

Van Schaik, J., 2017. [Interview] (7 11 2017).

Warmcel, 2017. *sustainability/.* [Online]
Available at: http://www.warmcel.co.uk/warmcel/sustainability/

Wellsconcrete, 2017. *ChaseRadue3-29-17-02.gif?resize=423%2C200&ssl=1.* [Online]
Available at: https://i0.wp.com/www.wellsconcrete.com/wp-content/uploads/2017/03/ChaseRadue3-29-17-02.gif?resize=423%2C200&ssl=1

Wiki, 2015. *List_of_European_countries_by_average_wage.* [Online]
Available at: https://en.wikipedia.org/wiki/List_of_European_countries_by_average_wage

Wiki, 2017. *List_of_forests_in_Denmark.* [Online]
Available at: https://en.wikipedia.org/wiki/List_of_forests_in_Denmark

Wiki, 2017. *Physical_geography.* [Online]
Available at: https://en.wikipedia.org/wiki/Geography#Physical_geography

Wiki, 2017. *Public–private_partnership.* [Online]
Available at: https://en.wikipedia.org/wiki/Public–private_partnership

William McDonough + Partners, 2010. *Park 20|20 Master Plan.* [Online]
Available at: http://mcdonoughpartners.com/projects/park-2020-master-plan/
[Accessed 13 11 2017].

William McDonough + Partners, 2010. *Towards a Cradle to Cralde park 20|20,* s.l.: William McDonough + Partners.

WirtschaftsWoche, 2014. *Deutschland erzeugt mehr als die Hälfte seines Stroms aus Sonnenenergie.* [Online]
Available at: http://www.wiwo.de/technologie/green/tech/solar-rekord-deutschland-erzeugt-mehr-als-die-haelfte-seines-stroms-aus-sonnenenergie/13549534.html
[Accessed 30 10 2017].

WISA plywood, 2017. *certificates/Pages/default.aspx.* [Online]
Available at: http://www.wisaplywood.com/WisaDownloads/certificates/Pages/default.aspx

Wittchen, K. B. & Kragh, J., 2016. *Danish building typologies and building stock analyses,* Copenhagen: Aalborg university.

Wood Products, n.d.a. *Wood Products: Wood is a renewable natural resource.* [Online]
Available at: http://woodproducts.fi/content/wood-a-renewable-natural-resource
[Accessed 14 11 2017].

Wood Products, n.d.b. *Wood Products: Strong wood from the northern coniferous forest belt.* [Online]
Available at: http://woodproducts.fi/content/strong-wood-northern-coniferous-forest-belt-1
[Accessed 13 11 2017].

World Green Building Council, 2016. *About Green Building: The benefits of green buildings.* [Online]
Available at: http://www.worldgbc.org/benefits-green-buildings

World Green Building Council, 2017. *About Green Building: Rating tools.* [Online]
Available at: http://www.worldgbc.org/rating-tools

WRAP, 2017. *WRAP and the circular economy.* [Online]
Available at: http://www.wrap.org.uk/about-us/about/wrap-and-circular-economy
[Accessed 20 09 2017].

Xero flor, 2017. *Xero flor.* [Online]
Available at: http://www.xeroflor.sg/home/
[Accessed 28 10 2017].

ZAE Bayern, 2017. *ZAE Bayern.* [Online]
Available at: https://www.zae-bayern.de/en/the-zae-bayern.html
[Accessed 31 10 2017].

Appendix

This chapter contains the following: scope management, time management and resources, cost management, project monitoring and control, Belbin questionnaire, quality management, risk management, personal goals and the corporate identity.

Appendix 1: Scope management

The scope management contains the information required for the project and the requirements from the stakeholders for the product/ project.

Project mission and vision

Mission: Research as a team the implementation of CE in the European construction industry as our EPS project at Novia University of Applied Science. The aim is to improve our engineering skills and our international and interdisciplinary teamwork skills.

Vision: A report which gives a clear insight in the current implementation of CE in the European construction industry and can contribute to the project 'Circular Economy – A Game Changer for the Wood Building Industry' as part of the EU funded Botnia-Atlantica 2018-2020 project.

Project objectives and requirements

"Requirements are a negotiated set of measurable customer wants and needs." (Motlagh, 2009) Therefore Table 17 shows the SMART goals of the project, which are specific, measurable, attainable, realistic and time limited.

Table 17. SMART goal

Specific	The EPS project Circular Economy within the construction industry will contain both a research part and an implementation exercise. The research part will act as a pre-research for an (The) upcoming (Circular economy 'A game changer of the wood industry) research project carried out by the R&D department from Novia University of Applied Science. The following goals have been set for this project:
	
	Research
	
	• Basic information of CE and the construction industry
	• Find examples, best practice cases and concepts of CE properties
	  o Maintenance of CE buildings
	  o Disassembly of CE buildings
	  o Technical CE solutions for renovating non CE buildings
	  o Re-use and recycling solutions for old buildings
	• Explanations of the found examples/best practice cases/concepts
	  o Influencing factors for implementation of CE for construction SME's
	  ▪ Government influence (Europe and country)
	  ▪ End Users involvement (Europe and country)
	  ▪ Industries vision, resources and know-how (Europe and country)
	  o Specific reasons for success or failure of found CE examples/ best practice cases/ concepts
	
	Implementation exercise
	
	- Create a business idea/ plan for an CE product/ service

Measurable	The results will be presented in a midterm report and presentation, final report and presentation, in a video and on a website.
Attainable	All team members accepted the project charter.

Realistic	A duration of 15 weeks with a team of 4 members is realistic for this project.
Time limited	The project has to be finished before 18th December 2017.

Project management triangle

The project management triangle in Figure 121 shows the scope, time and budget performance of the project.

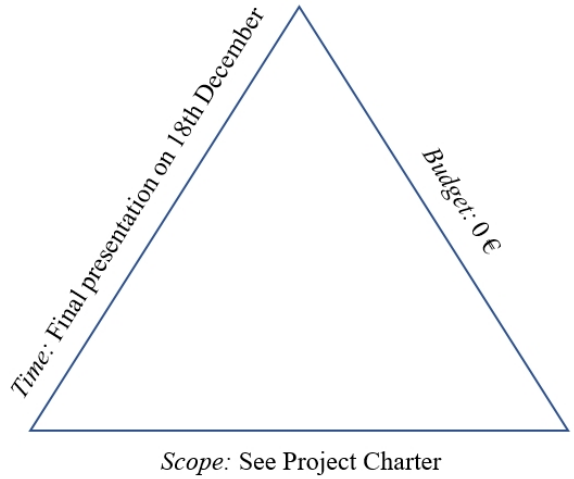


Figure 121. Project management triangle

Limitations & exclusions

This chapter contains the limitations and exclusions within the project. The limitations can be influences, consequences and/ or shortcomings that cannot be controlled. The most common limitations are sickness/ absentee of project members or client and insufficient resources due to changing environments. These limitations are implemented into the risk analysis.

The exclusions are parts which, in agreement with the client, will not be included in the project. The following parts/ topics will not be included:

- The website does not contain information about the following research (Circular economy: a game changer for the wood building industry) and will not be designed as a format for said research.

- The business idea will not be confined to the construction industry. Any sector can be used.
- A maximum amount of six examples will be chosen for deep research due to our limited resources. Companies, technical solutions and down cycling will not be the focus of the project, due to wishes of the client and the abundance of examples trough already wide-spread implementation.

Project deliverables and milestones

This project will deliver the following documents:

- Midterm report
- Final report
    - Research report
    - Business plan/ idea
- Video about EPS project
- Website about business plan/ idea or pre-research

The important milestones for the project are:

- Presentation at BAR (Business and Research) in Vaasa on 15th September 2017
- Deadline Midterm-Report on 17th October 2017
- Midterm-Presentation on 24th October 2017
- Deadline Final-Report on 11th December 2017
- Final-Report on 18th December 2017

Work breakdown structure

The overall work breakdown structure is shown in Figure 122. The project ‘CE’ is divided into five phases being: ‘Initiation Phase’, ‘Orientation Phase’, ‘Planning Phase’, ‘Execution Phase’ and ‘Closing Phase’.

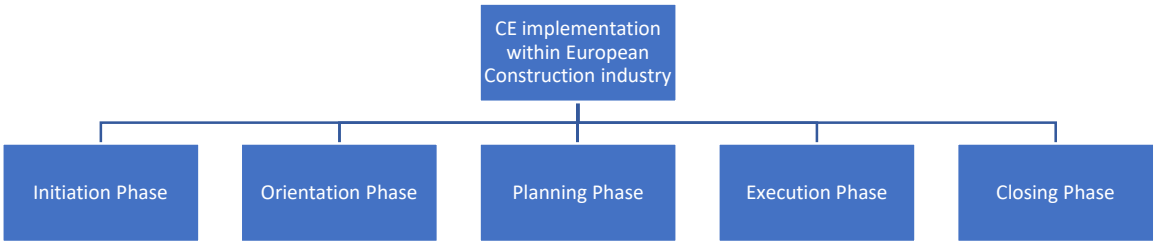


Figure 122. Work breakdown structure

Appendix 2: Time management and resources

Time management contains the schedule and information about the team and teamwork.

Input, tools and techniques, output

To fulfil the activities stated in the Gantt-chart, inputs, tools and techniques and outputs/deliverables are defined as well as responsible persons. The general structure is shown in Figure 123.

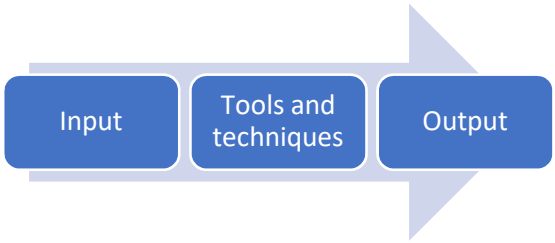


Figure 123. Input, tools and techniques and output

Organization plan

Figure 124 shows the Organization plan for the project. The team consisting of Thijs Bod, Killian Durieux, Jonathan Greco and Alina Reuter as well as the team coach Stefan Pellfolk, customer Annika Glader, project management teacher Roger Nylund and English teacher Hanna Latva are listed.

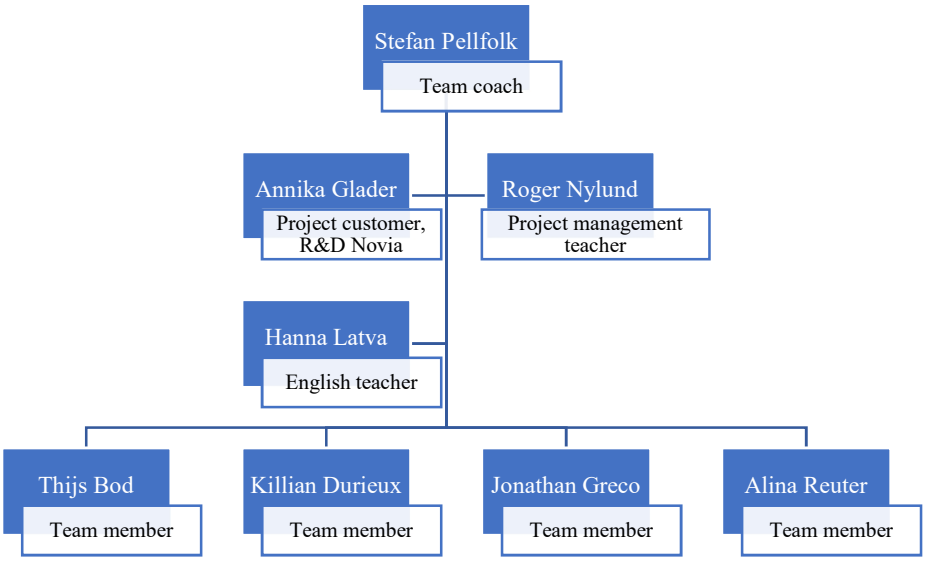


Figure 124. Organization plan

Table 18 gives a short presentation about the team members, their field of studies, nationality and home university.

Table 18. Team members

	Name: **Alina Reuter** Age: 22 Field of studies: Industrial Engineering (M.B.A. & Eng.) Home University: University of Applied Sciences Rosenheim, Rosenheim – Germany
	Name: **Jonathan Greco** Age: 25 Field of studies: Business Administration (B.B.A.) Home University: Novia University of Applied Sciences, Vaasa – Finland

	Name: **Killian Durieux** Age: 22 Field of studies: Mechanical engineering (B. Eng.) Home University: The Hague University of Applied Sciences, Delft – Netherlands
	Name: **Thijs Bod** Age: 23 Field of studies: Industrial Product Design Engineering (B. Eng.) Home University: Saxion University of Applied Sciences, Enschede – Netherlands

Stakeholder analysis

Table 19 shows the stakeholder analysis. The stakeholders, their goals, motivations and interests are identified, their power and influence are rated and an appropriate action, including the win-win strategy is worked out.

Table 19. Stakeholder analysis

Stakeholder	Goals, motivations and interests	Power	Influence	Action	Win-win strategy
Team coach, Stefan Pellfolk	Gaining overview over CE in the European Construction industry, High interest in a new business idea	High	High	Manage closely	Sign off key decisions and stages via existing channels

Customer, Annika Glader	Having a helpful contribution for the EU project	High	High	Manage closely	Sign off key decisions and stages via existing channels
EPS coordinator, Roger Nylund	Seeing team working together and according to project management tools	Low	High	Keep informed	Deliver project management report on time
English teacher, Hanna Latva	Academic written report according to Novia UAS rules	Low	High	Keep informed	Keep informed about work progress and handing in finished text documents

Figure 125 visualizes Table 19, by putting the stakeholders in different quadrants; ‘keep satisfied’, ‘manage closely’, ‘keep informed’ and ‘monitor (minimum effort)’.

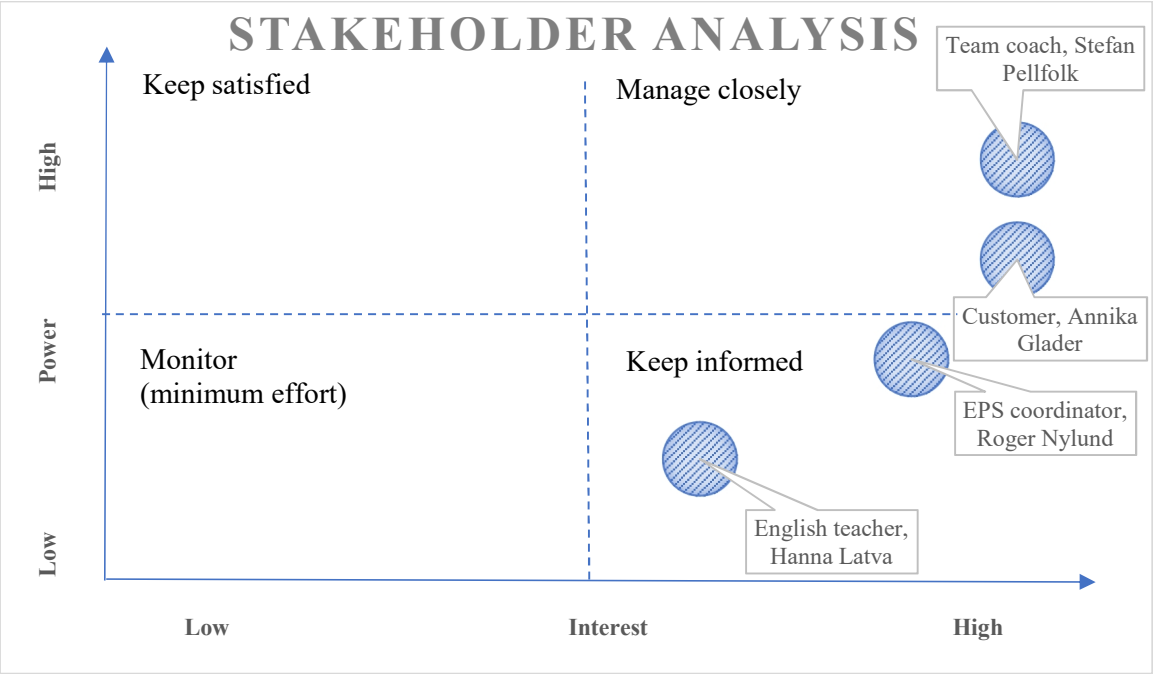


Figure 125. Stakeholder analysis

Communication plan

Table 20 shows how the project team will communicate to important parties telling which information will be exchanged.

Table 20. Communication plan

Audience	**Information**	**Method**	**Frequency**	**Who is responsible**
Team coach, Stefan Pellfolk	Detailed project status	Meeting	Weekly	Chairmen
Customer, Annika Glader	Information about research	Meeting, E-Mail	As required	Project team
EPS coordinator, Roger Nylund	Information about Project management	Meeting, E-Mail	As required	Project team

English teacher, Hanna Latva	Status of Midterm-/Final-Report	Meeting, E-Mail	As required	Project team

Appendix 3: Project monitoring and control

This chapter contains the basis rules of teamwork and team roles.

Chairmen and Secretary

The midterm report divides the project in a 2-time span. The position of chairmen and secretary changes at that point.

First period (until midterm report): *Chairmen:* Alina Reuter, *Secretary:* Killian Durieux

Second period (after midterm report): *Chairmen:* Thijs Bod, *Secretary:* Jonathan Greco

Weekly meetings

The team agreed on weekly meetings with the team coach Stefan Pellfolk. Meetings with the customer Annika Glader are not periodically fixed, but arranged when necessary.

Agenda

One day before the team meeting the chairmen has to pass around an agenda.

Minutes of Meeting (MoM)

Every team meeting is logged by the secretary in the minutes of meeting.

Rules

The team agreed on the following rules:

Meeting related:

- There will be one meeting every week with team coach Stefan Pellfolk (and Annika Glader as needed)

- Chairmen uploads the agenda for the next meeting at least 24h before the next meeting
- Secretary uploads MoM (Minutes of Meeting), a summary of the last meeting, within 3 days after a meeting
- A 5-minute rule occurs to all the meetings
- During the meeting, instant messaging is forbidden
- Informing others about absenteeism is a must
- There will be at least one meeting every week for discussing issues and splitting up new tasks

Task related:

- The work will be spitted up equally and according to interest of each team member (as far as possible)
- Everybody follows the timetable and tasks on the given schedule/agenda/checklist
- There will be a weekly peer review which means that every work being done bill be checked by another person giving feedback
- The working language is English

Platforms and software:

- The agenda and MoM's are uploaded on OneDrive
- The platform to share information and documents is Office 365
- The platform for the project planning is GanttProject

Appendix 4: Belbin Questionnaire

The Belbin questionnaire is a commonly used tool to find the most likely role of a group member within a team. The result is not definitive, so changes from the prospected roles is a possibility. This chapter will contain a short overview of the possible roles and what they tend to do. Afterwards the results of the project group will be evaluated to find strengths and possible threats from weaknesses.

Overview

Resource Investigator

Uses their inquisitive nature to find ideas to bring back to the team.

Strengths: Outgoing, enthusiastic. Explores opportunities and develops contacts.

Allowable weaknesses: Might be over-optimistic, and can lose interest once the initial enthusiasm has passed.

Don't be surprised to find that: They might forget to follow up on a lead.

Teamworker

Helps the team to gel, using their versatility to identify the work required and complete it on behalf of the team.

Strengths: Co-operative, perceptive and diplomatic. Listens and averts friction.

Allowable weaknesses: Can be indecisive in crunch situations and tends to avoid confrontation.

Don't be surprised to find that: They might be hesitant to make unpopular decisions.

Coordinator

Needed to focus on the team's objectives, draw out team members and delegate work appropriately.

Strengths: Mature, confident, identifies talent. Clarifies goals.

Allowable weaknesses: Can be seen as manipulative and might offload their own share of the work.

Don't be surprised to find that: They might over-delegate, leaving themselves little work to do.

Plant

Tends to be highly creative and good at solving problems in unconventional ways.

Strengths: Creative, imaginative, free-thinking, generates ideas and solves difficult problems.

Allowable weaknesses: Might ignore incidentals, and may be too preoccupied to communicate effectively.

Don't be surprised to find that: They could be absent-minded or forgetful.

Monitor Evaluator

Provides a logical eye, making impartial judgements where required and weighs up the team's options in a dispassionate way.

Strengths: Sober, strategic and discerning. Sees all options and judges accurately.

Allowable weaknesses: Sometimes lacks the drive and ability to inspire others and can be overly critical.

Don't be surprised to find that: They could be slow to come to decisions.

Shaper

Provides the necessary drive to ensure that the team keeps moving and does not lose focus or momentum.

Strengths: Challenging, dynamic, thrives on pressure. Has the drive and courage to overcome obstacles.

Allowable weaknesses: Can be prone to provocation, and may sometimes offend people's feelings.

Don't be surprised to find that: They could risk becoming aggressive and bad-humoured in their attempts to get things done.

Implementer

Needed to plan a workable strategy and carry it out as efficiently as possible.

Strengths: Practical, reliable, efficient. Turns ideas into actions and organises work that needs to be done.

Allowable weaknesses: Can be a bit inflexible and slow to respond to new possibilities.

Don't be surprised to find that: They might be slow to relinquish their plans in favour of positive changes.

Results

The results of each team member are shown in Figure 126 – Figure 129.

Thijs Bod

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	0	0	3	2	0	3	0	2
2	1	3	1	3	1	0	0	1
3	0	3	1	2	1	1	1	1
4	1	2	1	1	0	1	1	3
5	0	3	0	1	3	1	0	2
6	2	1	0	2	3	0	0	2
7	2	1	0	0	0	1	3	3
Tot	6	13	6	11	8	7	5	14

think act

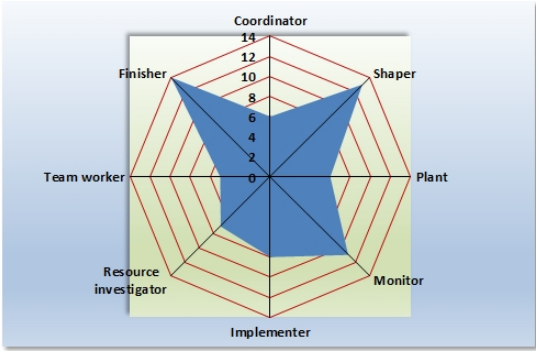


Figure 126. Belbin Questionnaire result Thijs Bod

Killian Durieux

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	0	2	2	5	1	0	0	0
2	1	4	2	3	0	0	0	0
3	0	0	2	4	0	1	0	3
4	0	1	2	1	2	2	2	0
5	0	3	0	1	0	2	0	4
6	0	0	3	2	5	0	0	0
7	0	1	2	3	2	0	0	2
Tot	1	11	13	19	10	5	2	9

think act

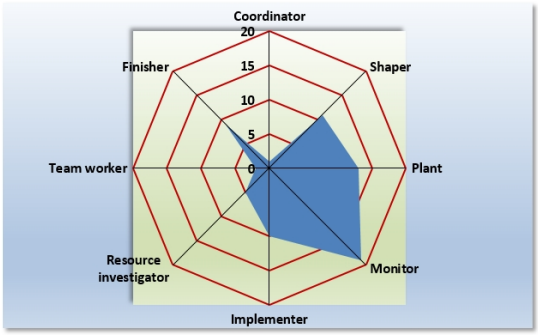


Figure 127. Belbin Questionnaire result Killian Durieux

Jonathan Greco

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	0	2	0	0	0	4	4	0
2	0	3	4	0	0	3	0	0
3	2	0	2	0	0	3	3	0
4	0	2	3	0	0	3	2	0
5	2	0	2	0	0	4	0	2
6	0	1	0	5	0	4	0	0
7	1	3	3	0	0	2	0	1
Tot	5	11	14	5	0	23	9	3

think act

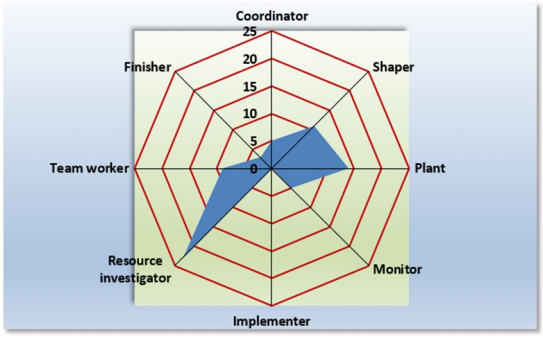


Figure 128. Belbin Questionnaire result Jonathan Greco

Alina Reuter

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	2	2	0	2	3	0	1	0
2	3	2	0	1	1	2	0	1
3	1	1	0	0	3	2	1	2
4	1	2	0	1	1	2	1	2
5	3	3	0	0	3	0	0	1
6	1	2	1	1	1	0	2	2
7	3	2	0	0	1	3	0	1
Tot	14	14	1	5	13	9	5	9

think act

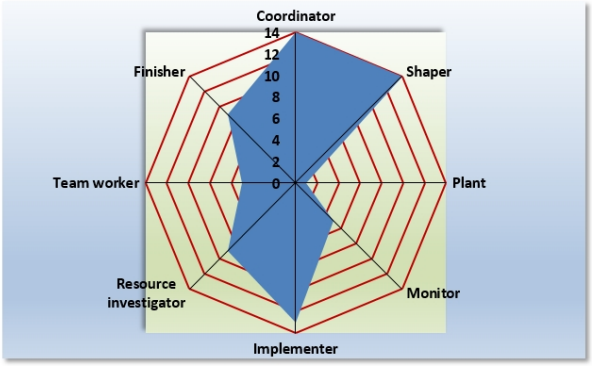


Figure 129. Belbin Questionnaire result Alina Reuter

Evaluation of results

Group evaluation

As a team, we cover most roles and therefore aspects that a group might need. The only role that is lacking in the group is Team Member. This might become a challenge, since the tendency to work by yourself and splitting tasks could drive the team apart. Teamwork as a challenge was also an outcome of the group's Ofmans quadrant. This threat must be dealt with in the project by certain rules, such as review moments and meetings/groupwork sessions.

Another possible threat might be the inclusion of shaper as a role with all the group members. This urge to arrange and the drive to do might cause some clashes within the team. This is something that has to be monitored to make sure it will not impact the group dynamics and/or the end result.

Single evaluation

Thijs Bod, *Finisher, Shaper, and Monitor*. Thijs can have a good contribution towards the end of the project and help shape & control the projects progress.

Killian Durieux, *Monitor, Plant and Shaper.* Killian can bring a critical view to the project by reviewing progress, bringing new ideas and shaping them.

Jonathan Greco, *Resource investigator, Plant and Shaper.* Jonathan can bring a fresh, new and positive influence by finding new and creative ideas and then giving form to them.

Alina Reuter, *Coordinator, Shaper and Implementer*. Alina can bring guidance to the group by dividing tasks, making decisions and make sure the team works as efficiently as possible.

Appendix 5: Quality management

To ensure the quality of the work, the team collected different methods and procedures that will be used to accomplish the task. The ideas listed under 'quality assurance and control' show how the team constantly take care of staying on the right track.

Quality plan - methods and procedures

The following methods and procedures will be used in order to fulfil the task:

General tools:

- Every team member works 37,5 hours each week on the project (according to EPS rules)
- The team, consisting of four people, makes use of every team members knowledge and skills

Research tools:

- Research on the internet, e.g. reports, documents, websites, etc.
- Research in databases, e.g. reports and books in the library and online
- Contact with people working in the field of construction industry and circular economy, e.g. interviews with representatives of companies that have applied circular economy in some way

Quality plan – search terms

A search plan can be made in order to improve the efficiency during the research and as a guideline for searching. The search plan will contain the topics/ subjects which are relevant to set goals and deliverables.

The terms are divided in general search and specific example search. This division has been made to first create a large pool of examples. The second search will act as a guideline to find the reasoning/ explanation of why an example is successful or not and how it works.

General search

- CE properties
- CE maintenance
- CE disassembly
- CE Concepts/ initiatives

Specific example search

  - General information (Name, Description, Location , Age)
- Supply chain
  - Before building (Supplier network, credibility, availability, trustworthiness)
  - During building
  - After building
- Influence from
  - Law and incentives
  - Resources end user/ constructer
  - End user demand/ market value CE
  - End user involvement strategies
  - Maintenance/ Disassembly strategies
  - Company culture and know how
  - Biological / Technical cycle (Technical solutions: e.g. 3d printing wood & CE refurbishment solutions)
  - Geographical influences

Quality assurance and control

- The team stays in close contact to customer Annika Glader and team coach Stefan Pellfolk

- The team will include knowledge and skills learned from the project management lecture by Roger Nylund

- The team will draw special attention to use many different resources to make sure that the information found fulfils the task.

Appendix 6: Risk management

In order to reduce the risk, a risk analysis has been performed and a risk monitoring and control plan has been made. The risks will be handled with the use of prevention and mitigation plans.

Risk analysis

Table 21 shows the risks of the project divided into 3 categories: ‘Team-related’, ‘Task-related’ and ‘Others’. After the definition – a short description of the risk – the impact and probability are evaluated (3 = high, 2 = middle, 1 = low). If the sum of the impact and probability evaluation is above 5, the risk is considered as a high-level risk and discussed in the next chapter ‘risk elimination’. For every risk preventive measures show how to avoid these risks, whereas the corrective measures concentrate on how to deal with the risk when it has already arisen.

Table 21. Risk analysis

Risk	Definition	Impact	Probability	Preventive measure	Corrective measure
Lack of communication	Tasks may be done twice or in a wrong way.	3	1	- Keep project status up-to-date - Weekly meeting with presentation of current work progress	- Repetition of task explanation - Doing tasks twice
Language barriers	Tasks or discussions are not understood. Team members are not able to communicate or express their opinion.	3	1	- Keep working language in English - Ask for explanations	- Repetition of task explanations
Poor team dynamics	The team does not focus on the task or is not motivated. Conflicts have not been solved.	2	2	- Team development (Strengthfinder Workshop) - Develop conflict resolution plan	- Higher workload at the end of the project

Overly optimistic schedule	Schedule does not meet the actual effort that is needed.	2	1	- Ask for feedback - Add time buffer	- Higher workload
Insufficient resources	No proper resources are found.	3	2	- Search for or contact all potential resources (books, journals, universities, companies, people, …) - Ask other EPS members for ideas	- Search for more resources
Friction between project team and customer	The understanding of the tasks aim differs between the project team and the customer.	3	1	- Keep project status up-to-date - Proactively manage communication	- Repetition of clarification of project scope and goals
Scope Creep	Continuous growths of project scope.	3	2	- Work closely with customer (weekly meetings) - Define clear (SMART) project goals and the scope	- Higher workload

Lack of knowledge	Team members do not have the technical or business knowledge	2	2	- Help each other within the team - Ask other EPS members for help - Train yourself on a foreign field	- Train yourself on a foreign field
Bad planning	The project is not well planned and organized	3	3	- Ask for feedback and check plans consciously	- Higher workload
Sickness	Team members cannot fulfil their tasks because of illness	3	1	- Add time buffer	- Higher workload

Figure 6 visualises the previous table of risks. Attention should be drawn to the upper right corner as these risks have both, a high probability and high impact on the project. There are three risks having a sum above 5 of impact and probability evaluation. These risks might affect the project in a negative way:

- *Insufficient resources:* as the project is based on researching, suitable (re)sources are of great importance
- *Scope creep:* for research topics limits and borders are essential in order to find an end at some point
- *Bad planning:* no one of the team members did a project like this before, therefore no one can estimate or calculate the duration for every task

Risk elimination

For the three main risks mentioned above an elimination strategy was developed:

Insufficient resources

For a research topic, resources are of a great importance. Without suitable sources, the task cannot be accomplished. Therefore, the team has to look for several different types of sources, such as books, journals, people or companies. The support and inputs form team coach Stefan Pellfolk and customer Annika Glader has to be asked for.

Scope creep

Scope creep is the increase of tasks within a project. To minimize that risk, SMART goals have to accepted by both parties, the project team and the project owners. The sooner those tasks are defined the better for the team as they can start than with the effective project work.

Bad planning

Since no one of the team members had ever to manage a project like that it can easily occur that the important phase of planning is skipped as everyone just wants to get started right away. But still, the team members must focus on a good and realistic planning of tasks, which have to be done to not forget certain issues. Planning also includes the task splitting and the communication of those subtasks to the responsible person so every task will be accomplished and only being done once. To eliminate or minimize the risk the team has to

take some time in the beginning for creating SMART goals, and task splitting. Asking for feedback from external persons can also be a contribution. Monitoring and steady reviewing the planning is also of paramount importance.

Mitigation strategies and contingency plan

The mitigation strategy and contingency plan are included in the risk analysis in Table 20 under ‘preventive measures’ and ‘corrective measures’.

Appendix 7: Personal goals

This Bod

In the project, I would like to broaden my understanding of circular economy. For me becoming a bit more a specialist on this topic would be a desired outcome. Beside I would like to improve my English and communication skills as well as my research, documentation and management skills. It would be nice to have enjoyable conversations and have some teambuilding between and during the working ours. As a final grade a 8 of higher, on a scale from 1 to 10, would be a nice outcome.

Killian Durieux

I would like to gain new skills as far as team working goes, and improve my own weaknesses. Learning more about the subject, and more specifically the economic aspect of renewability should also give me a better perspective on the need renewability and the challenges that come with it. Working with a multidisciplinary and multinational team will be a new to me, but the biggest challenge for me is living on my own for an extended time abroad.

Jonathan Greco

As I'm soon to graduate I'd like to get warmed up before going out to the ‘real world’ so to speak. Circular Economy turns out to be a really interesting topic so I'd like to get a feel of it, which can surely turn out to be useful in future working life since the topic is currently up-to-date. Apart from the reasons I just mentioned I'd like to implement my cooperation and organizational skills as well as optimize my teamwork performance in a real-life situation. Last but not least I'd like to build friendships, networks and improve my cross-cultural communication skills as well as getting a degree at my home University.

Alina Reuter

The project provides to me the opportunity to learn and research about the circular economy and its implementation in the European Construction industry. Aside from gaining new (technical) knowledge there are a couple of other challenges as working independently in a multi-national and multi-disciplinary team. My goal is to learn about how team members can work efficiently together and what kind of soft skills are necessary for it.

Appendix 8: Corporate identity

The corporate identity of our project group contains a team name, logo, business card, website and a video.

Team name

The team name for the project is 'The Circle'. The project name aims to represent the mission and vision of the project in a minimum amount of words. Similar principles are used for creating the team name and for creating the logo, which can be seen below in Figure 130.

Logo

A study has been executed to create a logo. The logo aims to be in line with the team name and therefore represent the mission and vision of the project. Also, the features of a good logo have been taken in consideration while creating the logo. This section only shows the final result.

A good logo has the following features:

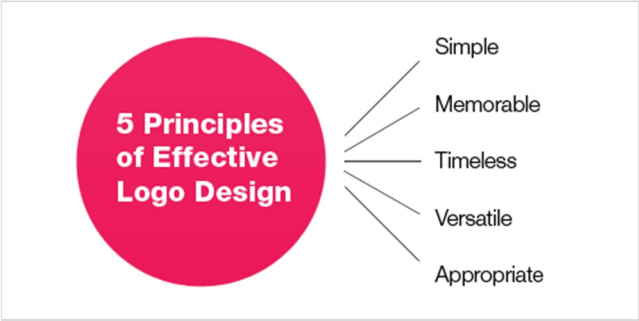


Figure 130. Features of a good logo design (JUST Creative, 2009)

The logo that has been created can be seen in Figure 131. It shows a green circle, which stands for circular economy. The leaf at the end emphasizes this. The word ‘’the’’ has been incorporated in the logo, in which the letter ‘’T’’ resembles a crane which refers to constructing a real estate object. It also aims to follow the guidelines for a good logo design.

Figure 131. The project logo

Business card

In the creation of the business card the following principles for a good business card has been taken into account:

1. Include your logo and tagline
2. Name and functional job title
3. Contact information
4. Your website
5. Social media profiles
6. White space
7. Creativity

(Melymbrose, 2016)

The business card that has been created can be seen in Figure 132 and Figure 133.

Figure 132. Business card front

Figure 133. Business card back

Website

The website of the project can be found under:

Thecircleeps.wordpress.com

The website contains all the relevant information of the project divided in 'project management', 'circular economy and its implementation in the European construction industry' and 'business idea'.

The ‘heart’ of the website is a map (designed with Google Maps) that visualizes all the CE buildings the team found in Europe. The map can be filtered by the type of house (e.g. residential buildings, office buildings, …) or by searching for a specific tag that makes the building outstanding (e.g. maintenance, usage of recyclable materials, …).

The website provides additional information about the EPS and the team as well as a gallery with pictures of the teamwork and a download page where reports or formats can be found.

Video

The video will be presented in the final report.

Mail correspondence with Johan Saarela

Mail to: Johan Saarela
19.12.2017, 18:11

Hejsan,

Jag heter Jonathan Greco och går på YH Novia i Vasa. Jag skriver mitt examensarbete om cirkulär ekonomi och ditt namn kom upp i och med ett samtal med Göran Östberg från Vasek, när vi pratat om projektet "Cirkulär ekonomi Korsholm". Jag förstod att du är utvecklingschef på Stormossen och jobbar med olika projekt, och skulle vilja få din kommentar om cirkulära ekonomins implementation i Österbotten:

- Nuvarande tillstånd
- Framtida utveckling
- Möjligheter och hinder
- Tankar kring Finlands mål att bli pionjär i cirkulär ekonomi till år 2025

Frågorna är relativt öppna och ditt bidrag skulle vara till stort nytta för mig och för slutförandet av mitt arbete. Jag är flexibel och är tillgänglig för träff om tiden finns, annars går det också bra via telefon. Om du har mycket att göra nu innan nyår kan vi försöka hålla det så kort som bara möjligt.

Hälsningar,

Jonathan Greco

YH Novia - Företagsekonomi

Mail to: Jonathan Greco
22.12.2017, 10:28

Hej Jonathan,

Här kommer korta svar på dina frågor. Jag svarar på frågorna utifrån en avfallssynvinkel.

- Nuvarande tillstånd
    - Användande av slam och bioavfall till biogas för fordon och jord är en bra början. En stor del går dock till förbränning som blivit lite av den nya deponin.
- Framtida utveckling
    - Avfalls som kan återvinnas som material kommer att minska till förbränning t.ex. bio, plast etc.
- Möjligheter och hinder
    - Möjlighet är att lagkrav kommer att kräva mer materialåtervinning.
    - Hinder är att Finlands låga befolkningsantal, långa transporter osv. gör att det blir icke kostnadseffektivt.
    - Både möjlighet och hinder är inställningen bland producenter och konsumenter, om attityden till lokal producerat och förnybart väger starkare än ekonomin så finns säkert en god möjlighet för att utveckla nya produkter.
    - En möjlighet är tjänster för olika ändamål, kan inte säga något specifikt nu just men där borde finnas en möjlighet för SME:s.
- Tankar kring Finlands mål att bli pionjär i cirkulär ekonomi till år 2025
    - Samma problematik som ovan plus långsam förvaltning och inställning ta som ex. Biobränslen till fordon blev först möjligt i och med EU:s krav på skattereform i Finland i början av 2000-talet. Eller för att nämna Uber, det är

ju också cirkulärt, man använder sin egen bil för två ändamål plus får en arbetsplats.

- Så kort svarat, knappast.

Jag åker på julledigt nu och är tillbaks på jobb igen efter den 2:a januari, men endast några dagar sen ska jag iväg igen. Så om du vill diskutera svaren skulle 2-5 januari passa bäst.

God jul och gott nytt år!

//Johan