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Introduction to Circular Economy

A toolkit for practitioners and a case study

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This thesis is aimed to be used as a handbook by companies that want to increase their circularity. The goal of the study is to provide a comprehensive big picture on circular economy that covers both general and local perspectives.

This qualitative research can be divided in two major parts. The theoretical part aims to give the reader an overview about the concept of circular economy and a toolkit of actions that promote circularity. This part was carried out as a desk research is based on literature, academic articles and previous theses about circular economy. The empirical part surveys the current state of circularity in Finland and examines a case study. This part is mainly based on expert interviews.

The findings of this study indicate that there is a paradigm shift happening in the fields of business, production and consumption. Finding effective ways to loop products and materials reduces the risks of the companies and allows them to utilise the maximum value of each resource. Instead of regarding only the raw material value, also the value of engaged in the product during processing stages should be taken into account.

Circular economy holds a vast amount of value potential in the form of reduced losses, increased stability in the materials supply and new business opportunities. Circular economy will work as a soil for new types of business ecosystems and value networks. The job creating potential is significant. According to the findings in the empirical part, the shift towards a more circular economy has already started in Finland and circularity can be an integral part of successful business.

Keywords	Circular economy, sustainability, prevention of value losses

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Tämä opinnäytetyö on suunnattu yrityksille, jotka haluavat kehittää toimintojaan kiertotalouden suuntaan. Työn tavoitteena on tarjota kattava yleiskuva kiertotaloudesta. Tämä kvalitatiivinen tutkimus koostuu teoreettisesta ja empiirisestä osasta. Teoreettinen osa esittelee kiertotalouden käsitteen ja sen toimintaperiaatteet. Se pohjautuu kirjallisuuteen aiheesta. Empiirinen osa kartoittaa kiertotalouden nykytilaa Suomessa ja syventää näkökulmaa case studyn muodossa. Se pohjautuu asiantuntijahaastatteluihin.

Teollisuudessa ja liike-elämässä on meneillään paradigman muutos. Komponenttien ja materiaalien kierron lisääminen vähentää yrityksen riskejä ja arvohävikkiä. Pelkän raaka-ainearvon sijaan yrityksen tulisi huomioida myös tuotteisiin valmistusprosessin aikana sitoutunut arvo. Kiertotalous tarjoaa merkittävää arvopotentiaalia muun muassa vähentyneen arvohävikin, ennustettavamman raaka-aineiden saatavuuden sekä uusien liiketoimintamahdollisuuksien muodossa. Kiertotalous mahdollistaa uudenlaisten liiketoimintamallien ja arvoverkostojen syntymisen. Se vaikuttaa merkittävästi myös uusien työpaikkojen syntymiseen.

Empiirisen osan havainnot osoittavat, että vaikka kiertotaloustoiminta ei ole Suomessa vielä valtavirtaa, sitä harjoitetaan jo Suomessa osana menestyvää liiketoimintaa.

Avainsanat	Kiertotalous, kestävä kehitys

Contents

1 Introduction

There is a significant change of paradigm happening in the fields of business, production and consumption. Humanity is becoming more and more aware that our current consumption rate exceeds the pace of Earth's renewal capacity. What makes this matter even more urgent is that in the near future there will be even more consumers and more demand for goods due to increasing population and economic growth in developing countries.

Our currently prevalent paradigm is based on the linear consumption model, often referred to as 'take-make-waste'. In linear economy materials and resources are collected for production and consumption on a one-way track, eventually ending up in landfills, incinerators or wastewater. This is not only ecologically short sighted, but also massive waste of economic resources.

The value chains in the linear model are often based on complex and international supply chains. They are material and energy intensive, relying on the economy of scale. However these features also make them vulnerable to increasing scarcity and price fluctuation of natural resources as well as other disturbances in the supply chain. One might say that our current economic system is broken.

There is a need for alternative production, distribution and consumption models. Circular economy is an answer to this demand and has already caught the attention of many leading businesses and industries around the globe. Finding effective ways to loop and recycle products and materials reduces risks for the company and allows them to utilise the maximum value of each resource.

Circular economy holds a huge amount of business potential. It forces companies to rethink their business processes from product design, manufacturing and distribution to their relationships to their customers and other companies. During the following years circular economy will deliver to emerging of whole new business ecosystems. This could create numerous business opportunities and new jobs to the West that has been struggling with recession and deindustrialisation.

1.1 Proposed outcomes of the thesis

The goal of this thesis is to introduce the concept and main principles of circular economy. The study is composed of two major parts: the theoretical part and the empirical part.

The theoretical part aims to give the reader an overview about what circular economy is and a toolkit of actions that a company can take to become more circular. This part is based on literature, academic articles and previous theses on circular economy. It is made to be used as course material for a joint project by Metropolia University of Applied Sciences and University of Rotterdam.

The empirical part aims to give an expert insight on the current state of circularity in Finland and performs a case study of a Finnish forest machine producing company, Ponsse. This part is based on interviews with a circular economy expert M.Sc. (Tech.) Heikki Sorasahi from Sitra and the director of R&D and Technology, Dr. Juha Inberg from Ponsse. Publications from Ponsse, such as the website, annual reports, brochures and press releases were used as additional material in the case study.

The goals of this thesis can be summarised as following:

1. A theoretical overview on the concept of circular economy followed by a toolkit.
2. Expert insights on circular economy deepened with a case study on a specific company.

Table 1. The proposed outcomes of this thesis.

Theoretical part. Outcome 1: an overview on circular economy.	Overview on the concept. (Chapter 2) A toolkit of actions to promote circularity. (Chapter 3)
Empirical part. Outcome 2: an empirical study on circular economy in Finland.	Expert insights. (Chapter 4) Case study. (Chapter 5)

As can be seen from the table above, each of these goals is composed of two parts. The purport of these components is to form together a comprehensive big picture on circular economy that covers both general and local perspectives.

1.2 The structure of the thesis

This thesis is composed of seven chapters. The first chapter contains the background of the study covering the pursued outcomes, research plan, methods and materials. The second chapter introduces the concept and its main principles. The third chapter offers a toolkit composed of practical steps that a company can take to become more circular. The fourth chapter aims to deepen the previous chapters based on expert insights on circular trajectory especially in Finland. The fifth chapter introduces Ponsse, the sample case in this study. The sixth chapter consists of the findings and analysis. The final chapter provides a summary to the topics covered in this study along with a conclusion.

1.3 Methods and materials

This qualitative research can be divided in two parts: building of the theoretical framework and the in-depth interviews. The first part is carried out as a desk research by orienting in literature, academic articles and previous theses about circular economy. The second part aims at a more practical view of the topic and is mainly based on conversations with some experts on the field.

Circularity is not new as a concept. Especially in the field of process industry companies have utilised waste and side products of other companies as their raw materials. One may say that the term ‘circular economy’ is much younger than the idea itself. However, circular economy has become the focus of attention quite recently.

Even though the concept has been described before, for instance in 1982 by Walter J. Stahel, almost all material about circular economy, at least under that name, have been published over the past five years. When exploring the material, it became very clear that circular economy is a rising trend in the business field as well as in research.

The Ellen MacArthur Foundation in co-operation with the global management consulting company McKinsey & Company have done some groundbreaking research on circular economy and brought onboard numerous global business leaders. As many other studies, such as publications by Sitra and many companies, constantly refer to the foundation’s original research, it was natural to use their reports as substantial base material.

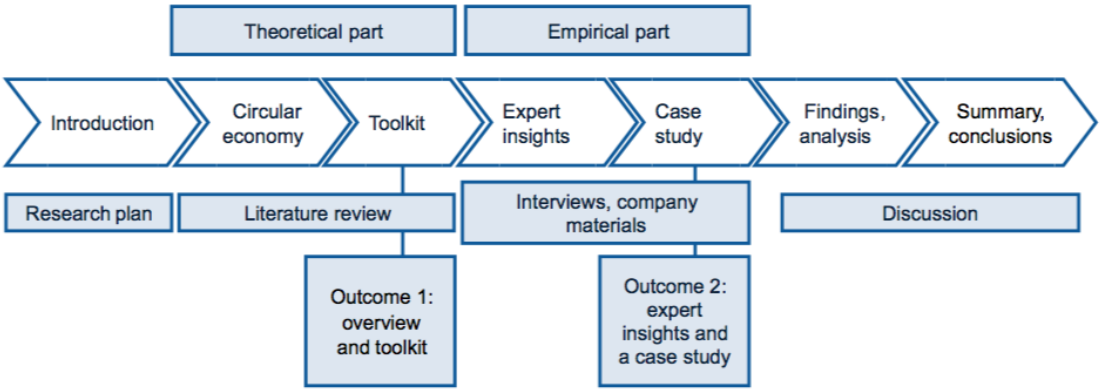

Figure 1. Bachelor's Thesis structure, proposed outcomes and methods illustrated on a timeline.

The empirical part is based on theme interviews. The first interviewee is Mr. Heikki Sorasahi, M.Sc. (Tech.), from Sitra. His special fields of expertise are responsible mining and circular economy. Sitra is a public fund founded by the Bank of Finland to promote Finland's competitiveness and the well-being of the Finnish people. Their tasks are defined by law and they report directly to the Finnish Parliament.

The organisation employs a number of experts working on projects focusing on themes such as 'resource-wise and carbon-neutral society' and 'new working life and sustainable economy'. They have produced several publications on the topic of circular economy and have hands-on knowledge on Finnish business life, which makes their outlook valuable for this research.

The case company, Ponsse, was chosen for a subject of further examination because they are one of the pioneering companies of circular economy in Finland. They represent a traditional field of business in Finland, machine workshop industry. Their operations and products are very concrete which makes their appliances of the circular concept very tangible. It is also interesting to see how the industry has changed, expanding from sole production and sales towards services and information technology.

The interviewee from Ponsse is Dr. Juha Inberg, the director of Technology and R&D. Publications from Ponsse, such as the website, annual reports, brochures and press releases were used as additional materials.

The next chapter aims to introduce the concept and core principles of circular economy, go through some drivers that have an influence on the phenomenon and review its ways of creating value and economic impact.

2 Circular economy

This chapter aims to present the concept and main principles of circular economy in comparison with the traditional ‘make-take-waste’-model and the criticism targeted towards it. The concept of ‘closed loop economy’ is briefly delineated in chapter 2.5. The next chapter describes the categorisation and the circulation of the materials.

Chapters 2.7 – 2.8 focus on societal and economic phenomena related to circular economy: the mainline drivers of the trend and the prospective effects on business economics. Chapter 2.9 briefly discusses circular economy in Finland. It also lists value leakage points and ways of promoting circularity that work as the basis of the conceptual framework applied in the empirical part of this study.

2.1 The definition and concept of circular economy

Ellen MacArthur Foundation in co-operation with global management consulting enterprise McKinsey & Company, defines circular economy as “an industrial system that is restorative or regenerative by intention and design”. (Ellen MacArthur Foundation, 2013: 7). Circular economy aims at maintaining the value of products, materials and resources as long as possible and minimising the generation of waste. (European Union Commission, 2015: 2)

The keyword in circular economy is sustainability – using resources at a rate that allows the Earth to renew them. The ultimate goal is to create renewal energy based closed resource loops, where one’s waste is another’s resource thus maximising the value of each resource. The ideology of circular economy draws analogy from biological ecosystems that are cyclical by nature. There is no such thing as ‘waste’ in the nature: as organisms die, they become nutriment to other organisms eventually ending up to enriching the soil. (Ellen MacArthur Foundation, 2013: 22-23, 27)

2.2 The linear model and planned obsolescence

The concept of circular economy is often approached in comparison to its opposite, the so called linear model which is currently prevalent. The linear consumption model is also often referred to as the ‘take-make-waste’ model.

In the linear model of resource consumption the flow of material streams works as a one-way street: companies extract the materials, use energy and labour to manufacture it into a product that is sold to the end user. When it no longer serves its purpose, it's discarded and usually ends up to landfill or incinerator.

Walter Stahel described this mindset in his Mitchell Prize winning paper already in 1982 as follows: "Fast replacement has been a persistent trend in economic history, and has gained momentum in our fashion-based consumer society ("bigger-better-faster exciting new products") as economists have become preoccupied with production optimization, economy of scale and fast depreciation and replacement. The result has been short-life, incompatible goods and products characterized by lack of reparability." (Stahel, 1982)

Examples of this kind of design are easy to find from everyday consumer goods. Often for example home electronics are built as sealed units, and getting access to a broken component requires breaking the whole thing. Replacement parts are not easily available for consumers and often their prices are out of proportion compared to the price of the overall product. Companies also often make unnecessary changes in their standards making the older parts and accessories incompatible with the newer models. (Stahel, 1982)

The current way of using resources has been mainly due to low level of resource prices relative to labour costs; there has been no major incentive for companies to change their wasteful ways. Actually through most of the past century the real resource prices have declined and using more resources - especially energy - to reduce labour costs has been a competent way to increase efficiency. (Ellen MacArthur Foundation, 2013: 15-16)

Another concept closely related to 'take-make-waste' model is planned obsolescence. Planned obsolescence was first introduced by Bernard London in his booklet, "Ending the Depression through Planned Obsolescence", in 1932 (London, 1932, 1). The idea of planned obsolescence is to artificially increase demand by limiting the product life, thus making the consumer buy new products to benefit the manufacturers. This can take form in 'forcing' the consumer to buy new goods by making the products fail by design or by persuading the customer to replace the still functional product with new, slightly different versions of it. (Keeble, 2013: 6)

As Stahel points out the result is that an ever-increasing part of our income goes to replacing of products, maintaining – not adding to – wealth. Even though it is evident that this not beneficial to the consumer let alone to the nature, planned obsolescence is still very much apparent in our modern technology society.

2.3 Criticism of the linear model

The linear model has reached its limits and is no longer adequate in many ways. First of all, we've become aware that we're approaching the limits of the world's finite resource base.

According to Club of Rome it takes almost 18 months to regenerate what we use in a year. Resource constrains and increasing amounts of waste and pollution impose increasing threats to welfare and wellbeing. They also threaten the continuity of businesses. As the club epitomises: "We are in urgent need of decoupling, or put in other words, a transition to an inclusive and circular economy." (Club of Rome 2015: 4)

What makes the need for change even more urgent is the growing population and increasing consumption. The world economy is expected to quadruple and the population of the planet to increase from current 7 billion to over 9.2 billion by 2050. (Club of Rome 2015: 11)

It's also noteworthy that the ecologic footprints in developing countries are significantly smaller than in developed countries. If everyone in the world lived by US standards, we would need four more planet Earths. (Club of Rome, 2015: 9) According to OECD the size of the middle class is growing from current 1,8 billion people to 3,2 billion by 2020 and to 4,9 by 2030. That's more than 3 billion new consumers entering the market! The majority of this growth (85%) comes from Asia. (OECD, 2010: 27)

The second notice is that the consumption-based system is inefficient in its wastefulness, entailing significant losses all along the value chain and causing other costs in the waste it creates.

According to estimations by the Ellen MacArthur Foundation, 80 % of the value of fast-moving consumer goods is currently not recovered. About 18 % is recovered for decom-

position (to be recycled or biodegraded depending on the material) and only 2 % is recovered for reuse (including direct reuse for the same or different value streams or industries). (12: Ellen MacArthur Foundation 2013: 87)

Another example: metals. Recycling metals is significantly more energy-efficient than extracting them as virgin materials, and in theory they can be used and reused endlessly. However, according to a study from 2011 considering some 60 metals, less than third of the metals had recycling rates of more than 50, and 34 metals had recycling rates lower than 1 %. (9: Club of Rome 2015: 13-14)

2.4 Key principles of circular economy

JWTIntelligence – a 'think tank' part of international marketing communication company J. Walter Thompson – has adapted the principles of circular economy from the Ellen MacArthur Foundation into the following list:

- "Design out waste.
- Understand that everything within the economy has value.
- Design with disassembly and reuse in mind, with minimal changes required to reuse components of a product.
- Differentiate between consumable and durable components. Biological materials go back into nature; durable, or technological, materials stay in use for as long as possible.
- Find ways to reuse materials across the value chain.
- Eliminate toxic chemicals, making it easier to reuse components without risk of contamination.
- Fuel the system with renewable energy.
- Build resilience through diversity.
- Adjust prices to reflect the true cost of the effort required to produce a product.
- Think in systems, taking into account how one action will impact the whole." (13: JWT 2014: 5)

To put the concept of circular economy into an even more compact form, the Ellen MacArthur Foundation has wrapped it up into three key principles:

- Preserving and enhancing natural capital. For example using renewable energy sources.
- Optimising resource yields. Maximising the utilisation of products, components and materials by sharing or looping them and by extending their life spans.
- Designing out negative externalities, such as pollution, toxins and negative health effects. (Ellen MacArthur Foundation, 2015: 22)

In the philosophy of circular economy, waste does not exist. Components of a product can be designed to fit within a materials cycle, suitable for disassembly and refurbishment, remanufacturing or repurposing. 'Waste' can be thought of as 'nutrients'; biological nutrients can be composted, and technical nutrients, such as polymers and other man-made materials, can be reused or recycled. (Ellen MacArthur Foundation 2013: 22)

To extract the maximum value from each material and resource, the cycles are kept as small and local as possible, the materials as pure as possible for easier reuse and the quality as high as possible over the longest possible time. (IMSA 2013: 14)

Another keyword in circular systems is resilience. In the circular model resilience is built through diversity. (IMSA, 2013: 14) Production systems that are capable of using many different inputs are more flexible and resilient against external shocks than systems built on throughput maximisation. (11: Ellen MacArthur Foundation 2013: p. 22-25)

2.5 Closed loop economy as described by Stahel

The main criticism towards the linear model is directed at wasteful use of materials, losses of resources along the value chain and the amounts of waste it creates. However Walter J. Stahel described an alternative method, already in 1982, that is based on resource loops, even though the term 'circular economy' wasn't yet in use.

According to Stahel, the optimisation of the total life span on materials by extending the product life actually increases wealth. It contributes to the society by increasing the amount of skilled jobs available as the weight moves from large, capital-intensive enterprises towards smaller, labour-intensive, locally integrated work units. It creates business opportunities, decreases the dependence on strategically essential materials and supports a sustainable society where the use of resources is balanced.

In Stahel's vision the economy is based on a spiral-loop system based on four activities: reuse (loop 1), repair (loop 2), reconditioning (loop 3) and recycling (loop 4). The goal of this system is to create a self-replenishing economy that minimises matter, energy flow and environmental strain without restricting economic growth or social and technical progress. Figure 2 below shows the activities of the life-replenishing systems depicted with the loops.

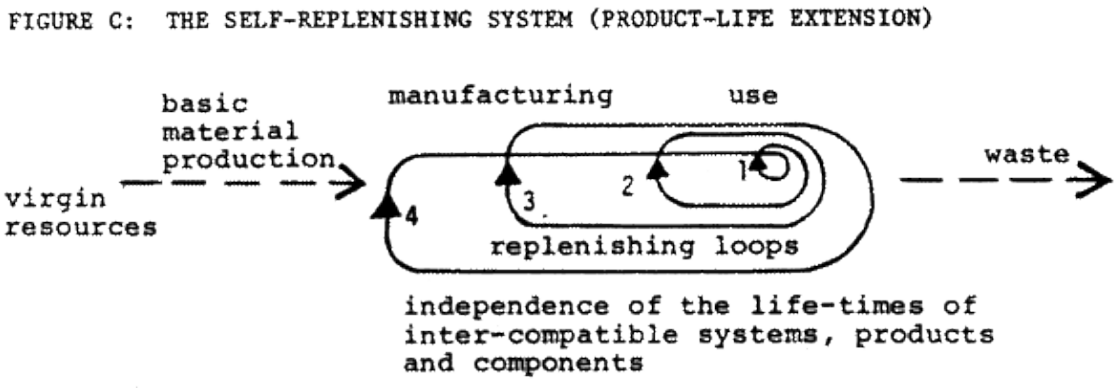

Figure 2. The self-replenishing spiral system by Stahel, 1982. http://product-life.org/en/major-publications/the-product-life-factor

As illustrated in Figure 2, another characteristic of this spiral-loop system is a built-in inertia that keeps the loops as small as possible: replace or treat the smallest possible unit only. It's more cost-effective to repair than recondition and to recondition than recycle. (Stahel, 1982)

2.6 Material cascades

One of the fundamentals of circular economy is thinking in systems – understanding how the parts influence each other and the whole. Circular economy can be depicted as a flow of material cascades and loops. The materials are categorised into two groups: biological and technological. Figure 3 below illustrates these cascades.

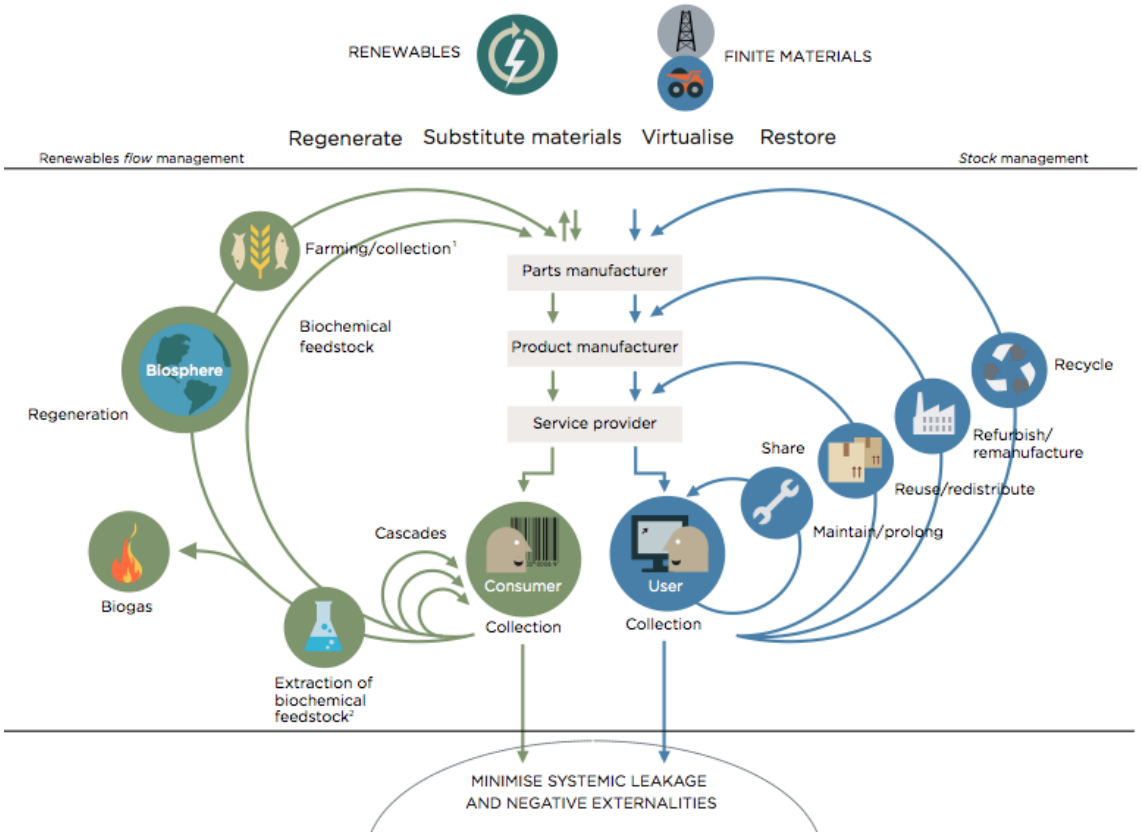

Figure 3. Picture of the loops and cascades of biological and technical materials. (Ellen MacArthur Foundation: A toolkit for policymakers: 20.)

The system of circular economy is so-called non-linear system, referring to a feedback-rich system. It means that “the combination of imprecise starting conditions plus feedback leads to multiple, often surprising consequences and to outcomes that are not necessarily proportional to the input”. (Ellen MacArthur Foundation 2012: 24)

The first key principle is to design out waste. Like in Stahel’s vision described earlier, to utilise the maximum value of energy and labour embedded in products, components and materials, it is most efficient to keep these cycles as tight as possible. This starts from the design level: the products are planned to be disassembled and reused. (Ellen MacArthur Foundation 2015: 14) Same principles can be detected from the waste hierarchy of the European Environmental Bureau depicted in figure 4 below.

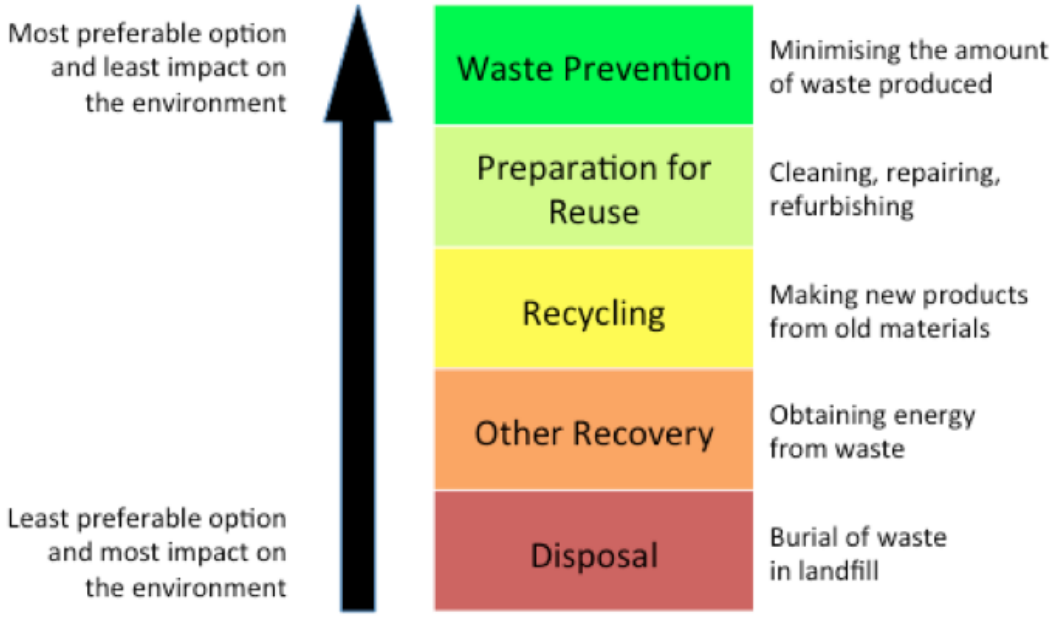

Figure 4. Waste hierarchy. European Environmental Bureau, 2015: 3.

As in Stahel's model and Ellen MacArthur Foundation's recommendations, also the EEB recommends treating the smallest unit possible for maximum efficiency and minimum impact on the environment, as can be seen from the Figure 4 above.

The second principle is differentiating the components of the product into durable and consumable categories. In some sources the terms are biological and technical materials, or 'nutrients' as they also work as inputs in other circles. This aspect is often not thought thoroughly in current product design: some products and components break prematurely while some others that are meant to be used a few times or just once, like packaging materials and textiles, can be very durable.

2.7 Drivers of the trend

Even though the concept of circular economy is more than 30 years old, it has caught the interest of big companies quite recently. There are several reasons that make circular economy essential for right now. For businesses the reasons of adopting circular concepts are mainly practical. They are mainly related to profits, securing the stability of material supply and production, enabled by technological advancement. Also governments, especially the European Union, have been getting behind the idea. Another factor

is a shift in consumers' opinions. The whole concepts of consumerism and ownership are going through a change.

2.7.1 Resource scarcity

Companies have noticed that following the linear production model makes them more vulnerable to material cost changes and supply disruptions. The demand for raw materials is increasing: according to McKinsey, in 2010 some 65 billion tonnes of raw materials entered the economic system, but by 2020 this amount is expected to increase to about 82 billion tonnes. (Ellen MacArthur Foundation 2012: 6)

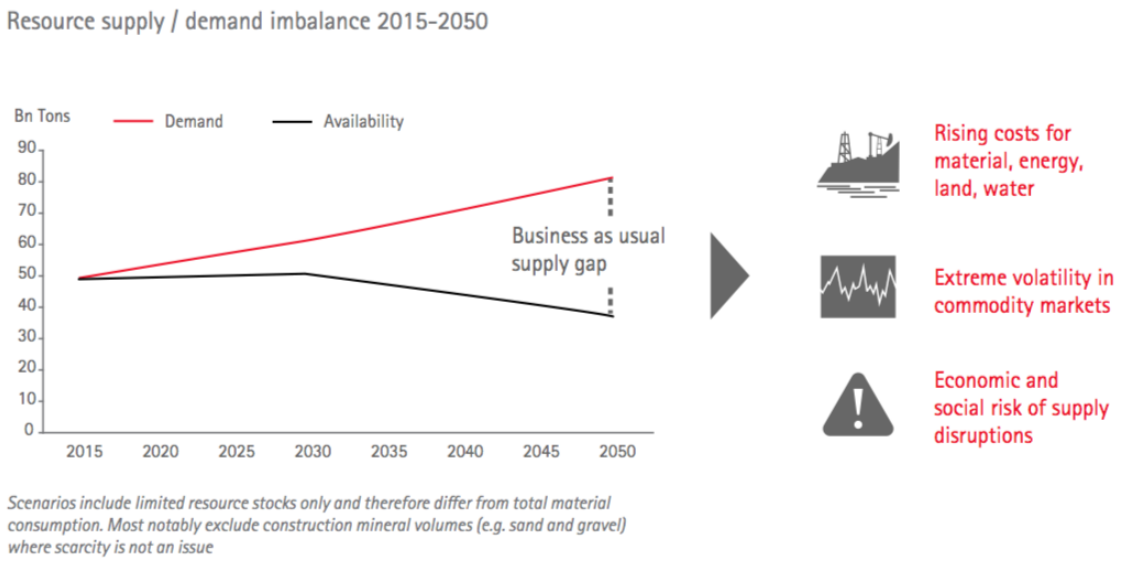

Figure 5. The widening gap between resource availability and demand. (Accenture, 2014: 9)

Experts are warning that this growing demand for resources is leading to looming shortages in supply. Reserves of several essential elements like gold, silver, indium, iridium and tungsten might run out within 50 years. Also demand for energy is increasing: according to a report by the U.S. Energy Information Administration from 2013, the global energy consumption is estimated to grow by 56% between 2010 and 2040. (JWT 2014: 9)

2.7.2 Increasing material costs and price volatility

Throughout most of the last century real resource prices, especially of fossil fuels, have been declining. (Ellen MacArthur Foundation 2013: 17) However in this century the prices of natural resources have risen dramatically. According to McKinsey's Commodity Price Index for 2011, the average prices in categories of food, non-food agricultural items, metals and energy were higher than at any time in the 20th century. (Ellen MacArthur Foundation 2012: 18)

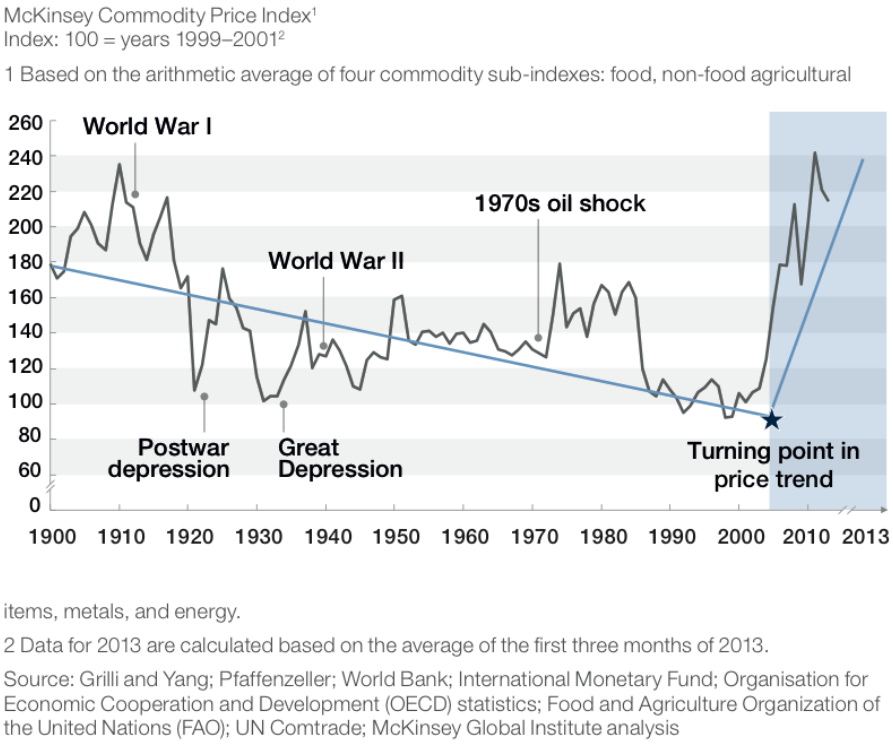

Figure 6. McKinsey Commodity Price Index: Commodity prices 1900-2010

Another problem is the volatility of resource prices. As seen in the Figure above, impetuous fluctuation in resource prices is a typical character in economy. Evidently this phenomenon increases risks for a company and makes it harder to predict the future. There are several factors that have an effect on this.

One of the reasons is that demand for many metals has increased. This has pushed the metal producers into the part of the cost curve where the cost of producing an additional unit of output is relatively high. As the easily accessible reserves of commodities like oil, gas, zinc and gold, are being exhausted, the technological requirements for tapping into

these materials have increased. In a situation like this even relatively small shifts in demand can cause disproportionately sized price swings. (Ellen MacArthur Foundation 2012: 18)

Other reasons are for example weather patterns and political crises. Another factor not to be dismissed is opening the commodity markets to stock market speculations, although there is controversy among economists about the significance of the effect.

These phenomena are realised to companies in the form of input cost spikes, increased hedging contract costs and shrunken profit margins. These costs affect not only the companies and businesses involved but the whole economic growth as this money is also 'away' from other projects, investments and research. (Ellen MacArthur Foundation 2012: 18)

2.7.3 Technological advancement

As the report by ING encapsulates, technology and the ability to innovate are important prerequisites for a circular economy. Some examples of already available technological solutions that benefit and enable circular economy are mobile internet, the internet of things, advanced materials, renewable energy and energy storage technology that levels the momentary imbalances between the demand and production of renewable energy. As the shift has just begun, more technologies are yet to come. (ING, 2015: 23)

Modern technologies, like wireless sensor networks connected to cloud-based, big-data platforms, heightened levels of centralised remote management and new levels of automation have revolutionised many industrial processes. They increase the control and flexibility in manufacturing processes, production and supply chain. (Sitra, 2015: 6) Internet of Things and Big Data tools enable companies to the track their products and parts, and identify the value and leakages that were invisible inside the value chain before. (JWT 2013: 9)

These smart technologies, combined with smart design, enable high efficiencies in disassembly and re-manufacturing. 3D printing enables printing parts and products instantaneously on demand. According to an estimation by Sitra, by 2050 the smart factory and 3D printing markets will grow up to 397 and 207 billion dollars. (Sitra, 2015: 6)

Automated sorting technology has also entered the business of waste management. For example an automated infrared sorting equipment can identify and separate different types of plastic polymers from a mingled waste stream at a rate of 6500 kg per hour. (Environmental Services Association, 2013: 8)

2.7.4 Demographic trends

As discussed in Chapter 2.3, due to population increase and economic growth in developing countries, the sheer number of new consumers is going to put a massive impact on resource demand. However, there are significant changes happening not only in the amount of the population but also inside of it. The world population has become wealthier on average since the Industrial Revolution. According to OECD the global GDP has nine folded while it has fifteen folded in Europe. (ING, 2015: 19)

Prosperity has increased especially in developed countries, but also the worldwide number of people living in extreme poverty (less than 1.25 $ per day) has declined from 50% in 1980 to 19% in 2014. (ING, 2015: 19) According to a forecast by United Nations Population Division, the global middle class will grow by 3 billion new consumers entering the market by 2030. (Ellen MacArthur Foundation 2012: 20)

Another phenomenon in demographics is urbanisation. According to the World Health Organisation about half of the world's population lives in cities and by 2030 this will rise to 60 %. This transition might work as a catalyst on the way towards greener economy as more population dense areas can host cost-effective and high quality distribution and collection systems for goods. Also systems based on sharing assets require enough affiliates to work efficiently. (JWT 2014: 9) Car sharing is one example of this.

2.7.5 Consumer preferences

Through supply and demand, consumers have a significant role in the transition towards a greener future. Many studies indicate that consumers are interested in ethical and environmental issues, and these values definitely have an influence on their decisions. According to a study by Roy et al. from 2009, the importance of ecological and environmental criteria for consumers will grow even more in the future. (Pajunen, 2015: 54)

2.7.6 Governmental pressures

The most of current legislation and institutional arrangement are based on linear thinking. Several national and EU policies have been identified as hindrances or obstacles when moving towards a more circular economy.

However, there is also effort towards the opposite direction among lawmakers, on national levels as well as on a wider scale. The need for a circular economy is increasingly acknowledged among governments. For example China has integrated circular economy into its national policies to prepare itself for resource scarcity. Germany has done the same and the European Union has similar intentions. (IMSA, 2013: 28-29) The European Commission has already planned a roadmap as a part of their Circular Economy Strategy.

2.7.7 Service economy and preferring access over ownership

More and more businesses are shifting from selling products to selling services. In this business model the products remain as corporal assets making the raw materials traceable for later re-engineering or recycling. This also provides the manufacturers more incentive to make their products more efficient and durable.

For example car manufacturers like Daimler, BMW and Ford offer cars for short-term rent to people that don't own cars. Renault, instead of selling batteries to their electric cars owners, provides them to lease for a monthly fee. Philips has started a "Pay per Lux" service with municipalities: Philips takes care of the installation and equipment, and the city pays through a performance contract. The light bulbs adjust their brightness based on natural light availability.

The concept of leasing is expanding into whole new categories of products. For example Mud Jeans offers their customers jeans for €5.95 per month. After a year the jeans can be returned and traded for a new pair. During the lease period Mud is also responsible for any repairs. (JWT, 2014: 11-13)

2.8 Business opportunities

This chapter aims to take a look at economic and business aspects of circular economy. According to estimations, circular economy has significant economic potential in the currently untapped value. It provides auspicious job creation prospects around circular activities. The transition is also going to have interesting impacts on the business ecosystem as the new business models and rising market segments challenge the established conditions.

2.8.1 The economic and job creating potential of circular economy

According to an estimation by the World Economic Forum, the shift to a circular economic model could lead to the creation of 500 000 new jobs in the EU alone. (World Economic Forum, 2014: 4) The Ellen MacArthur Foundation estimates that within five years of a shift to the circular economy, there is potential for 100 000 new jobs globally. These jobs are forecasted to open up in the fields of remanufacturing and recycling. There is also potential for new industries built around specialties like repair and new forms of waste management logistics. (JWT, 2014: 7)

The estimations vary, but it is obvious that the business potential of the transition is huge. The European Commission estimates that the net benefits of improving business efficiency are between 245 – 604 billion euros per year, while in the Ellen Mac Arthur Foundation's vision the business opportunities of circular economy could be up to 630 billion USD annually in Europe alone. (IMSA, 2013: 12)

According to Accenture, the varying results of studies estimating the overall value of circular economy are due to varying definitions of the concept. Also the calculations based on certain products, materials and industries are not always comparable to studies with different starting points. However, also Accenture concludes that circular economy has the potential to become a trillion-dollar opportunity. (Accenture, 2014: 6)

2.8.2 Value creation in circular economy

Accenture has divided the value creation of circular economy into four areas:

1. Lasting resources. This means using resources that can be continuously regenerated, like renewable energy and biochemical. This area makes up about 40% of total value.
2. Liquid markets. The use of products and assets is optimised effectively and idle time is minimised. The idea is to have the assets easily accessible and convertible between multiple users to grow the number of users that benefit from the same volume of goods. For example sharing or trading idle product and asset capacity are methods of catching up this objective. Estimated value: 10% of total.
3. Long life cycles. By increasing the product longevity through product durability, services, upgrades and remanufacturing the goods can satisfy a greater demand and provide more utility without needing additional natural resources. Extending product life creates 30% of the total value.
4. Linked value chains. Minimising resource value destruction by looping materials: linking waste outputs into useful inputs in another production process. The goal is zero waste generation. This makes 20% of the total value. (Accenture, 2014: 6)

2.8.3 Circular business models

Most companies are rooted in the linear approach to growth and their strategies, structures and operations are not built to capitalise on the circular economy. Many big corporations have already taken the initiative towards a circular model, but it means steering their course and changing their established praxes – it's not something that is built inside them.

Accenture analysed more than 120 case studies and identified five underlying business models:

1. Circular Supplies.
2. Resource Recovery.
3. Product Life Extension.
4. Sharing Platforms.
5. Products as a Service.

The Circular Supplies business fuels the loop with renewable, recyclable or biodegradable resource inputs that underpin the circular production and consumption systems. For example Royal DSM is already shifting from a virgin material supplier to a company that

reuses materials and provides new eco-friendly ones. This business model suits especially companies that deal with scarce commodities or ones with a large environmental impact. In the Figure below, Circular Supplies is illustrated with black.

Resource Recovery feeds the output of one industry into an input of another through innovative recycling and up-cycling services. Technology allows recovering the value of the resource from end of life products, leading into integrated closed loops and new industrial symbioses. This model works best for companies that produce large amounts of by-products like process industry, or where waste materials can be easily reclaimed and reprocessed. In Figure 7, the functions of Resource Recovery are presented in dark red.

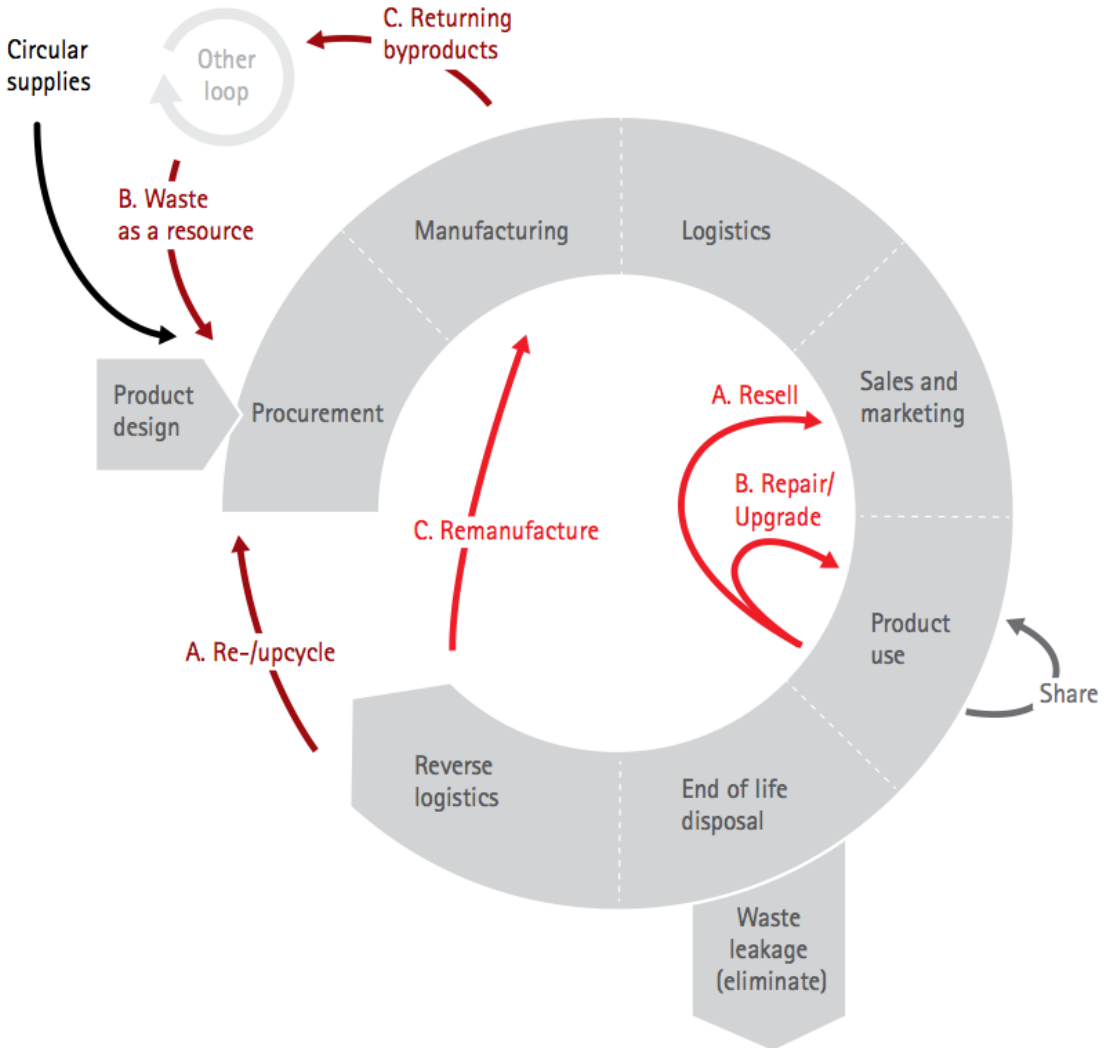

Figure 7. The five circular business models. (Accenture, 2014: 12)

The function of Product Life Extension is, as the name points out, to extend the lifecycle of products and assets. The means of maintaining, or even increasing value are repairing, upgrading, remanufacturing and remarketing products. This model fits best for capital-intensive B2B segments like industrial equipment and B2C companies that offer pre-owned products (“re-commerce”) or markets where new versions of the product offer only partial performance benefits compared to the previous. The mobile phone industry is an example of that. As a solution for example Google’s Project Ara aims to create a modular cell phone in which the components are easy to remove and replace for repair or upgrade. Product Life Extension are depicted in red.

Sharing Platforms increase the utilisation rates of products by making them accessible to more users – either individuals or organisations - by shared use, access or ownership. This model is most appropriate for companies that have products and assets with a low utilisation rate. For example ride-sharing company Lyft found a business opportunity in the remark that in the cars making trips within cities, 80% of seats were empty and started a mobile app where people who need a ride and people with cars meet. In the Figure, the sharing loop is grey.

Product as a Service is a business model in which the traditional “buy and own” is replaced with a leasing or pay-for-use arrangement. It can be applied to any part of the value chain of the picture. The benefits of this model are that it provides companies incentive to improve their product durability and upgradability, shifting their focus from volume to performance. It is most powerful for companies whose products’ cost of operation is high and that have a skill advantage in the maintenance of their products. For example Michelin has started a “tires as a service” program, in which customers pay per driven miles. (Accenture, 2014: 12-14)

Some of these business models, especially the shift from products to services, are already discernible in our society. ING Bank has adapted their vision of how moving to circular economy will change the traditional business models into the following Table.

	Conventional business models	New business models
Principles for value creation	Business continuity and profit optimisation are the overriding principles	Circular business models open the way to incorporate multiple principles for value creation. Beyond financial values, environmental and social business values are also taken into account. Creating impact is a central theme in these models.
Co-operation	Traditional buyer supplier relationships in linear supply chains. The benefits of the product or service are limited to the buyer and seller (exclusive business models).	Companies in circular supply chains often co-operate beyond traditional buyer supplier relationships that characterize linear supply chains. Instead they operate in a network of companies and institutions that often involve a strong element of collaboration and co-creation.
Transaction	Transactions emerge in B2B or B2C markets with money as medium of exchange.	New market segments arise in which consumers interact with other consumers (C2C) and in which economic agents act both as manufacturer as well as consumer (C2B). Money is the main, but not necessarily the sole, medium of exchange as goods or services are for example exchanged against energy, time or waste.
Ownership	Ownership is central for the consumption of products and services.	Access to a service is more important than ownership of a product that delivers the service.
Success measurement	Success is measured in a financial cost benefit analyses for the parties involved in the transaction (seller and buyer).	Success is measured in a cost benefit analyses that incorporated financial and non-financial values for all the stakeholders involved as well as society at large.

Figure 8. The main elements and differences between conventional and circular business models. (ING Economics Department, 2015: 28)

2.8.4 The rise of new market segments

The circular economy models usually focus on increasing economic and environmental efficiency on production processes and supply chains, but it is harder to estimate its impact on consumer behaviour. ING Bank forecasts that sharing economy will create new forms of market transactions and segments in addition to the traditional B2B (Business to Business) and B2C (Business to Consumer) markets. These new segments both create new business opportunities, but also set challenges the current business models in the B2C and B2B market.

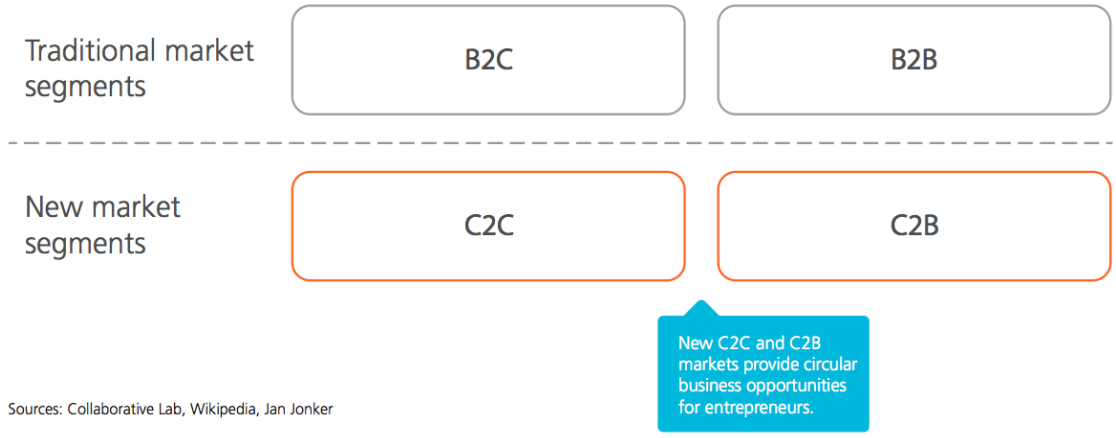

Figure 9. Circular economy creates business opportunities in new market segments. (ING Economics Department, 2015: 22)

According to ING, the Customer to Customer (C2C) segment is going to grow as different Peer to Peer (P2P) platforms in the internet enable consumers to efficiently share products and services in their local communities. ING forecasts also a rise of a new market segment, Customer to Business (C2B) in which consumers become producers and sell their products to businesses. Consumers might for example sell surplus energy generated by solar panels to electricity companies. (ING, 2015: 22)

2.9 Circular economy in Finland and recommendations by Sitra

According to the Finnish Innovation Fund Sitra and McKinsey, even moderately estimated there is about 1.5 to 2.5 billion EUR value potential in circular economy for the national economy of Finland. (Sitra 2015: 3)

Even though the conversation on circular economy has mainly focused on recycling waste and usage of organic side streams, when it comes to value creation, the greatest potential lies in practices such as maintenance, reuse and remanufacturing. As pointed out earlier, recycling should only be done when other value recovery processes are no longer viable. (Sitra 2015: 3)

In Finland about 90 tonnes of waste is generated each year and 54% of it is not reused or recycled. Rather than focusing on maximum exploitation of waste, we should have our priority on prevention of waste and value loss. (Sitra 2015: 3) There are three key leakage points where value is lost:

- Value lost in production due to sub-optimal material efficiency.
- Value lost in economic activities, such as consumption and use.
- Value lost after usage; recycling the raw material when the product could have been e.g. reused or remanufactured.

As discussed earlier, there are five ways to promote the circulation of products and raw materials:

1. Maintenance, i.e. extending product life span and offering services that enable the product to stay longer in use.
2. Reusing/redistribution, i.e. resale markets.

3. Remanufacturing/refurbishing, i.e. reselling the product after elaborate refurbishment or remanufacture.
4. Recycling, i.e. collecting and utilising the materials, whether technical or biological.
5. Cascading, i.e. routing the materials or parts to another value chain. (Sitra 2015: 4)

These two lists basically summarise the theory of this study into a simple framework. The next chapter aims to add a more practical view to these topics in the form a toolkit of practical actions that can be taken to prevent value losses and accelerate the transition to increased circularity. These two lists are also used as a basis in the conceptual framework introduced in chapter 3.18.

3 Toolkit

The previous chapter described the rudiments of circular economy. As can be seen from the table below, this chapter aims to deliver the second half of the first outcome, an overview on circular economy.

Theoretical part. Outcome 1: an overview on circular economy.	Overview on the concept. **A toolkit of actions to promote circularity.**
Empirical part. Outcome 2: an empirical study on circular economy in Finland.	Expert insights. Case study.

Table 2. The proposed outcomes of this thesis. This is the second part of outcome 1.

This chapter is going to propose some practical actions companies can take to increase their circularity, including examples of their implementations. What actions work best in each company depends on their field of industry, operating model and product type.

3.1 Product design

The initial design phase determines up to 80 % of the costs of product development, manufacturing and use. The earlier the consideration of environmental impact is done in the product design, the bigger potential for environmental benefit and cost reduction it has. (Pajunen, 2015: 49)

Some examples of decisions that are made on the design phase that affect the circularity of the product are as follows:

- Ensuring the possibility of disassembly. There needs to be a non-destructive way to disassembly the product for maintenance and repair, as well as for end of life treatment.
- Ensuring that the components can be easily exchanged or upgraded. Modular design is a favourable method.

- Making material choices. Preferring recyclable materials and avoiding or excluding materials that are (or their extraction process is) harmful or are not easily recycled. (European Environmental Bureau, 2015: 6)
- Constituting product features, like performance and durability.
- Deciding production methods, planning logistics, distribution methods and packaging.
- Planning the collection and treatment in the end of the life cycle.

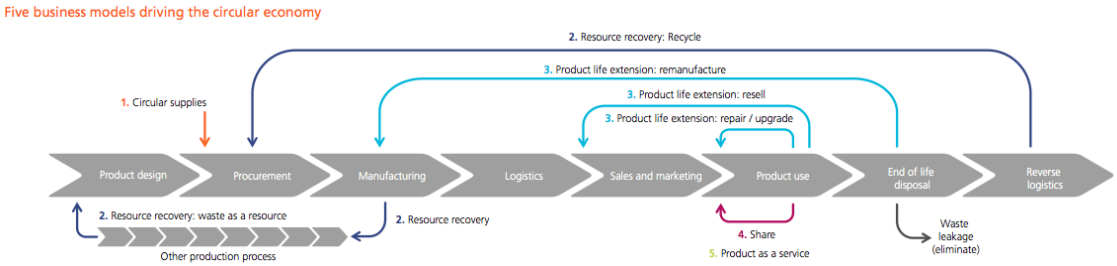

Figure 10. Circular loops in the value chain. (ING Economics Department, 2015: 7)

3.2 Life-cycle thinking

The life-cycle approach seeks to identify and lower the environmental impact and reduce the use of resources through all stages of the product's life cycle, starting from raw material extraction, manufacturing and distribution, through use and re-use, ending to recycling of materials, energy recovery and final disposal. For most products the end of life stage is probably the most crucial from the sustainability aspect. (Pajunen, 2015: 48-49)

3.3 Material choices and dematerialisation

Companies have adapted new dematerialisation strategies to reduce the energy and material flows needed to fuel the industrial system. Also the materials themselves have been changed by new technical innovations, like composite and hybrid materials that combine the advantages of different materials, being lighter, cheaper and more durable than traditional materials. They are often multifunctional and can be used for several purposes, but as they contain a wide variety of elements, separating them can set challenges to recycling. (Pajunen, 2015: 50-51)

Designers should use as much recycled materials as possible instead of virgin raw materials. Materials that are (or their extraction process is) harmful or are toxic or are not easily recycled should be avoided or excluded if possible. The same applies to packaging materials. Using different materials like plastic and card fused together makes it difficult to separate them during processing. (European Environmental Bureau, 2015: 6)

3.4 Re-thinking the supply chains

Today's markets are global and value chains long. A change in the modus operandi of a large company may impact the whole supply chain. Within the supply chain there are several stakeholders from contractors and service providers to the end user. Achieving a successful shift requires co-operation between all these operators. Especially big corporations have notable influence over their suppliers. (Pajunen, 2015: 2)

When making procurement decisions, companies should consider the total cost of ownership that includes also maintenance and disposal instead of lowest price only. They can develop circular procurement strategies and consider buying products and services from their suppliers as i.e. pay per use services. It is a good idea to make life cycle assessments of the product and seek co-operation in the parts of the value chain where the impact is highest. Involving waste contractors in the circular activities of the company may lead to mutually prolific co-operation. (ING, 2015: 27)

As a report by World Economic Forum from 2014 summarises: supply chains are the key unit of action and will jointly drive change. The materials leakage points need to be identified and overcome. According to the report, "a supply chain management approach that balances the forward and reverse loops and ensures uniform materials quality is critical to maximizing resource productivity globally". (World Economic Forum 2014: 10)

3.5 Facilitating second hand sales

Some brands are already facilitating the resale of their products. For example Ikea has turned their Facebook site into a market place where people can sell their used Ikea furniture. Some fashion stores already sell used clothes too, and people can trade their used clothes for store credit. (JWT, 2014: 13-14)

3.6 Facilitating product repair

As mentioned before, the product must be designed in such a way that the components are accessible without breaking the product and spare parts need to be easily available and affordable. Making repair information, service parts and diagnostic tools available to all independent re-use operators is highly recommendable. (European Environmental Bureau, 2015: 4)

Some companies already provide their customers with instructions, tools and replacement parts for repairing their products. For example certain computer parts from Dell and Lenovo are designed to be easily removed and replaced by the customer. (JWT, 2014: 15)

3.7 Collecting and recycling used goods

Companies can utilise collecting used goods as a way of extending and deepening their relationships to their customers. (JWT, 2014: 26) Some of the leading textile companies like Puma, H&M and American Eagle Outfitters provide their customers collection points for returning used clothes. The used materials are then given to charities or used as raw materials for new products. (JWT, 2014: 18) Marks & Spencer has set their goal to recycling as many textiles as it sells. (JWT, 2014 13-14)

3.8 Remanufacturing goods

Remanufacturing engines and electronics means replacing obsolete or worn-out parts and reintroducing the product into the market. Some companies have been doing it for years, but many products are designed for linear economy and they are not easy to dismantle and repair.

Renault has been remanufacturing engines since 1949 and has grown its remanufacturing operations into a 200 million euro business. According to Renault, remanufacturing parts is 30-50% less expensive than producing new parts and generates 70% less waste. (JWT, 2014: 19)

3.9 Product-centric recycling

Some materials like valuable metals can be difficult to identify and separate from highly mixed products where only small quantities of them are used. Especially nanomaterials and microelectronics are problematic to recycle. (Pajunen, 2015: 51)

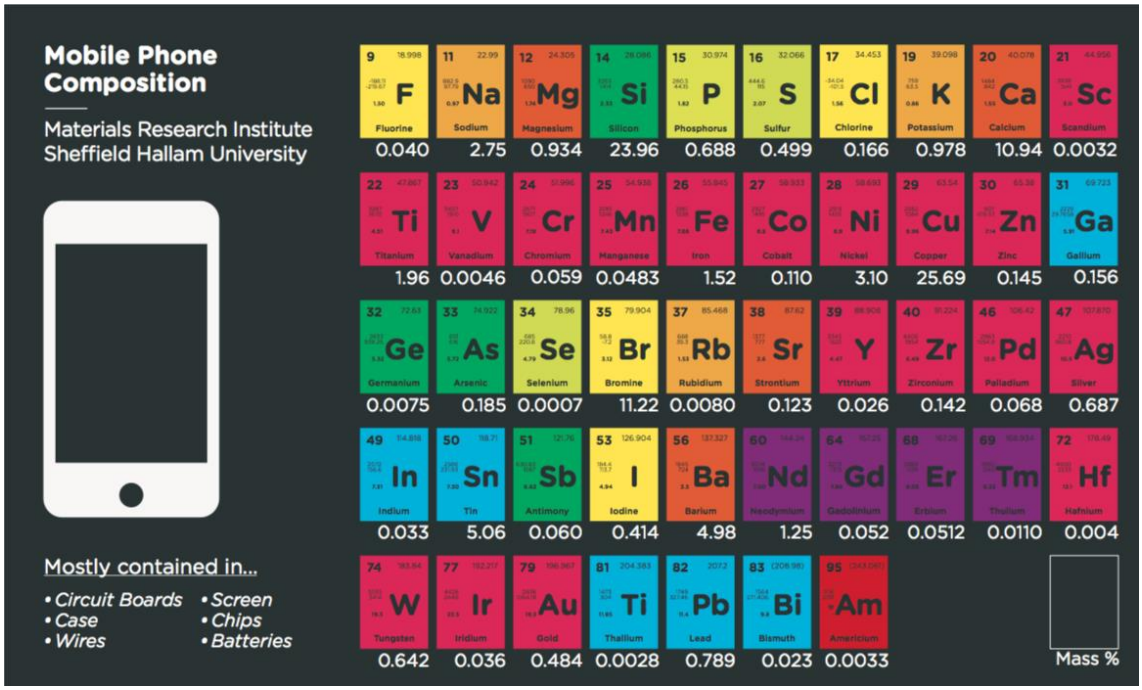

Figure 11. Mobile phone composition. Materials Research Institute Sheffield Hallam University. (RSA, 2013: 9)

There are surmises that “urban mining” from e.g. old landfills could be richer that virgin mining ores, i.e. in the case of the total amount of gold in cell phones, but at present there are no technical solutions for recycling rare earth metals from electronic devices. Often attempting to recover one material component destroys another. Again, solutions to these problems must start from the product design. (Pajunen, 2015: 51)

3.10 Recycling through partnerships

There are several examples of one factory’s waste becoming material for another. Instead of turning to traditional waste management companies, businesses are looking for resource management or reverse logistics partners to retain used materials. (JWT, 2014: 16)

For example Ford's new prototype Ford Fusion Energy hybrid car has its cushions, door panel inserts and some other components made of fibre taken from recycled plastic Coca-Cola bottles. (JWT, 2014: 19)

3.11 Utilising waste and side products

Especially process industries produce large amounts of residues and by-products. These materials can be utilised by other industries to create something new with value. (Pajunen, 2015: 52)

3.12 Finding new uses for waste

For example GM has realized annually a billion dollars from recycling and reusing its waste. It e.g. recycles shipping waste into sound-dampening materials. Also Procter & Gamble claims to have generated more than a billion dollars in value since 2009 from its program "Worth from Waste". It e.g. uses scrap from a Pampers plant for upholstery filling and waste from a Charmin plant for making roof tiles for the local community. (JWT, 2014: 16)

3.13 Co-operation and synergy between companies

The World Economic Forum recommends catalysing a series of "trigger projects" as the most efficient way to reach tipping points for recycling different types of materials. Findings of different players across industries and geographies are often transferable to other materials in the same category. (World Economic Forum, 2014: 11)

Business associations can arrange seminars and workshops where companies can share their experiences, solutions and success stories. It is even better when operators from different sectors are assembled as this allows them to make connections, learn from each other, co-operate and come up with creative solutions that none of them could have found alone. Companies can also set together quality standards or certifications and come up with best practices and policies on environmental sustainability.

The RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce) recommends creating safe spaces for trial, error and progress through collaboration. It

sees some intellectual property laws and business secrecy in supply chains and production methods as hindrances in progress towards circularity and as enablers of some bad social and environmental business practices going un-noticed. (Environmental Services Association, 2013: 11)

3.14 Education

Circular economy, including thinking in systems and biomimicry, should become an integral part of education. It is relevant for degree programmes like the MBAs, economics, engineering, design and policy sciences, but it should also be added to leadership programmes for business leaders. Companies can also start training programmes for their personnel. (IMSA, 2013: 21-22)

The manufacturer's organisation EEF recommends educating and engaging the entire supply chain and people that influence it, including politicians, designers, manufacturers, retailers and consumers. (Environmental Services Association, 2013: 12)

Educating politicians and other decision makers is also important. There are several hindrances and obstacles in moving to circular economy caused by current legislation and other political decisions. For example raw materials are now cheaper than recycled because the negative effects of take-make-waste are not taken into the calculation. The taxation on labour is high but resources remain untaxed or are taxed at a lower rate. This makes companies want to minimise their number of employees and provides no incentive to reduce their resource use instead. There is a need for a tax shift from labour towards resources. (IMSA, 2013: 25-26)

3.15 Involving the community

Integrating customers deeper by crowdsourcing. For example a survey by a repair site iFixit, based on crowdsourcing, indicates that people are more likely to become a repeat customer when they have successfully repaired a manufacturer's product. (JWT, 2013: 15) iFixit also rates products by their repairability. For example Google Nexus is rated to 8/10 because of easy disassembly, partly due to being screwed together. In comparison iPad which is glued together rates only 2/10. (Environmental Services Association, 2013: 4)

3.16 Thinking in systems

The world is a complex system. Numerous operators' actions are interconnected and the decisions that companies take do not affect just itself, but also the societies, communities and economies around them. Companies are surrounded by actors like customers, shareholders, banks, insurance companies, media, politicians, auditors, competitors and authorities. (Pajunen, 2015: 1)

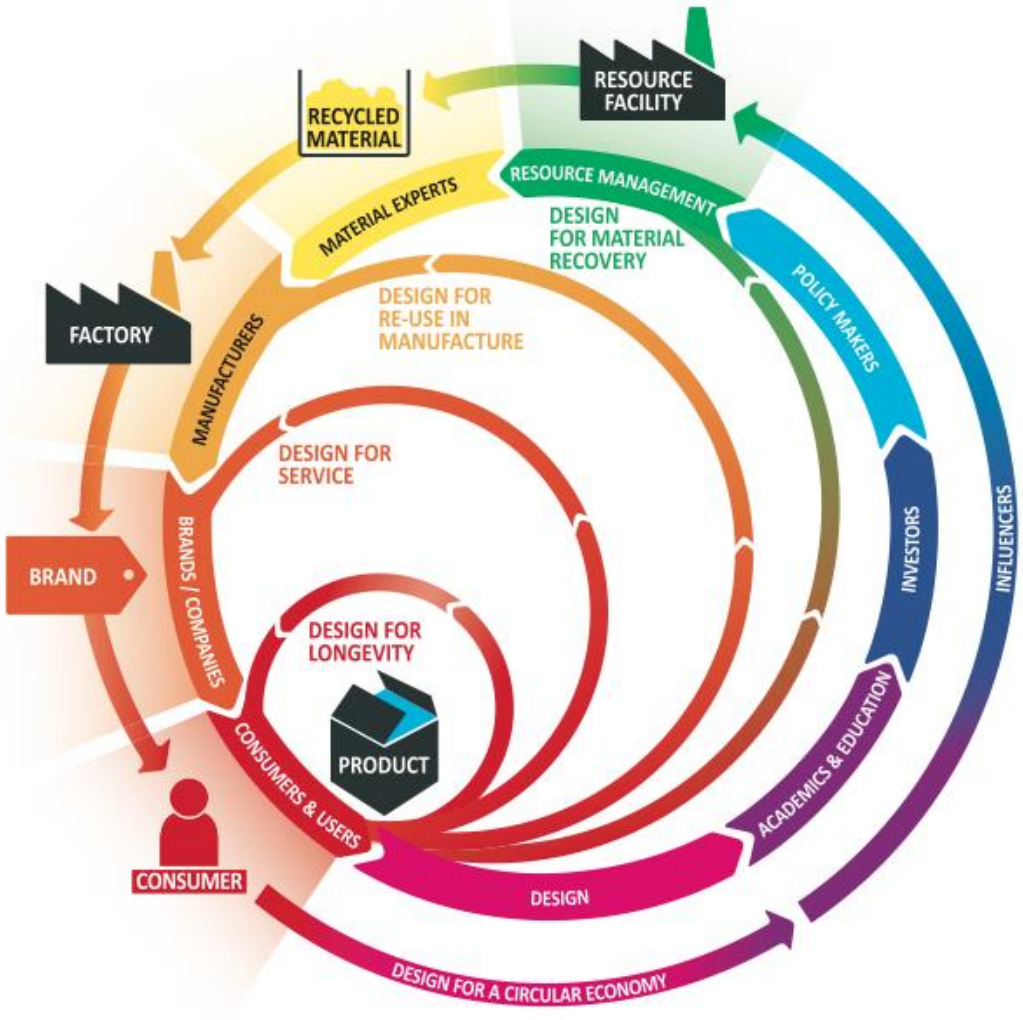

Figure 12. The transition to circular economy requires involving all the actors. (RSA, 2013: 34)

The transition is not something to be carried out by single decisions, single companies, single countries, consumer activism or political decisions alone. It requires global co-operation between all the actors on all these fields.

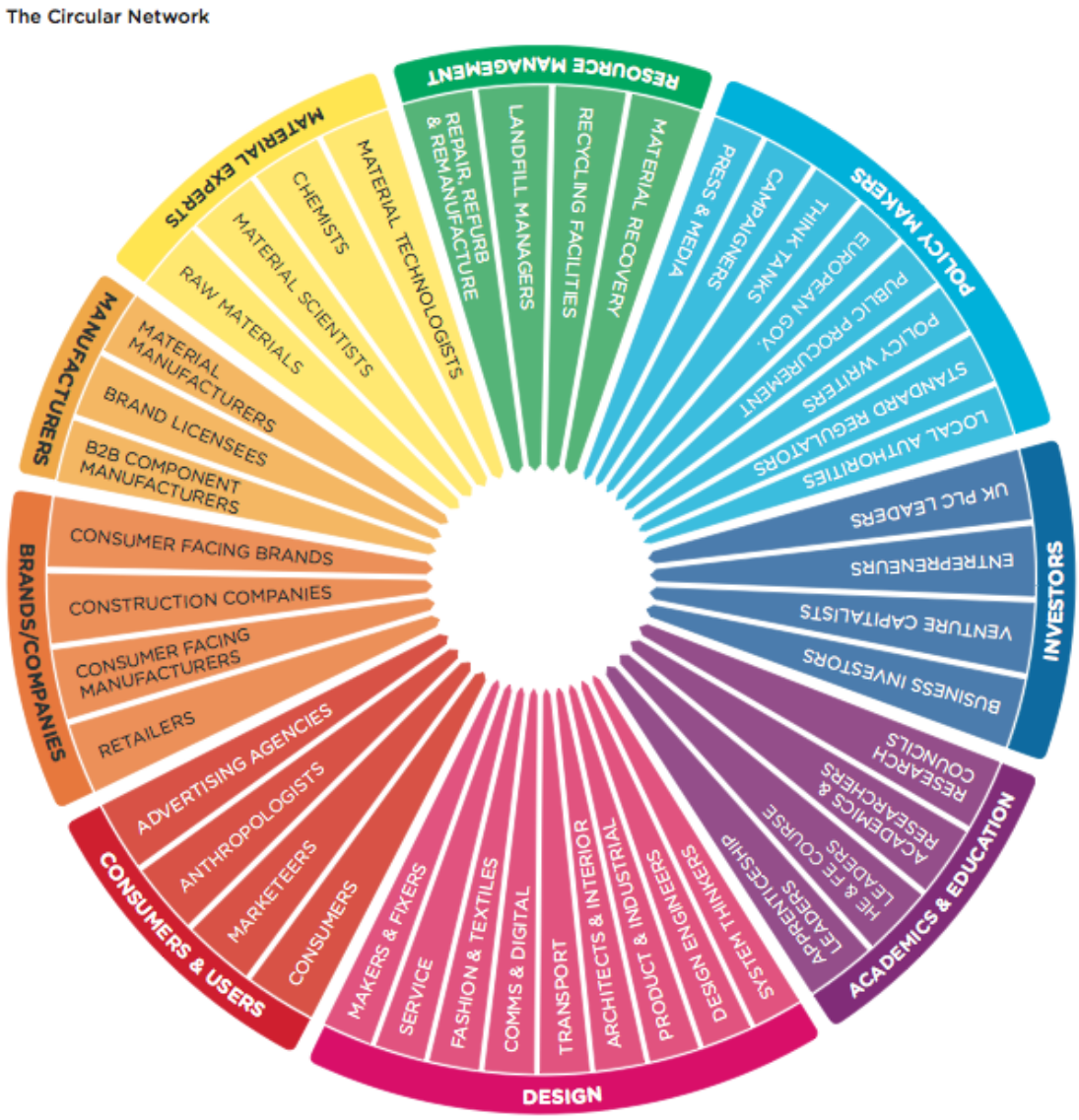

Figure 13. The circular network. (RSA, 2013: 16)

3.17 Theory review

This chapter closes the part 2 of the first proposed outcome, an overview on circular economy. To crystallise the concept introduced in chapter 2, the idea in circular economy is to minimise the waste of materials and value. Instead of regarding only the raw material value, also the value engaged in it during processing stages should be taken into account. The materials and components should be looped in ways that utilise its maximum value, e.g. preferring refurbishing over recycling. This should be carried out in ways that minimise the externalities such as harming the environment.

The shift towards circular economy involves change in the mindset and operational levels, including re-thinking business models, design, production methods and relationships to other companies and customers. The circular way of thinking should infiltrate the whole supply chain, including the end user. New kinds of partnerships and co-operation play an important role in the shift. Also the customers need to re-think their relationship to the products and consumption in general.

The shift towards a more circular economy is not just a necessity or a virtue, but provides vast value potential in the form of reduced losses, more stability in the materials supply, and new business opportunities. The job creation potential in new industrial fields such as remanufacturing and new market segments such as peer economy is significant. Circular economy will work as a soil for new types of business ecosystems and value networks to emerge and prosper.

There are some suggestions for circular actions listed in chapter 3. Some of them involve also the consumer community. By no means is this list comprehensive, but directive. What actions suit best different types of companies depends on their industry field, business model and product type. Regardless, any company can do something to increase their circularity, even if it is a small step. As systems thinking is in the core of the philosophy of circular economy, each decision has an impact to the whole.

3.18 Conceptual framework

The conceptual framework of this study is summarised in Tables 3 and 4 below. Table 3 that lists value leakage points is based on the list by Sitra introduced in chapter 2.9. It's complemented with prospective actions and main actors/functions associated adopted from Figure 12 in chapter 3.16 and Figure 7 in chapter 2.8.3.

Leakage points of value	Proposed actions	Main actors/ functions associated
Value lost in production	Co-operation and communication between all the actors. Material choices. Improving efficiency and commitment to constant improving.	Design. Material experts. Procurement. Resource management. Manufacturing & production methods. Material suppliers and subcontractors. Logistics.
Value lost in economic activities	Product life extension: high quality, durability, repairability, upgradability, availability of spare parts. Maintenance and other customer-supporting services. Education.	Design. Manufacturing. Consumers & users. Maintenance and services.
Value lost after usage	Repairing/upgrading, reselling. Remanufacturing. Recycling. Cascading. Waste elimination.	Design. Material experts. Services. Consumers & users. Partners and other companies that utilise the returning waste.

Table 3. Leakage points of value, prosed actions and main actors/functions associated.

As the table above indicates, there are several actions that can be taken to prevent the value losses in each of the leakage points. However communication and co-operation between the actors involved plays a vital role in reducing value leakage.

Table 4 below that lists actions that promote circularity is also based on the wrap-up by Sitra in chapter 2.9 and complemented with suggestions of actions from chapter 3 and main actors rounded up from Figure 12 in chapter 3.16.

Actions that promote circularity	Proposed actions	Main actors/ functions associated
Maintenance	Product life extension: high quality, durability, repairability, upgradability. Maintenance services. Education.	Design. Manufacturing. Consumers & users. Maintenance and services.
Reusing/redistribution	Actions that lengthen the life cycle and maintain the resale value. Selling or encouraging sales of used products.	Design. The manufacturing company or distributor and their partners. Other resellers. Consumers and users.

Remanufacturing/ refurbishing	Considering the remanufacturing opportunity in the design. Promoting the return of used products/components to the manufacturer.	Design. The manufacturer and distributor. Consumers and users.
Recycling	Considering recyclability in material choices. Preferring recycled materials in production. Promoting the return of materials into recycling.	Design. Consumers and users. The manufacturer, partners or companies specialised in recycling.
Cascading	Co-operation, strategic partnerships, industrial symbioses. Planning production to use 'waste' as input if possible.	The manufacturer and its partners.

Table 4. Actions that promote circularity.

These tables make up the framework to be applied in the case study presented in chapters 5-6. The aim of the case study is to examine the forest machine manufacturer Ponsse and to reflect how the leakage points of value in Table 3 are considered, what kind of practical circular actions from Table 4 are carried out and what kind of factors may contribute to these actions.

4 Expert insights

This chapter is the first part of the empirical part of this study, aiming to

1. survey the current state of circular economy in Finland based on expert interviews (chapter 4)
2. examine a specific company from the view of circularity as a case study (chapter 5).

Chapter 6 aims to summarise the findings, cross-analyse them and draw conclusions.

Theoretical part.	Overview on the concept.
Outcome 1: an overview on circular economy.	A toolkit of actions to promote circularity.
Empirical part.	**Expert insights.**
Outcome 2: an empirical study on circular economy in Finland.	Case study.

Table 5. The proposed outcomes of this thesis. This is the first half of outcome 2.

This chapter is based on an interview with a circular economy expert, M.Sc. (Tech.) Heikki Sorasahi from Sitra. The interview took place on 27 April 2016. Sitra is a public innovation fund founded in 1967 by the Bank of Finland to promote stable and balanced development, economic growth and international competitiveness of Finland.

Sitra employs a number of experts working on projects related to e.g. sustainability. Sitra has produced several publications on the topic of circular economy. The tasks of Sitra are defined in the law and it reports directly to the Finnish Parliament.

The interview was very prolific. The chapter was revised by the interviewee afterwards. Several good points and interesting views came out during it. The major themes of the conversation were the following:

- The vision and purport of circular economy
- The current state of circular economy in Finland
- The roles of different business fields and types of companies
- The special characteristics of circular economy in Finland
- The challenges on the way towards circular economy.

This chapter aims to group and digest the views and findings of the interview.

4.1 The vision and purport of circular economy according to Sitra

The vision of Sitra is that Finland will succeed as a pioneer in sustainable wellbeing. According to Mr. Sorasahi, Sitra promotes a transition to a carbon neutral circular economy where the constant growth of resource use is decoupled from the growth of the economy and wellbeing. Circular operations models and mind-set are the means of reaching this goal. In addition to the resource point of view, it is also closely linked to impeding the global climate change and achieving the set emission goals.

Another relevant aspect is the job creation potential and pursuit of business solutions that are sustainable on the long term. Mr. Sorasahi believes these ambitions are achievable, but it requires a change in the way of thinking in consumers as well as in the ways that business activities and supply chains are arranged.

4.2 The current state of circular economy in Finland

According to a research covering a sample of 524 companies of various sizes executed by EK (Elinkeinoelämän keskusliitto, the Confederation of Finnish Industries) in 2015, 74% of the respondents were familiar with the term of circular economy, so one may say that the concept is widely known. A quarter of the companies participating in the study see remarkable business potential in it.

However, Mr. Sorasahi estimates that the transition is still in the beginning. Referring to EK's study, only 17% of companies have taken lots of circular economy related actions in their planning and strategy work and 65% have taken little or not at all. On the other hand, according to Mr. Sorasahi in process industries, forest industry as a great example, secondary material streams and industrial symbioses have been utilised for a long time before the term 'circular economy' became renowned.

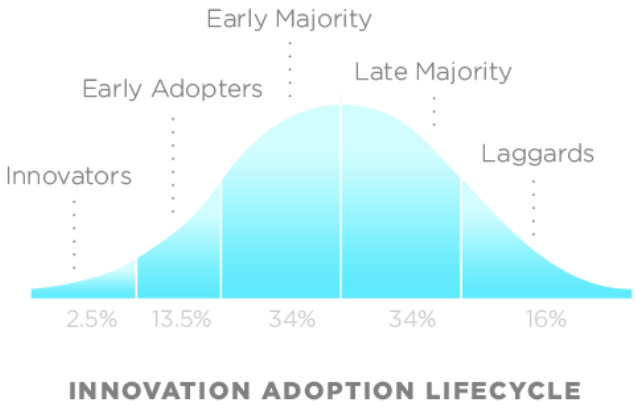

Figure 14. The technology adoption lifecycle pictured as a bell curve. (https://en.wikipedia.org/wiki/Technology_adoption_life_cycle) It can also be applied to companies' adoption of circular economy.

When making estimations, the answer depends on the definition of circular economy, which is not very clear. When compared to the big vision of decoupling, if the technology adoption life cycle model was applied to circularity, we would probably still be in the 'innovators' phase. We're still in the beginning of that road, but we've definitely already started the journey.

4.2.1 The pioneering business fields on circular economy in Finland

According to Mr. Sorasahi the majority of actions taken in Finland are related to process innovations and less on business models. The field of process industry is the voluminous executor on circular economy, but another big one is machine workshop industry field in which for example Ponsse and Valtra carry out remanufacturing and maintenance services. The expansion from manufacturing to selling services can be seen from them.

The third field on the rise is peer-to-peer business and sharing economy. This phenomenon has started already before circular economy became a 'trendy topic'. This phenomenon has huge value potential.

The slowest industry fields to adopt circularity would probably be the ones in which the transition would require radical changes in their business model, large and expensive investments and that are most dependent on fossil fuels. The air traffic business might be an example of such.

4.3 The role of different types of companies

The majority of enterprises in Finland are small and medium sized. However, referring to the same study by EK, the biggest role in transition to circular economy has been on large enterprises. However the study didn't take note if the actions taken were process innovations or something else. If a big company wants to change its course, the process can easily take a decade. That probably explains why the companies rather change their processes than business models. However when the volumes in production are large, even small improvements can have a significant impact.

The advantage of smaller companies is agility. Start-up companies have a special role in this transition. Start-ups make up the largest group among companies with an innovative, divergent business model. Even though big companies might have the biggest role in the change, the start-ups with radical and innovative business ideas work as disruptors in the game.

According to Mr. Sorasahi the co-operation between companies is going to increase when moving towards circular economy. That makes also the role of small, specialised companies grow. Until recently each company has basically taken care of their own lot in the value chain, but in circular economy co-operation that infiltrates different business fields, value chains and different types of companies is going to be a substantive driving force.

4.4 Special characteristics of Finland

Some typical characteristics in Finland are long distances, loose settlement and few people. Achieving the critical mass might be a challenge – for example sharing economy works better in the cities. In Finland the emphasis in discussion has been on waste utilisation and process industry symbioses. It's natural, because the raw material value is calculable but there are no common, generally accepted indicators for tracking circularity.

There have been less business innovations and selling products as services in Finland. There was a study by Deloitte that compared 50 classical cases of circular economy with 30 Finnish companies that carry on circular economy. The findings indicated that in Finland all 30 companies have done process improving when the classical examples have

done much less process development but focused on business innovations. So one might say that the Finns are more eager to change processes than business models. That is probably the most pivotal difference. In Finland as well as universally, technology works as a catalyst and enabler of the change.

4.5 Challenges in the transition towards circular economy

According to Mr. Sorasahi, probably the biggest challenge on the road to circularity is creating supporting conditions. The business environment should be such that it is stable and encourages circular actions, e.g. to utilise secondary materials, design durable products and to use renewable energy.

It is a complex dilemma: while companies hope for less regulation and more flexibility, in the other hand steering mechanisms are also needed. As long as virgin materials have an advantageous position compared to secondary materials, it is difficult for the transition to happen. What is more advantageous and compelling to companies should be compatible with circularity too.

Some business related challenges are transition investments and gaining the critical mass to make the business model worthwhile even if the idea is good. We need integrated financing instruments to make the transition possible. Often companies are able to get financing for a smaller scale pilot project, but when they want to scale their ideas up, they hit the wall as such funding is currently difficult to obtain in Finland.

The third major challenge according to Mr. Sorasahi is that as already mentioned, there are no generally accepted indicators for following up circularity. Even the term itself is quite wide and complex, which makes it somewhat indeterminate what is circular economy and what is not. It makes exact tracking of progress difficult.

4.6 Observations and findings from the interview

The interview was very interesting and successfully widened the view on circular economy. Some of the themes that came across in the interview were similar to the themes discussed in the theory part or at least indirectly discussed as the table below designates.

Theme from the interview	Parallel in the theory
Technology as an enabler and catalyst in the shift.	Chapter 2.7.3
Utilising side products in process industry; industrial symbioses.	Chapters 3.11 – 3.13, 2.8.3
The role of remanufacturing.	Chapter 3.8
The business between consumers. Sharing economy.	Chapter 2.8.4
Change in the thinking of companies and consumers.	Chapters 2.7.5, 2.8.3
Expanding business on services, Product as a Service.	Chapters 2.7.7 and 2.8.3
The role of co-operation between companies.	Chapters 3.10 and 3.13
Infiltrating the value chains.	Chapter 3.4
Creating a supporting operating environment.	Chapter 2.7.6 and 3.14
Job creation potential.	Chapter 2.8.1

Table 6. Constituent themes that came out in the interview and their parallels in the theory.

Some of the themes were new and not related to previous material, such as the roles of start-ups and SMEs, the lack of exact definition and common indicators for circular economy. Especially the challenge of creating an environment favourable to circularity is an important factor that obviously deserves more attention even though briefly touched upon in chapters 2.7.6 and 3.14.

Generally, it seems that the procession of the course, the drivers behind it and the actions available are quite alike in Finland as well as elsewhere at least in the Western world, but the pace and the phase vary.

5 Case study: Ponsse

5.1 Research context and methods

Chapters 5 – 6 of this study make up the case study that constitutes the second part of the proposed outcome of the second proposed outcome. These chapters aim to examine the following objectives:

1. To examine what kind of circular activities the company is doing and how they relate to the framework of value leakage points and recommended circular actions introduced in chapter 3.18.
2. To reflect what factors may contribute to these actions.

This part of the study is based on a theme interview with Dr. Juha Inberg, the director of Technology and R&D at Ponsse. Other material used is Ponsse's website and Ponsse's publications such as annual reports, brochures and press releases. The case represents a Finnish machine workshop industry company and the emphasis is on the practical implementations of circularity in its actions.

5.2 Introduction of the company

Ponsse is a Finnish family-owned company that is specialised in the production, sales and maintenance of forest machines. It was established in 1970 in a rural locality, Vieremä, and has grown to one of the world's leading manufacturers of cut-to-length method forest machines since.

As Ponsse operates in 40 countries and 77% of the company's revenue comes from exports (2015), the machines need to be able cut different types of trees from old pine to eucalyptus and to work reliably in demanding climate and terrain conditions from arctic to tropical. The backbone of Ponsse's operating model is high quality and innovativeness. The core values of Ponsse are honesty, innovation, Ponsse spirit and closeness to customer.

Ponsse's shares are quoted on the NASDAQ OMX Nordic List. In 2015 its net sales reached 390,8 million euro. The Ponsse Group consists of the parent company Ponsse Plc and its subsidiaries in Sweden, Norway, France, Great Britain, USA, Brazil, Russia,

Hongkong, China and Uruguay. The headquarters and factory plant are still located in Vieremä. Also about 90% of the components come from Finland. (Ponsse, 2016)

5.3 Product portfolio

Ponsse operates in three main areas: forest machines, information systems and services.

5.3.1 Forest machines and equipment

There are two dominant methods of mechanised tree harvesting: tree length method and cut-to-length method (CTL). With tree length method the trees are harvested in the forest and the logs are transported to the factory as whole or almost whole. Separating the parts of the trunk suitable for different purposes takes place in the factory.

With the CTL method the logs are cut and sorted out in the forest. A harvester fells, delimbs, measures and bucks the trunks, then a forwarder carries them to the side of the forest road keeping each type in a separate pile. From there a timber truck equipped with a crane brings them to the mill.

Ponsse produces forest machinery designed for the CTL method: harvesters, forwarders, dual harwarders that can be easily changed between harvesters and forwarders, harvester heads, cranes, loaders and special products for harvesting bioenergy such as load scales, multi-stemming harvester heads and variable load areas for trucks. Ponsse sells also used machines that have been refurbished in the factory.

5.3.2 Information systems

Ponsse designs and manufactures four types of information systems: forest machine systems, wood procurement software, simulators for training purposes and fleet management tools.

Harvester systems

Ponsse harvesters are equipped with Opti4G information system. It works as a user interface between the operator and the machine and as a tool for managing data. It's used for calibrating the machine, managing marking for bucking files and controlling the cutting of logs according to the settings the user has set to the system. It also collects and transfers information about operator working hours, time distribution, production, machine operation and fuel consumption.

OptiGIS Harvester is a GPS based map software that allows the operator to track their location on the map and warns them when they are getting close to the stand border, a power or telephone line or a protected nature area.

Forwarder systems

The forwarders are equipped with OptiControl system and an electronically controlled diesel engine. OptiControl system enables controlling the crane, handles and the engine as a single entity which makes the machine easier to operate.

The EcoDrive app surveys the efficiency and frugality of the machine operation. It monitors the load and fuel consumption of the machine during its different functions and gives the driver feedback in real time. As optional equipment there is also a load scale, LoadOptimizer, that weighs and reports the transported timber in real time.

Wood procurement software

Ponsse offers several tools for forest owners that help in e.g. keeping track of the state of the forest, planning the cutting, communicating with the machine operators and monitoring, reporting and analysing the outputs.

Fleet management tools

Ponsse Fleet Management is an application for monitoring the machines in real time. It enables following for example the location of the machines, engine working hours, the amount of fuel in the tank, the amount of wood harvested and comparison of machine productivity and fuel consumption for different operators. It also predicts the need for spare parts and services and allows ordering carriages to the right place at the right time. Fleet Management app is compatible also with mobile phones and tablets.

5.3.3 Services

Parts

Ponsse offers a wide variety of spare parts and accessories. In addition to new parts, Ponsse also sells used parts, remanufactured parts and classic parts for older machine models that are no longer in production. The remanufacturing service is based on recycling used spare parts. When the customer returns a damaged part to Ponsse and buys a remanufactured part, they receive a credit. The remanufactured parts are cheaper than the genuine parts, but they are carefully reconditioned and have the same quality and warranty as the new ones.

Performance packages

Ponsse offers performance packages for updating and improving forest machines. They can be used for example on older machines to make them comply with modern requirements or for updating systems such as the harvester head or the base machine. Also the information systems can be retrofitted to older machines by installing a harvester head with a PC in it.

Service agreements

Ponsse offers services that allow the entrepreneur to outsource the forest machine's scheduled maintenance to Ponsse. Professional maintenance allows the forest entrepreneur to focus on their productive work, lengthens the machine's life span and retains its resale value. The service works as a fixed-price agreement. The work is invoiced after completed maintenance, so there are no advance fees.

The basic package, Logger's Total, includes scheduled maintenance for 6 000 hours or three years but no unnecessary component replacements. Additional Security service is an optional extension to Logger's Total and covers fully all main components, computers and control modules of the machine. There are different types of service agreements from fixed contracts to tailor-made solutions.

Technical support

Ponsse offers its customers technical support in the form of service centres, field maintenance and technical assistance via telephone or e-mail. The goal is to offer support whenever it is needed and as close to the customer as possible, considering the local customer requirements.

There are about 150 service centres in the Ponsse maintenance network. The locations are chosen in terms of the business operations and logistics of the customer. The wide network of service centres secures the easy availability of spare parts when needed and minimises the machine's downtime. The service centres also offer telephone assistance.

Sometimes the problem is best solved on the field, and for this purpose Ponsse has field maintenance service that brings assistance with a highly equipped service vehicle straight to the working site. Some issues and maintenance tasks, such as optimising adjustments, can be handled via mobile connection between the machine and service centre.

Training services

Ponsse offers operator training for their customers as a part of a new forest machine delivery. The goal is to ensure that the operators can use and maintain the machines and the Opti information systems correctly and efficiently. Both machines and simulators are used in the training.

Ponsse Full Service

Ponsse Full Service package allows the entrepreneur to outsource the entire maintenance of the harvester equipment to Ponsse professionals.

As can be seen from the introduction of the company, information technology and services make up a significant part of the product portfolio of Ponsse. Their roles are further examined in the next chapter.

6 Findings and analysis on case Ponsse

The previous chapter introduced the company. This chapter aims to delve deeper into the case by collating it with the conceptual framework from chapter 3.18 and reflecting what factors may contribute to circularity in this case. This chapter is mainly based on an interview with Dr. Juha Inberg, the director of Technology and R&D at Ponsse and the quotations have been revised by the interviewee afterwards.

6.1 Actions taken against loss of value

As pointed out in Chapter 3.18, there are three leakage points where value is being lost:

1. in production,
2. during economic activities such as use
3. after usage, for example in the form of waste or as recognising only the value of the raw material in a product that could have been refurbished.

The leakage points, proposed actions and main actors/functions associated are compiled into the table below.

Leakage points of value	**Proposed actions**	**Main actors/ functions associated**
Value lost in production	Co-operation and communication between all the actors. Material choices. Improving efficiency and commitment to constant improving.	Design. Material experts. Procurement. Resource management. Manufacturing & production methods. Material suppliers and subcontractors. Logistics.
Value lost in economic activities	Product life extension: high quality, durability, repairability, upgradability, availability of spare parts. Maintenance and other customer-supporting services. Education.	Design. Manufacturing. Consumers & users. Maintenance and services.
Value lost after usage	Repairing/upgrading, reselling. Remanufacturing. Recycling. Cascading. Waste elimination.	Design. Material experts. Services. Consumers & users. Partners and other companies that utilise the returning waste.

Table 7. Part 1 of the conceptual framework of this study: leakage points of value.

When these leakage points are recognised and identified, action can be taken against them. Based on the analysis on the operations of Ponsse, the following actions can be noticed:

Leakage points of value	**Actions taken**
Value lost in production	Close co-operation and communication between the R&D, assembly line and component manufacturer. Constant improving of production methods.
Value lost in economic activities	High quality. Efficiency. Product life extension. Repairability. Maintenance services. Training of the operators. Feedback from customers.
Value lost after usage	Remanufacturing parts and machinery. Recycling materials.

Table 8. The actions taken to prevent value losses.

As revealed by the interview with Mr. Inberg, constant improving of both the manufacturing process and product design are substantial ambitions for Ponsse. They enable efficient tackling of these challenges.

6.1.1 In production

An important element against value losses in production as came out in the interview, is the importance of co-operation. The assembly of the machines takes place in the factory plant at Vieremä, but most of the components come from subcontractors. However, about 90% of the components also come from Finland, often from the same region as Ponsse. Some of the key component manufacturers even operate at the same building ground as the assembly site. Also the R&D and headquarters operate in the same site, enabling constant dialogue.

Decisions done in R&D influence the whole manufacturing process, for example what it comes to processing methods and the usage of resources. The assembly line often sends suggestions of improvement and those ideas are taken into account in design and planning of production. Naturally decisions made at Ponsse have a strong impact on

their component suppliers as well. As a summary, constant interaction between the partners, the willingness to take in and respond to feedback, and commitment to constant improvement are the cornerstones of efficient production.

6.1.2 During economic activities

The second point in which value is lost is during economic activities. The machines and their components inevitably get broken or worn-out. However there are several actions that can be taken to prevent redundant losses and to lengthen the life span of the machine.

As pointed out several times in the study and confirmed by the interview, the design phase plays a fundamental role in determination of the product life span. The quality in production and production materials is another. Durability and reliability are the key selling points of Ponsse, and they work as the baseline in design and production. As emphasised before, both are committed to constant improvement. Repairability and easy maintenance are considered in the design.

The third factor is the consumer – obviously for example conscientious maintenance and using machine the ways and for the purposes it was designed to, have a significant contribution to the product life span.

When the customer orders a new machine from Ponsse, each machine is assembled to fit the needs of the customer. Training is a part of the new forest machine delivery and it aims to ensure that the users know how to use the machines correctly and efficiently. It also covers preventive maintenance actions.

As can be seen from the product portfolio and discussed during the interview, maintenance services make up a crucial part of Ponsse's business. The customer can fully outsource the maintenance operations to Ponsse if they want to.

When systematically preventing losses in economic activities, communication plays a vital role again. It is important that the knowledge and feedback from the field – maintenance services and customers – is taken heed of.

6.1.3 After usage

Typically the customer ordering a brand new machine from Ponsse is a logging enterprise that keeps the machine on heavy use for about three years before purchasing a new machine and giving the used one in exchange back to Ponsse. Ponsse then refurbishes the machine, changes worn-out components and sells it to next user. Usually that is also a logging company.

After some years they change again to a new or less used machine, and the used machine returns back to Ponsse to be fixed and sold again. Ponsse remanufactures full machines as well as parts and components. However, when the machine comes to the end of its life, it is no longer taken back to Ponsse. Usually the final owner delivers it to a company specialised in recycling.

Most of its materials can be easily utilised. By far the largest amount of its mass is steel and is utilised as raw material. As for example in the case Outokumpu, the largest producer of stainless steel in Finland, more than 80% of its material intake is recycled content. (Outokumpu website) The plastic parts are either recycled as raw material, or used as energy waste. The parts that are problem waste are handled by companies specialised in problem waste, such as Ekokem.

To make the identification of the materials easy, Ponsse marks each material with visible labels. However, as came out in the interview, this after usage is the phase in which there may still be room for improvement. Some materials, such as rubber tubes strengthened with steel that have oil inside might be difficult to dispose of, but at the moment there are not as good alternative materials available.

Another thing to consider might be that even when the machine has come to the end of its life and is no longer worth fixing, there still might be some working components worth salvaging in it, especially if some parts have been replaced recently. It might be worth considering if there is a way to recognise them and to ensure they return to Ponsse for remanufacturing.

6.2 Circular actions taken

Table 4 in Chapter 3.18 listed five circular actions: maintenance, reusing/redistribution, remanufacturing/refurbishing, recycling and cascading. They can be found also from Table 9 below with some proposed actions and the main actors/functions associated.

Actions that promote circularity	**Proposed actions**	**Main actors/ functions associated**
Maintenance	Product life extension: high quality, durability, repairability, upgradability. Maintenance services. Education.	Design. Manufacturing. Consumers & users. Maintenance and services.
Reusing/redistribution	Actions that lengthen the life cycle and maintain the resale value. Selling or encouraging sales of used products.	Design. The manufacturing company or distributor and their partners. Other resellers. Consumers and users.
Remanufacturing/ refurbishing	Considering the remanufacturing opportunity in the design. Promoting the return of used products/components to the manufacturer.	Design. The manufacturer and distributor. Consumers and users.
Recycling	Considering recyclability in material choices. Preferring recycled materials in production. Promoting the return of materials into recycling.	Design. Consumers and users. The manufacturer, partners or companies specialised in recycling.
Cascading	Co-operation, strategic partnerships, industrial symbioses. Planning production to use ‘waste’ as input if possible.	The manufacturer and its partners.

Table 9. Part 2 of the conceptual framework of this study: actions that promote circularity.

When comparing the list of actions that promote circularity with the actions of Ponsse, one can notice that the first three of them are present in Ponsse’s operations and the last two are loosely related.

Actions that promote circularity	**Actions taken**
Maintainance	Product life extension. Maintenance services. High quality in products. Durability and repairability as goals in design. User training.
Reusing/redistribution	Sales of used machines.
Remanufacturing/refurbishing	Remanufacturing machines and components. Refurbishing used machines before resale.

Recycling	On the responsibility of the owner, but the materials used are labelled for easy identification. – Steel is recycled as a raw material. – Plastic is recycled as raw material or utilised as energy waste. – Problem waste handled by a specialised company.
Cascading	The steel is recycled by a steel company; for example in Outokumpu's steel production, >80% is made of recycled content. From there it ends up metal industry and other appliance.

Table 10. Recommended actions to promote circularity and the actions taken.

Extending product life span and offering services that enable the product to stay longer in use are important "components" of maintenance. Both are done at Ponsse – actually even though machine industry is its main field, maintenance services can be seen as one of its core functions as well.

Maintenance and product life extension are typically interwoven, but there are also other actions that Ponsse has taken to lengthen the product life. Durability and high quality are of course features that make the machine worth fixing in the first place, and availability of spare parts and upgrades even for out of date machines are what make it possible. Long product life is kept in mind as an aspiration since the design phase.

As can be seen from Ponsse's product portfolio in Chapter 4.3.1, Ponsse sells also used and refurbished forest machines. The volumes of used machine sales are several hundreds of machines annually. Ponsse sells also other brands of used machines.

Ponsse remanufactures both machines and components. They have a product line of remanufactured spare parts. They are cheaper for Ponsse to produce than brand new parts and they are sold at a more affordable price to the customer, but they come with the same warranty as the genuine parts.

The actions of recycling and cascading are handled by other companies than Ponsse, but recyclability is taken into account in design phase in material choices and labelling.

6.3 Factors that contribute to circularity at Ponsse

Behind circular actions, or the lack of them, there are often several underlying factors that can work either as catalysers or hindrances to circularity. The aim of this chapter is to try to identify if any of the phenomena discussed in the theoretical part can be detected at Ponsse and to identify what their role is in the circular actions of the company.

6.3.1 The role of services

Even though Ponsse operates on a very traditional industry, an expansion from solely selling machines to selling services can be clearly seen. Even though manufacturing machines remains the core function around which the other functions are built, as came out also in the interview with Mr. Inberg, the role of services, maintenance being the most important one, has definitely grown and is recognised as a crucial part of Ponsse's business.

Ponsse wants to support the customer through the entire life span of the machine instead of just selling the machine and then leaving the customers on their own. This has a positive impact on the business in two ways: the income of revenue does not stop when the machine is sold and it deepens the customer relationship. According to Ponsse, this definitely has a positive impact on the business.

A forest machine is an expensive investment. As the machines are the single most important assets that do the productive work thus bringing value to the customer, it is essential that they are kept fully operational without any futile or prolonged stoppages. When Ponsse takes care of the maintenance and repair operations, it releases resources from the customer to be directed to their core activities.

6.3.2 The role of computer technology

The presence of computer technology is prominent and plays a supportive role as an enabler of increased efficiency. Embedded computer technology enables for example analysing if the machine is used efficiently, archiving the maintenance history and even predicts the need of oncoming maintenance operations.

Computer technology makes maintenance easier in many ways. An interesting application is distant maintenance enabled by a modem embedded in the machine. It can be

used for example for optimising adjustments, analysing problems and updating software. It works in areas covered by the 3G data network.

6.3.3 Involving the supply chain

In the machinery manufacturing business the manufacturing supply chain is often decentralised – the R&D is done in one country and the components may be manufactured in several countries of Asia to be assembled in East Europe for example. What is remarkable about Ponsse is that they have done quite the opposite and decided to keep the manufacturing supply chain highly local.

In Posse's case the headquarters, R&D, assembly and even many of the key component suppliers operate in the same plant. About 90% of the components come from Finland – an exception is for example the diesel engines that come from Mercedes Benz in Germany. As came out in the interview, this is a big advantage that enables a seamless cooperation between the partners. There is constant interaction between R&D, assembly, component manufacturers, maintenance and customers.

As emphasised earlier in this study, for efficient circular business the circular principles should infiltrate the whole supply chain. When it comes to this, closeness to partners – literally as well as figuratively - is definitely an advantage. High quality is an elementary factor in lengthening the product life. This arrangement allows instant feedback between the partners and agile reacting.

6.3.4 Systematic product life extension in operations and design

The quality in production is one factor in the product life span, but as pointed out earlier in this study and confirmed in the interview, everything starts from the design table where many essential decisions are sealed. Repairability and the fluency of maintenance such as accessibility to check points of the oil etc. are carefully considered in the design phase.

The design of the machines is modular, meaning that worn out or broken components can easily be replaced. Also recyclability in the end of the life cycle is considered in the design.

High quality, durability and reliability are cornerstones in Ponsse's business. The company started in 1970. In the beginning of 2015 Ponsse finished its 10 000th machine. Back then it was calculated that 8 000 of the machines produced are still in active use.

On the contrary to planned obsolescence, Ponsse wants to keep their machines operational for as long as possible. They offer spare parts and upgrading services also to older types of machines that are no longer in production. Even the information systems can be retrofitted to older machines by installing a harvester head with a PC in it.

6.3.5 The business perspective

The circular actions Ponsse carries out are clearly business driven. They recognise the value in used machines and components and want to benefit from them. Remanufacturing used parts is cheaper than producing new ones and there is demand for more affordable parts from the customers.

Selling maintenance services, as pointed out in Chapter 5.3.1, is a crucial part of business that benefits both, Ponsse and the customer. It deepens the customer relationship, makes the customer feel more secure when they can trust maintenance operations to Ponsse and makes the income of revenue continue even after sales.

Customer orientation is the first one of the four company value pillars defined by Ponsse. The aim is to be "the logger's best friend" and the company was founded based on the founder's own needs for strong and durable machines that can stand heavy-duty use. They know their customers and their customers' needs.

The machines are often operated far from repair services and paved roads, so they need to be reliable. A forest machine is a big investment and the customers want a long life span for their purchase. Selling machines that break down abruptly and are unfixable would be extremely bad business.

6.3.6 Other observations

A factor that has perhaps caught a less attention is the role of the company's values in the process of increasing circularity. After all, the values are the soil from which the "tree"

sprouts up. It can be easier to make strategic level changes in the company than to change the company values on a more profound than paper deep level.

For example Ponsse can be described as a strongly value-lead company. Even though circularity is not explicitly mentioned in the company's core values, the value basis is such that circularity can easily be integrated in, even derived from it, without being in contradiction to anything else. Also the less explicit values, such as the role of the local community go together well with the ideas of circularity. The value perspective is something that should not be neglected when considering the transition to circular economy.

6.4 Conclusions and recommendations

Ponsse has already taken several steps towards a more circular economy in the form of concrete, practical steps. As can be noticed when comparing Chapters 6.1 and 6.2, or even more clearly when comparing at tables 7 and 8 in chapter 6.1 with tables 9 and 10 in chapter 6.2, preventing value losses and taking circular actions walk hand in hand.

It is an interesting notice, because when regarding environmental sustainability, recycling and circularity, some companies still hold on to the notion that it is something expensive, cumbersome and brings no extra value. The case of Ponsse, among other successful examples, indicates the opposite: circularity can be integrated in as an essential part to the business operations. It should not be a burden, but an advantage.

However, there are still areas with some room for improving. Even though the primary objective of this study was not to make improving suggestions, a couple of ideas sprouted up as a side product. The prospect of ensuring that all usable parts from a machine that has reached the end of its life return to Ponsse might be worth consideration. Even though the majority of stainless steel in Finland already comes from recycled content, the possibility of increasing the use of recycled materials in component production could also be investigated.

Some of the phenomena discussed in the theory part were noticeable also in Ponsse's case, such as technology as a catalyst and enabler of increased circularity, the importance of product design and life-cycle thinking, involving the supply chain, second hand sales, repairability, remanufacturing and the expansion from solely selling products

to selling services too. Unfortunately the scope of this study does not allow further analysis even though deeper research would be beneficial.

The importance of design came out in the theory part as well as in the interview several times and it is definitely one of the fundamentals when moving towards more circular products and business models. The relationship between the values of the company and circularity is something that has got less attention and did not really come out in the materials when doing research for the theory part. That would be an interesting field to study.

The circular actions of Ponsse are clearly business driven, and that is a good thing. They recognise the value in used machines, components, maintenance and remanufacturing, and want to benefit from them. The shift towards a more circular economy is necessary if we want to build our economy on such a basis that secures the availability of natural resources for future generations too, but it cannot be “sold” to companies as an intrinsic value, but as something that benefits all stakeholders. It needs to be in concordance with the business aspect too.

7 Closing words

7.1 Summary of the thesis project and its outcomes

As explicated in chapter 1.1 and shown in the table below, this thesis aimed at two outcomes composed of two parts each. The purport of these components was to form together a comprehensive big picture on circular economy that can be used as handbook by a company that wants to develop its processes into a more circular direction.

Theoretical part. Outcome 1: an overview on circular economy.	Overview on the concept. (Chapter 2)
	A toolkit of actions to promote circularity. (Chapter 3)
Empirical part. Outcome 2: an empirical study on circular economy in Finland.	Expert insights. (Chapter 4)
	Case study. (Chapter 5-6)

Table 11. The proposed outcomes of this thesis.

The first part of the Outcome 1 aimed at covering circular economy on a general level by introducing the concept, its core principles, drivers of the trend and its impacts on business and economy. Even though the idea of a closed loop economy is not new, the shift from a linear approach or 'take-make-waste' model towards a more circular economy is often referred to as a revolution.

Even though it might take some time, the simile is not necessarily exaggerated. It's evident that a paradigm shift is happening and many of the global business leaders have already awakened to it. Hopefully the overview helps companies to see the possibilities in circular economy, encourages them to seize the opportunities lying within and inspires them to pursuit increased circularity in their operations.

The second part of Outcome 1 aimed at a more practical approach offering practical actions that companies can take to increase their circularity with some examples. By no means is the list of actions in the toolkit comprehensive, but directive. It's not limited to a specific industry or business model but offers a variety of different types of actions that

suit for different types of companies. Any company should be able to find something that works for them from the toolkit.

The first part of proposed outcome 2 offers a more local perspective to circular economy. Its aim was to examine the current state and typical characteristics of circular economy in Finland based on an expert interview. There were several interesting themes that came out in the interview.

The findings were in concordance with chapters 2 and 3 that were not defined to a specific country. Perhaps the most significant difference is that the Finns are eager to improve their processes but have remained a conservative stance when it comes to changing business processes. However the findings indicate that even though we're still in the beginning of the process, the journey has definitely already begun.

The second part of outcome 2 consists of a case study. The company examined was a Finnish forest machine manufacturer, Ponsse. The conceptual framework introduced in chapter 3.18 was used as a reference point. Ponsse was a very prolific choice for a case company as it represents a traditional field of industry and offered very tangible examples of appliances of circular activities. It also indicates that circularity can be an integral part of successful business operations – an advantage that increases the revenues.

The conceptual framework is applicable to other companies and business fields as well. Hopefully also other people and companies can benefit from it in the future.

The flow of the thesis project followed the plan introduced in chapter 1.3 and rehearsed in the figure below.

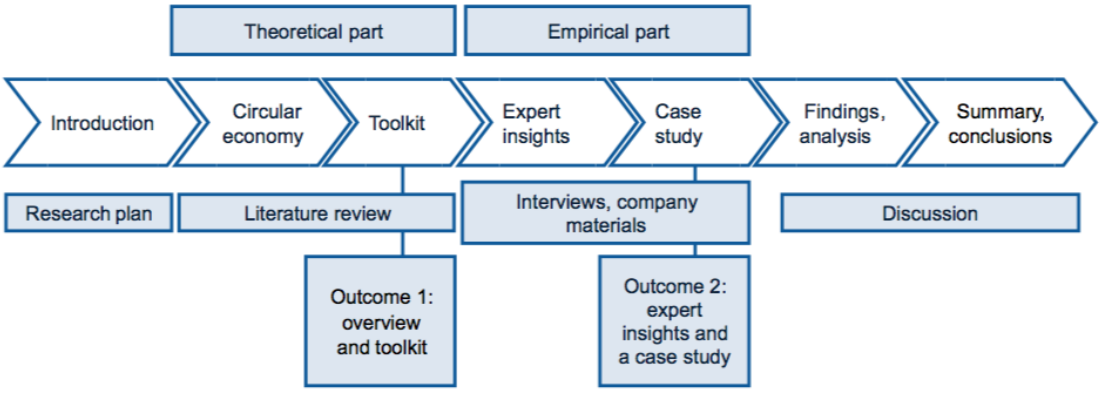

Figure 15. The structure, methods and proposed outcomes of this thesis illustrated on a timeline.

As the figure above shows, the theoretical part was to be based on previous literature on circular economy and the empirical part to be based on interviews. Both of these outcomes were achieved within the given timeline.

During the writing process there was plenty of material available. Circular economy is a wide topic and can be viewed from many perspectives. Cropping the covering area, keeping the objective clear and keeping the course straight was causing some challenges. The topic is interesting and important, which worked as a good motivator during the process.

7.2 Further discussion on circular economy

There are several different approaches to circular economy. Some approach it from the engineering point of view and see it mainly as a technological challenge. From the perspective of economics it can be seen as a shift from economy based on owning things towards an economy based on selling, buying and using services and performance instead. It can also be seen as a way to prolong economic growth in a world of finite resources. From the business point of view it can be seen as means of increasing commercial advantage by securing the resource supply and utilising maximum value from each resource.

Some people see it more as a societal shift, or a shift in the value system and collective mentality. Can prosperity and material consumption be decoupled? Is there a way to hold on to the achieved benefits and amenities of modern society, or are agreeable standards of living for all human beings and ecological sustainability an impossible equation? Should we move from measuring human wellbeing from measures of economic activity like GDP to other types of indicators?

Circular economy cannot solve all the problems in the world. It is not a perpetual mobile machine. Ultimately the laws of physics cause all materials to inevitably deteriorate in use. Some value and energy is always lost. Yet, I believe this transition is a significant step in the history and development of mankind.

How exactly this will happen, we cannot say. Probably it is going to take many years. As EMF describes the oncoming transitions: it is “likely to be a messy process that defies

prediction, and both the journey and destination will no doubt look and feel different from what we might imagine today". (EMF, 2012: 78)

Frans van Houten, the CEO of Philips, refers to the shift from linear to circular economy as a revolution that "500 years from now, people will look back at it as a revolution of Copernican proportions". (JWT: 7) As in any revolution, the outcomes are hard to forecast. However, it seems that some kind of general, global consensus is already formed: a change is inevitable.

References

World Economic Forum, 2014. Towards the circular economy: Accelerating the scale-up across global supply chains. Published by World Economic Forum, Geneva, Switzerland.

Pajunen, Nani, 2015. Decision making towards sustainability in process industry - Drivers, barriers and business opportunities. Aalto University publication series, doctoral dissertations 124/2015. Unigrafia Oy, Helsinki, Finland.

JWT Intelligence, June 2014. Writer: Jessica Vaughn. The circular economy. J. Walter Thompson Company, New York, USA.

Club of Rome, April 2015. Writers: Wijkman, Anders & Skånberg, Kristian. Circular economy and benefits for society. Swedish case study shows jobs and climate as clear winners.

Sitra, November 1015. Benefits of Carbon Neutrality in a Rapidly Changing Business Environments. Sitra Studies 102. Writers: Frost & Sullivan, Robinson, J et al. First revised edition. Lönnberg Print & Promo, Helsinki, Finland.

Keeble, Daniel, 2013. The culture of planned obsolescence in technology companies. Bachelor's thesis. Oulu University of Applied Sciences.

London, B. 1932. Ending the Depression through planned obsolescence. Wisconsin.

Ellen MacArthur Foundation, 2014. Accelerating the scale-up across global supply chains. Towards the circular economy, Vol 3.

IMSA. 2013. Unleashing the Power of the Circular Economy. Report by IMSA Amsterdam. April 2, 2013.

Ellen MacArthur Foundation, 2012. Economic and business rationale for an accelerated transition. Towards a circular economy. Vol 2.

Ellen MacArthur Foundation, 2013. Opportunities for the consumer goods sector. Towards a circular economy. Vol 1.

WEF. 2012. More with less: scaling sustainable consumption and resource efficiency. World Economic Forum.

European Environmental Bureau. March 2015. Circular Economy Package 2.0: Some ideas to complete the circle.

Environmental Services Association. June 2013. Going for growth: a practical route to a circular economy. London.

The RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce). June 2013. Investigating the role of design in the circular economy. The Great Recovery – redesigning the future. Report 01: June 2013. London.

ING Economics Department. 2015. Rethinking finance in a circular economy – financial implications of circular business models. May 2015.

Accenture. 2014. Circular Advantage – innovative business models and technologies to create value in a world without limits to growth. Accenture strategy. Accenture.

European Commission. 2015. Communication from the Commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the Regions. COM(2015) 614/2

Stahel, Walter J. 1982. Product-Life Factor. Viewed on 01.02.2016. http://product-life.org/en/major-publications/the-product-life-factor

OECD, 2010. The Emerging Middle Class in Developing Countries. Kharas, Homi. Working paper no. 285. January 2010. OECD Development Centre.

Ellen MacArthur Foundation. 2015. Delivering the circular economy – a toolkit for policymakers.

Sitra. 2015. The opportunities of a circular economy for Finland. Sitra Studies 100. October, 2015. Erweko, Helsinki 2015.

Elinkeinoelämän keskusliitto. 2015. Kiertotalous Suomen työnantajayrityksissä. 3.12.2015. Viewed 28.4.2016. http://ek.fi/wp-content/uploads/EK_Kiertotalous_Tulokset_FINAL.pdf