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Advancing the circular economy

Reverse logistics and remanufacturing of dieselparticle filters

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Thesis for the fulfilment of the
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Abstract

The Circular economy (CE) is an economic system created as an alternative to the unsustainable linear economy. CE and its business models aims to deal with the challenges as resource depletion, waste creation and over consumption by closing the material loop. CE is today practiced using different business models. One such business model is remanufacturing. A business model that has gained a lot of attention in different industries, especially in the vehicle industry. The vehicle industry, is an industry that use a lot of materials, and have a huge impact on the environment, and with the use of remanufacturing, it accomplishes to reduce material usage and decrease environmental impacts. This creates the need to look further into the remanufacturing of vehicle parts, and the focus of this thesis is remanufacturing of more diesel particle filters in the Swedish market. The thesis involves three actors, Volvo Cars, Stena Recycling Sverige, and UBD Cleantech. The study originates from Giab godsinlösen Nordic AB, that had the assumption of that there are valuable streams of diesel particle filters that currently are not collected but could be collected for remanufacturing. This study goes through literature of different concepts with key concepts of drivers and barriers for remanufacturing in the vehicle sector. This to identify what drivers and barriers there are for remanufacturing in the vehicle sector. This is followed by interviews with representatives at Stena Recycling Sverige, Volvo Cars and UBD Cleantech to examine the possibilities to collect more diesel particle filters for remanufacturing. The findings show that there are established cooperations that could enable remanufacturing of more diesel particle filters. But barriers such as the customer demand, storing and sorting can be a difficulty to overcome. However, drivers such as the environmental incentive and laws and regulation is positive for it. The conclusion and recommendations suggest further research in evaluating the quality of the filters, and the customer demand for them, but also to research other actors such as car dismantlers and car workshops that are related to the collection of diesel particle filters.

Keywords: Circular economy, Remanufacturing, Reverse logistics, Diesel particle filters

Executive Summary

CE, or circular economy, is an economic system created to be a more sustainable alternative to the linear economy. The linear economy is based on the idea of infinite natural resources, where products are produced, consumed, and disposed, which has lead to an increased awareness of the unsustainable practices in the linear economic system, and given increased attention to the CE. Ellen McArthur foundation (2015) explains the CE as restorative by design, which aims to keep products, components, and materials at their highest utility and value, at all times.

According to Planning (2015) CE requires four essential building blocks, 1) materials and product design, 2) new business models, 3) global reverse networks, 4) enabling conditions. The focus of this thesis will be on one CE business model, as well as enabling conditions for reverse networks. From a business perspective, transitioning to a CE business model creates several advantages, including: lower material costs and increased resource efficiency, and better competitiveness in a market that requires green practices (Rizos et al., 2016). There are several different business models that practice CE and that aims to close the material loop. Business models such as industrial symbiosis, product service systems, recycling, repairing and remanufacturing are some amongst more business models used in the CE (Bocken et al., 2016).

This thesis focuses on the business model of remanufacturing, and more specific remanufacturing in the vehicle sector. Remanufacturing is a business model that aims to extend the product value by reusing the material of cores (Bocken et al., 2016). Remanufacturing is a preferable CE business model when compared to recycling and repairing, as remanufacturing requires much less energy and less materials (Karvonen et al., 2015). When compared to manufacturing, remanufacturing is also advantageous, as it creates cost savings, reduces the material use, has a possibility to enhance the product, and creates new revenue streams (Graham et al. 2015; Sundin et al. 2008).

When it comes to remanufacturing in the vehicle industry, it has been a practice that has been ongoing for a longer period of time, with a main focus on the engine, but also other parts such as brakes and servopumps (Zhang & Chen, 2015). The use of remanufacturing in the vehicle industry has been a common practice in the US, but is now also paving paths in China. China, that has a growing vehicle fleet, sees remanufacturing as a beneficial way to reduce the environmental impacts from the vehicle industry (Zhang & Chen, 2015; Subramoniam, Huisingh & Chinnam, 2009). The Chinese vehicle manufacturers sees advantages by using remanufacturing, in economic profitability, brand enhancement, and a way to tackle climate change (Zhang & Chen, 2015; Subramoniam, Huisingh & Chinnam, 2009). There are several drivers for remanufacturing in the vehicle industry. Karvonen et al. (2015) argues remanufacturing to be a "win-win-win" situation. This because it creates cost savings, enable lower prices on high quality products, and environmental benefits through reduction of waste, decreased use of raw material and less energy use. However, remanufacturing in the vehicle industry does also face barriers. Sundin & Dunbäck (2013) argued lack of control regarding quality and quantity and timing of the returned products as main challenges. Sundin & Dunbäck (2013) argued further that the imbalance of return of cores to also be a barrier for establishing a remanufacturing process.

Remanufacturing as a business model is a preferable model in many ways, but to make it work, it requires reverse logistics. Reverse logistics is when the EOL product comes back from the customer to the OEM for EOL treatment (Seitz & Peattie, 2004). The reverse logistics of EOL products is not easy, as it requires much more cooperation with different actors, such as customers, dismantlers, recyclers and workshops, which also creates the need of spreading information and knowledge between each other (Seitz & Peattie, 2004). Despite the challenges, reverse logistics is referred to as green logistics, because of its positive environmental impact by

making use of EOL products (Mao & Jin, 2014). It is also argued to have economic benefits, as reverse logistics enables reuse of EOL products through different CE business models (Mao & Jin, 2014).

With the use of remanufacturing in the vehicle industry, this thesis aimed to explore the possibilities to cooperate for collecting and remanufacturing more diesel particle filters in Sweden. By answering the questions of *Which are the main barriers and drivers for remanufacturing in the vehicle sector?* and *Which potential is there to collect more diesel particle filters for remanufacturing in the examined product chain in Sweden?* This through the involvement of three main actors, Stena Recycling Sverige, Volvo Cars, and UBD Cleantech. The idea to look into remanufacturing of more diesel particle filters in the Swedish market, arose after being in contact with GIAB godsinlösen Nordic AB. GIAB godsinlösen Nordic AB had the assumption of that there were more valuable streams of diesel particle filters that could be remanufactured at the Swedish market than those that are currently remanufactured by the company UBD Cleantech.

The research process was comprised of two main parallel going steps, namely a literature review and the collection of empirical data through interviews. Followed by data analysis and categorization.

A detailed literature review on concepts such as CE, CE business models, remanufacturing, remanufacturing in the vehicle industry, reverse logistics, and drivers and barriers for remanufacturing in the vehicle sector were conducted. With the drivers and barriers for remanufacturing of vehicle parts used to create interview guides and also to guide the analysis and discussion part. The interviews were semi – structured with representatives from Stena recycling Sverige, Volvo Cars and UBD Cleantech, that all were relevant for determining the possibilities to collect more diesel particle filters for remanufacturing. The interviews looked for the opinions of the representatives and in total were 9 people interviewed. The literature review served as background for categorization of the interview findings, and following interview categories were used: Logistical cooperation, Business cooperation, Economic incentives, Law and regulations, and environmental incentives.

The findings revealed that Volvo Cars worked within a closed loop system with the aim to collect their own parts for remanufacturing. Their logistical cooperation's were made out of Volvo resellers, and car workshops with UBD Cleantech as remanufacturer. Representatives at Volvo Cars experienced difficulties to expand their closed loop system, but were interested to look into what diesel particle filters they currently did not remanufacture and missing out of, and if the filters had a customer demand. Volvo Cars did not see any law restricting the process of remanufacturing more diesel particle filters, rather the opposite. Representatives at Volvo Cars did further state that remanufacturing was preferable for the environment, as they argued that it saved energy, raw material, and reduced waste. They also stated with assent of UBD Cleantech that remanufacturing diesel particle filters created cost savings and was much cheaper than newly manufactured diesel particle filters. However, remanufactured diesel particle filters did not compete with new manufactured diesel particle filters.

Representatives at Stena Recycling Sverige were more optimistic about cooperation to collect and remanufacture more diesel particle filters, and argued that the economic incentive was the most important one. If the remanufacturer had the right economic incentive, the right relationships could be established. Representatives at Stena Recycling Sverige also stated that the logistics could be accomplished for remanufacturing diesel particle filters, but challenges will be in storing and sorting of filters. It was further stated that the car workshops and car dismantlers connected to Stena Recycling Sverige valued the most preferable EOL alternative, and they saw remanufacturing to be the best alternative for diesel particle filters. Representatives at Stena Recycling Sverige did not see any law or regulations that hindered remanufacturing of diesel particle filters. For Stena Recycling Sverige was the economic incentive the most important one to enable a logistical process for diesel particle filters.

The analysis of the findings showed that a lot of drivers mentioned in literature were also mentioned in the interviews. Common drivers seen from literature and interviews related to the economic and environmental perspective, when waste reduction, cost savings, reduction of energy and material usage were stated to be drivers. Drivers for remanufacturing of diesel particle fitlers that were found in interviews but not found in literature were the drivers of taking social responsibility and car dismantlers and car workshops will to use the best EOL solution for diesel particle filters.

When it comes to barriers, were information, knowledge, uncertainties in core quality and storing costs were some common barriers seen in both interviews and literature. These barriers were hindering the establishment of a remanufacturing process. Barriers that was found from interviews were mainly coming from Volvo Cars. The greatest barrier for not expanding the network for remanufacturing more diesel particle filters were the already established closed loop system Volvo Cars had. They did not see that the value of diesel particle filters that were not collected was good enough. Volvo Cars also argued that they needed to see if there is a customer demand, as it today seems to be uncertainties whether the diesel particle filters not collected do have a customer demand or not.

To further research the possibility to collect and remanufacture more diesel particle filters, the quality and customer demand on the diesel particle filters currently not collected needs to be evaluated. It is also of interest to research other OEMs, for example Volkswagen, to see how their system works and if there are possibilities to engage more in remanufacturing diesel particle filters. What is also suggested is to look outside the actors that was researched in this thesis, and to research the car dismantlers and car workshops opinions regarding remanufacturing more diesel particle filters. One example could be to look into Stena Recycling Sveriges car dismantler network, but also other independent car dismantlers and car workshops. This can give a bigger picture of the market. Sorting and storing were stated to be a difficulty in the logistics for remanufacturing more diesel particle filters. By researching the opinions of car dismantlers and car workshops, it can give a clearer picture of sorting and storing diesel particle filters.

Future research could also focus on the design of diesel particle filters, to be made for remanufacturing, which could create a bigger incentive in collecting more diesel particle filters.

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Abbreviations

CE Circular Economy

EOL End of life

OEM Original equipment manufacturer

1 Introduction

Circular economy opportunities and challenges

The current take, make and dispose economy is threatening our society, environment and a sustainable future. High consumption rates, resource depletion and high waste generation are some of the negative impacts appearing from the linear economy, and some of the reasons which have paved paths for exploring new economic concepts (Ghisellini, Cialani, & Ulgiati, 2016). One concept that has gained a lot of attention the last decade is the circular economy (CE) (Ghisellini, Cialani, & Ulgiati, 2016; Ellen MacArthur Foundation, 2015). The CE aims to deal with series of challenges faced by the society today, including waste and pollution generation, resource scarcity, and energy usage, by closing material loops and creating a circular flow of materials (Lieder & Rashid, 2016; Ghisellini, Cialani, & Ulgiati, 2016).

According to the Ellen MacArthur Foundation (2015), CE aims to keep all sorts of materials, products, and components at their highest utility and value, at all times, by being restorative by design. Ellen MacArthur Foundation (2015) states that the CE is built upon three principles, taking both the biological and technical cycles into account. The foundations differentiate between two cycles; one is the flow of biological material, for example food, and the second is the flow of technical material for example mobile phones (Ellen MacArthur Foundation, 2017). See figure 1-1 for further explanation. The principles CE is built upon are, to preserve and enhance natural capital, optimise yields from resources in use, and minimise negative externalities by stimulating system effectiveness (Ellen MacArthur Foundation, 2015). An economic model that circle around these three principles are according to Ellen MacArthur Foundation (2015), following the concept of CE.

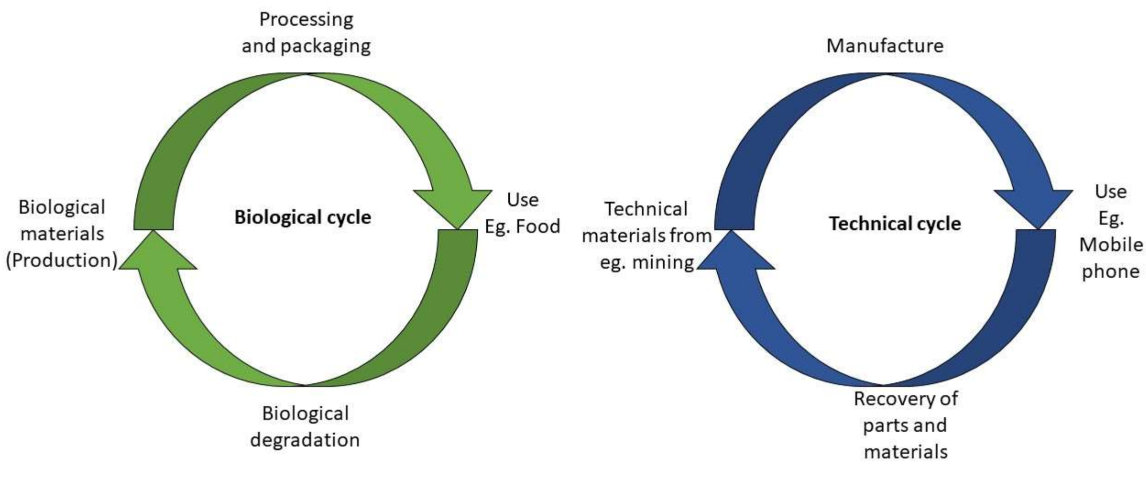

Figure 1-1. Biological and technical cycle in CE.

Source: Own illustration based on description from Ellen MacArthur Foundation (2017).

The CE encourgaes businesses to find opportunities to meet harsher environmental requirements, to profile themselves as “green”, to take social and ethical responsibility, and to meet the sustainable development goals (Andrews, 2015, Lieder & Rashid, 2016). With a mindset of making products reusable and close the material loop through different economic models, CE is stimulating the manufacturer to consider the whole life cycle of a product, and taking care of end of life (EOL) products in a way that benefits the environment and generate profit (Bocken et al., 2016).

CE is a regenerative concept developed to manage today’s challenges, associated with the linear economy (Muray et al., 2015). The CE also creates opportunities for product innovation, and stimulates profitable businesses, while benefitting the environment and the sustainable development (Murray et al., 2015; Ellen MacArthur Foundation, 2015). However, CE is not straight forward. CE business models face challenges in different stages, ranging from the design of products for closing the loop, to engage customers in a reverse logistics for EOL products, lack of "know how" and competent labour, and lack of communication and information between relevant actors (Ripanti et al., n.d.).

CE business models and strategies

Practicing CE often requires radical changes in business, but could also be an “add on” to current practices (Bocken et al, 2016). CE requires that all stages of a products lifecycle are considered, to support the closing of material loops, and the design of a product in such way so that material and components can be reused is an important part for closing the material loop (Bocken et al., 2016). There are also other CE strategies that not only focuses on the product itself, but on cooperations such as making use of residual outputs through business cooperation or making products more available to more people through hiring or leasing (Bocken et al., 2016). Bocken et al. (2016) outline six different business model strategies for slowing or closing the material loop. These strategies include practices such as recycling, remanufacturing, reusing, and sharing. The choice of CE business model is dependent on the purpose, but all models serve the same ambition of closing or slowing the material loop (Bocken et al., 2016). The table below gives an overview of business model strategies that are used when it comes to CE.

Table 1-1. Six business model strategies for slowing and closing loops.

Business model strategies for slowing loops		***Business model strategies for closing loops***
1. Access and performance model	2. Extending product value	5. Extending resource value
3. Classic longlife model	4. Encourage sufficiency	6. Industrial Symbiosis

Source: Own table based on the six business model strategies from Bocken et al. (2016)

The different strategies seen above are practiced by different economic models, that include, for instance, access to products without ownerships, remanufacturing, refurbishing, long life products, durable and repairable products, minimizing consumption by extending resource value, and company cooperation through industrial symbiosis by making use of another company’s waste, such as heat waste or other waste generation (Bocken et al., 2016).

Remanufacturing and Reverse logistics

Remanufacturing, a CE business model based on the principles of CE (Bocken et al., 2016), is of interest for this study. Remanufacturing is a business model, that aims to extend the product value and create a residual value (Bocken et al., 2016; Ellen MacArthur Foundation, 2015). According to Graham et al, (2015) remanufacturing is a process of giving new life to a product by using the components and materials the product holds. The remanufacturing process can return the product to the market as a new product, or in the best of cases as an upgraded product (Graham et al., 2015). For a functioning and successful remanufacturing process, it is beneficial if the product is designed for disassembly, the operation costs should be low, and the EOL product quality needs to be known in beforehand (Sabharwal & Garg, 2013). If the above-mentioned requirements are fulfilled, remanufacturing is argued to be a preferable practice for EOL products if compared to repairing and reconditioning (States & Kingdom, 2007). This is because remanufacturing has a higher level of quality, can give an upgrade to the product, and does not use additional materials in the process (States & Kingdom, 2007). At the same time, remanufacturing also conserve a higher amount of resources, contributes to environmental benefits as it uses less energy and natural resources compared to a new manufactured product (States & Kingdom, 2007). Remanufacturing is the interest of this thesis not only for its potential to slow the material loop, but also, because it has been practiced and researched in different industries, with the vehicle industry as one of the bigger industries focusing on remanufacturing of parts (Zhang & Chen, 2015). Remanufacturing in the vehicle industry is also what this thesis aims to look in to, considering diesel particle filters.

Despite the fact that remanufacturing is preferable to a lot of other CE models, there are still challenges in collecting cores for remanufacturing, which makes a functioning reverse logistics very important for successful remanufacturing (Ripanti et al., n.d; Abdulrahman et al., 2014). Reverse logistics is the collection of EOL materials, and the involvement of more actors such as customers and other companies in the supply chain, actors that typically are not involved in traditional logistics (Abdulrahman et al., 2014). Well coordinated reverse logistics is a basis for higher sales revenue and reduced operational costs and it requires cooperation (Abdulrahman et al., 2014). Reverse logistics serves as an enabler for treatment of EOL products, and is referred to as "green" logistics, compared to traditional logistics, because of its practice to collect and treat EOL products (Mao & Jin, 2014).

After introducing the key concepts, we now move on to the subject of this study. This thesis attempts to research the possibility to collect and remanufacture more diesel particle filters for personal diesel vehicles in Sweden, focusing on new material streams. The research is done in collaboration with four different Swedish companies, who are all interested in advancing remanufacturing and find more materials suitable for remanufacturing:

1. Giab Godsinlösen Nordic AB; A company that works with circular economy solutions. One of their core businesses is remanufacturing of cellphones.
2. Stena Recycling Sverige are also part of the project, the company is working with collection and recycling different materials, including vehicle parts.
3. Volvo Cars is a third involved actor. Volvo Cars is the original equipment manufacturer of a lot of diesel particle filters in Sweden. Volvo works in close collaboration with a remanufacturing company called UBD Cleantech.
4. UBD Cleantech, which is a remanufacturer of diesel particle filters for Volvo Cars.

The thesis originates from the information, provided by different actors, that there are additional filters – to those currently remanufactured – that could potentially be remanufactured, increasing revenue streams. Thus, a deeper cooperation between the companies involved may lead to additional collection of diesel particle filters from new material streams, which will reduce waste, reduce raw material use and advance the circular economy.

1.1 Company introduction and current remanufacturing practices

This part aims to introduce the actors involved in the research, and how and if they currently are related to each other. This information is provided to give a better understanding why the companies chosen for this research are of relevance. An overview of the remanufacturing process at UBD Cleantech is also presented, to provide a deeper understanding what is needed for a successful remanufacturing process for diesel particle filters.

1.1.1 GIAB godsinlösen Nordic AB

GIAB godsinlösen Nordic AB is a company with a main focus on circular economy business models. GIAB do consult companies in developing circular economy for smarter and more efficient use of materials. Currently are they working with for example remanufacturing of mobile phones and the re-use and resale of damaged goods. GIAB are constantly looking for opportunities to develop circular business models to further close the loops. GIAB godsinlösen Nordic AB is working in close relationship to UBD Cleantech, with an aim to collect and remanufacture more diesel particle filters and out from GIAB godsinlösen Nordic AB the interest for this research rose. GIAB godsinlösen Nordic AB is working in close relationship to UBD Cleantech, with an aim to collect and remanufacture more diesel particle filters and out from GIAB godsinlösen Nordic AB the interest for this research rose.

1.1.2 Stena Recycling Sverige

Stena Recycling Sverige is the biggest Swedish recycler of residual material, especially from industries. They collect and recycle the products to extract the value of the materials in them. Stena Recycling Sverige also takes care of hazardous material and landfilling of materials not possible to recycle. Car disassemblers and car workshops are two of the bigger customers to Stena Recycling Sverige, which also is the stream of diesel particle filters. The close connection to car disassemblers and car workshops, and the assumption of Stena Recycling Sverige get in contact with a lot of diesel particle filters, make Stena Recycling Sverige a relevant actor in this research to investigate the possibility to collect and remanufacture diesel particle filters, to further close the loop of material usage.

1.1.3 Volvo Cars

Volvo Cars is the original equipment manufacturer (OEM) of Volvo vehicles and for this research interest, also the diesel particle filters for their cars. Volvo has manufactured cars since 1927 with a high emphasis on road safety, and alredy since the mid 1970s Volvo Cars started engaging in environmental questions, with the development of the lambda sond 1976 as a breakthrough. As environmental issues have risen to become a big concern in the automotive industry, it is crucial for Volvo Cars to continuously develop in that field. Circular business models have been a part of the environmental engagement to tackle the environmental issues by Volvo Cars, and with a separate department for remanufacturing named Volvo Reman, do Volvo Cars remanufacture their own vehicle parts. When it comes to remanufacturing of diesel particle filters, Volvo Reman cooperates with UBD Cleantech (Intervju, Gunnar, Axel).

1.1.4 UBD Cleantech

UBD Cleantech is the main remanufacturer of diesel particle filters for Volvo Cars, and the customer range is covering the automotive industry across Europe, including other automotive brands such as Volkswagen, Ford, Seat and Toyota. With a 10 years experience of remanufacturing diesel particle filters, UBD Cleantech has developed a uniqe remanufacturing technique with the possibility to restore the filter to at least 95% of its capacity, and is an important business partner for Volvo cars in the remanufacturing industry. UBD Cleantech has an interest in closing the loop for diesel particle filters even more by establishing new cooperations to collect and remanufacture more diesel particle filters.

1.1.5 Remanufacturing Process

The remanufacturing process for diesel particle filters at UBD Cleantech follows seven steps after recieiving the material from the customer. The diesel particle filters are usually sorted by the customer, so the first step in the remanufacturing process starts with identification and classification. The diesel particle filter goes through a control and an assessment at this step to decide whether the diesel particle filter can be remanufactured or not. In most of the cases do filters have the capacity to be remanufactured, the only time it cannot is when the substrate is damaged. The following step is the purification step. Here is the filters are heated to 600-700 degrees; these temperatures are what a dieselengine heats up to when purifying the diesel particle filters, the heat creates soot and ash and purifies the filter. The soot and ash is in the third step vacuumed or water cleaned, depending on the type of filter. The fourth step is capacity testing, it tests the pressure and the cleaning capacity by the filter, using diesel to simulate the circumstances for the filter in an engine, the filters capacity should reach the same capacity as a new manufactured filter. This is followed by step five, of engraving the serial number and then step six, surface finish, which isolates the filter and gives it a new surface. In the final step, an inspection of the filter is done before packaging and sending it back to the customer.

A typical process for remanufacturing of diesel particle filters at UBD Cleantech is illustrated below.

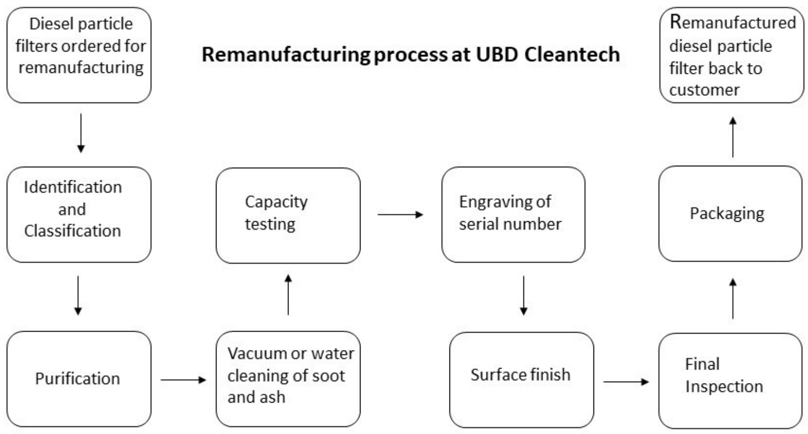

Figure 1-2. Remanufacturing process of diesel particle filters at UBD Cleantech.

Source: Own illustration based on studyvisit 2017-07-18.

1.2 Problem definition and research justification

When it comes to remanufacturing in the vehicle sector, remanufacturing practices has been researched and used for several years, concerning different vehicle parts (Sundin & Dunbäck, 2013). However, there are some parts that have been of more interest both in research and practice, those include engines, brakes and servo pumps (Sundin & Dunbäck, 2013). Ford is one automotive company, that in an early stage focused on the benefits of remanufacturing vehicle engines, and the automotive company developed an own remanufacturing method called Plasma Transferred Wire Arc (PTWA) coating technology for vehicle engines (Arc & Boagey, 2016) Ford incorporated remanufacturing to their business with the aim to benefit the environment through making use of EOL material, but also to prolong products economic life (Arc & Boagey, 2016). Ford's development of the remanufacturing technique was in line with an emerging remanufacturing industry in America, were the vehicle industry was of high interest when it came to remanufacturing (Sundin et al., 2008). That remanufacturing is an interesting business model for the automotive industry is not a secret, and it is a topic that is consistently being investigated (Sundin & Dunbäck, 2013). Remanufacturing practices in the vehicle industry has been researched and developed in different parts of the world, and one of the latest countries with interest in remanufacturing in the vehicle industry is China (Zhang, Yang & Chen, 2017). Zhang, Yang & Chen (2017) argued in their study, that a growing vehicle fleet in China contributed to a lot of adverse effects on the environment. One way that was considered the best way to slow and reduce these effects was through remanufacturing (Zhang, Yang & Chen, 2017). Zhang & Chen (2015) also argue thatt remanufacturing is the most sustainable practice to meet a growing vehicle fleet in China.

The vehicle industry is without any doubts an industry where remanufacturing is a hot topic of growing interest (Arndt, 2006; Sundin & Dunbäck, 2013). The interest to close the material loop in the vehicle industry through remanufacturing grows out of as above mentioned, reductions of the environmental impacts. But, remanufacturing as a CE business model is also argued to be a preferable model compared to other CE business models when it comes to the environmental benefits. When compared to repairing, recycling and reconditioning, remanufacturing is argued to be preferable for the environment as it uses less energy and requires less additional materials (States & Kingdom, 2007). Remanufacturing does further have the possibility to upgrade a product, something that repairing and reconditioning is argued not to have (States & Kingdom, 2007). Compared to manufacturing that is dependent on raw materials remanufacturing reduce environmental impacts, through the reuse of materials, energy savings and less waste creation (Karvonen et al., 2015). At the same time, it is argued that remanufacturing is profitable, create cost savings and offer high quality products to customers at a much lower price than new manufactured products (Karvonen et al., 2015).

With a CE business model that is argued to be environmentally preferable, and economical profitable, leads us to the problem of this study. This study aims to look at the possibilities to advance remanufacturing in the vehicle industry. This to look at the possibilities to collect and remanufacture more diesel particle filters in Sweden through cooperation between Volvo Cars, Stena Recycling Sverige and UBD Cleantech.

The idea to look into remanufacturing in the vehicle industry arose after being in contact with Giab godsinlösen Nordic AB, as the company saw a possibility to remanufacture more diesel particle in the Swedish market. It was told that there are remanufacturing of diesel particle filters in Sweden today through the company UBD Cleantech. However, there is an assumption that a lot of diesel particle filters are either going to waste or being recycled, when they instead could be remanufactured. Those streams that are assumed going to other EOL treatments and currently not remanufactured, is what this thesis wants to research. This by working with Stena

Recycling Sverige, a company assumed to get in contact with a lot of diesel particle filters, and Volvo Cars, OEM of diesel particle filters for their vehicles.

The assumption that a lot of diesel particle filters are wasted or being recycled, together with the facts of remanufacturing being an CE business model with a lot of advantages for slowing the material loop and enhancing CE., created an interest to look at the possibilities for finding more valuable streams for remanufacturing of diesel particle filters through cooperation between, Stena Recycling Sverige, Volvo Cars, UBD Cleantech, and GIAB godsinlösen Nordic AB.

The possibilities to establish cooperations for remanufacturing of more diesel particle filters in the Swedish market will be evaluated through looking at what drivers and barriers are there for remanufacturing in the vehicle sector. Also, what possibilities and what is needed between Volvo Cars, Stena Recycling Sverige, UBD Cleantech and GIAB godsinlösen Nordic AB when it comes to cooperation for collecting more diesel particle filters for remanufacturing will be examined.

The study serves as a first step to investigate possibilities for future cooperation between the companies for advancing remanufacturing of diesel particle filters.

1.3 Aim and Research questions

This thesis aims to explore the possibilities to cooperate for collecting and remanufacturing more diesel particle filters in Sweden. The thesis thereby aims to answer the following research questions (RQ);

RQ 1: Which are the main barriers and drivers for remanufacturing in the vehicle sector?
RQ 2: Which potential is there to collect more diesel particle filters for remanufacturing in the examined product chain in Sweden?

1.4 Limitations and scope

This paper focuses solely on remanufacturing of diesel particle filters in the Swedish market. The paper is focusing on interview persons from the companies earlier described, Volvo Cars, Stena Recycling Sverige and UBD Cleantech. All other actors will be excluded and not serve as an interview object. The scope of this research is limited to exploring the opinions from interview persons to be able to get a first overview of the possibilities to expand the network and create cooperation for remanufacturing of more diesel particle filters.

Unfortunately, the research is aslo limited to the difficulty to obtain exact numbers, such as prices of different activities concerning remanufacturing. A view of prices for activities related to the collection, logistics and remanufacturing process could have generated a better picture of the economic situation for developing a cooperation for remanufacturing more diesel particle filters and comparing with other alternatives. Further, is the study limited to the time limitation and the availability of interview persons during the summer vacation. The summer vacation and restricted time did limit the empirical data collection through interviews.

1.5 Ethical consideration

This thesis has two parts of findings, first the literature review followed by the interviews. The literature review is focused on already published literature that is available for the public and do not have any ethical considerations. The thesis second part is made out of interviews and an observation and thus uses anonymous interviewees to open up for personal opinions but do also consider to not share confidential information. The findings seek to respect the interviewees.

1.6 Audience

The target audience for this thesis are the companies involved, however the findings are also relevant to other companies indirect or direct related to the automotive industry. The thesis is also looking for possibilities to develop the CE, which is of interest for universities around Sweden, and for this project especially Lund University, Gothenburg University and Linköping University, and most notably researchers within the REES program. The research can hopefully give valuable insights as how to proceed with the development of an expanded network for remanufacturing more diesel particle filters by providing the first examination of the topic.

1.7 Disposition

The figure below shows this thesis disposition and each chapter's content. The initial parts of the thesis define the problem, specifies research questions and scope and limitation. Following chapter explain the methodology used for this thesis, followed the literature review chapter focusing on key concepts of the study. In chapter four are the findings from the empirical data collected through interviews presented, followed by the chapters of analysis and discussion of the findings, and conclusions and recommendations.

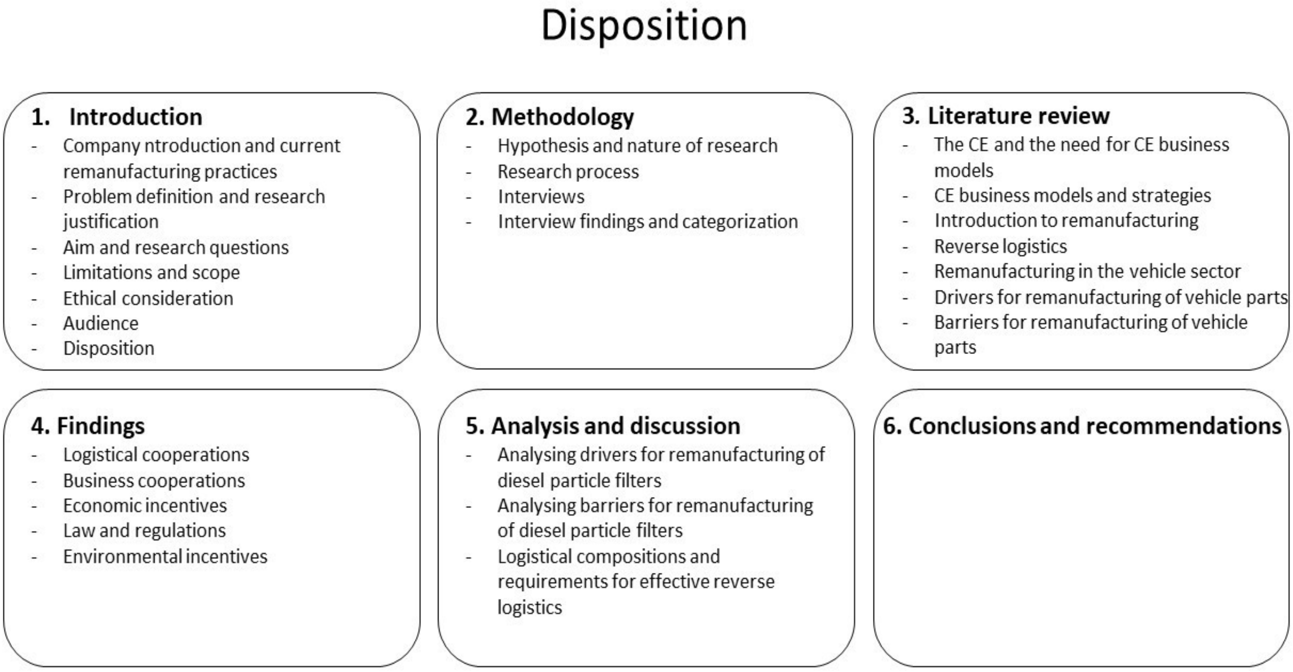

Figure 1-3. Disposition.

Source: Own illustration.

2 Methodology

This chapter gives a description of the methodology used for the research. It consists of following subheadings, hypothesis and nature of the research, research process, data collection and analysis, literature review and interviews with interview process and interview findings and categorization. Each heading is given a description so that the reader easily could follow the methodological process.

2.1 Hypothesis and nature of the research

The hypothesis of this research is that there is a possibility to collect and remanufacture additional diesel particle filters for personal vehicles in Sweden. However, it is a challenge to overcome barriers such as logistical issues and create a need for cooperation among actors, to exploit this material stream.

This thesis is an exploratory study that aims to analyse the potential for new business solutions related to the CE. It is also a case study of the potential to increase the number of remanufactured diesel particle filters in Sweden. It is a qualitative research in its nature, but do still use numbers such as prices, related to the diesel particle filters because it plays a role in for determining possibilities for cooperation between the different actors. However, most important is the opinions from the actors, to be able to evaluate the drivers and barriers for companies involved in the research.

2.2 Research Process

The research process where mainly based on two parallel going steps, the literature review and interview with stakeholders at Stena Recycling Sverige, Volvo Cars and UBD Cleantech.

1) Literature review of different academic articles and grey literature focusing on subjects as CE, Remanufacturing, Remanufacturing in the automotive industry and reverse logistics.
2) Collection of empirical data through interviews with representatives at Stena Recycling Sverige, Volvo Cars, and UBD Cleantech and a studyvisit at UBD Cleantech.

2.2.1 Data collection and analysis

The primary data collected for this research is qualitative through interviews, which were important for answering RQ 2. Qualitative research can vary a lot, but common for qualitative research is that the research seeks to collect evidence, or produce findings that were not determined in advance and this by not exploring numbers, but rather looking for opinions, values and observations through interviews and observations (6 & Bellamy, 2012). A qualitative data collection could also be done using written documents, to explore data written in the area of interest; the written documents could be reports, books, articles and newspapers amongst others (6 & Bellamy, 2012).

This research collected primary data primarily through interviews, focusing on three companies. The main priority was not to have a large number of interviewees but rather to obtain answeres and opinions from people with considerable knowledge about the relevant issues. It was also of high importance to have interview persons that could represent the views and experiences of the companies involved. In addition to the interviews a site visit at UBD Cleantech was conducted, with an observation of the remanufacturing process, which has been described in the introduction. The research did also consist of a literature review. The literature review was important as guidance for the interviews, and for interpreting the interview findings. The literature review focused on the main topics related to this study.

Data was analysed through the use of literature, in the chapter of analysis and discussion are interview findings and literature findings brought up and discussed. The analysis and discussion part relates to the drivers and barriers for remanufacturing, and logistical components. The analysis is made out of what literature brought up in relation to those concepts, and what the interviews brought up in relation to those concepts.

2.2.2 Literature review

The literature review was the first step for this study. A comprehensive literature review was made considering the topics of the CE, CE business models, remanufacturing, remanufacturing in the automotive industry, barriers and drivers for remanufacturing in automotive industry, and reverse logistics. The review provided the background necessary for knowledge about the key concepts, and was also important for the creation of the interview protocol. The interview protocols were created from the findings in the literature review, which also gave the interview persons further possibility to give additional thoughts and opinions to what was not found in the literature. The findings from the literature review did also play a significant role as data to analyse the interview findings. Data on CE and other concepts were mostly found through channels as LUBSearch, google, google scholar and Ellen McArthur Foundation. The main part of the literature review, focused on the drivers and barriers for remanufacturing in the automotive industry, giving an overview of what were written in the field. The drivers and barriers of remanufacturing in the automotive industry served as main ingredient when developing the interview protocol but is also the part focused on answering RQ 1. The other key concepts in the literature review are important to give a torough overview and understanding for the entirety of the functioning in CE and specifically remanufacturing as a CE business model. Words and phrases used in the literature search is shown in the table below.

Table 2-1. Search words and search phrases used in the literature search.

"Circular economy"	**"Remanufacturing in the automotive/vehicle industry"**	**"Barriers remanufacturing"**	**"Reverse supply chain"**
"Circular Business Models"	**"Drivers remanufacturing"**	**"Barriers remanufacturing in the vehicle industry"**	**"Reverse logistics network"**
Remanufacturing	**"Drivers remanufacturing in the automotive/vehicle industry"**	**"Reverse logistics"**	**"Remanufacturing system"**

Source: Own table, showing search words, and search phrases used in the literature review

2.3 Interviews

To be able to answer RQ 2, interviews with persons from Volvo Cars, Stena Recycling Sverige, and UBD Cleantech was of interest. To find people of interest, the research started with a kick-off meeting at Stena Recycling Sverige in Gothenburgh. The meeting involved actors from Volvo Cars, Stena Recycling Sverige and Giab Godsinlösen Nordic AB, and everybody were introduced to the research project. This meeting immediately generated interesting interview persons at Stena Recycling and Volvo Cars, but also contact persons at UBD Cleantech. The interview process started with people at Stena Recycling Sverige, people with relationships to car dismantlers and car workshops to give a first view. This was followed by interviews with people at Volvo Cars Reman, and people working related to environmental management at Volvo Cars. Interview people were also suggested by the interviewees, in those cases there were questions the interviewees were not able to answer, which gave additional people to interview. One Interview and a observation was also conducted at UBD Cleantech in Höör.

The interviews played a central role in this research and embodied the findings for RQ 2, and all people that were interviewed were in one way or another close related to diesel particle filters. In total was 9 people interviewed, 4 at Volvo Cars, 3 at Stena Recycling Sverige and 2 at UBD Cleantech.

2.3.1 Interview process

The interview process started with conducting interview guides, all guides were made to fit the interview person and were sent out beforehand, giving the interviewees possibility to comment and prepare. The interview guides were developed after the initial meeting with relevant actors, and after going through literature regarding key concepts for the thesis. The initial meeting generated interesting and relevant interview persons for the study and with the interview persons settled, and a thorough literature review made, interview questions could be developed. Questions were mostly linked to the findings obtained from drivers and barriers for remanufacturing vehicle parts in the literature review, but did also connect to other concepts relevant for the thesis. The questions were adjusted in order to suit the area of knowledge of the respective interviewee. During the interviews, additional interview persons was suggested by the interviewees. In total were 4 interviews based on recommendations, adding to the 5 that was planned beforehand. In total, there were 4 interviews at Volvo Cars, 3 interviews at Stena Recycling Sverige and 2 interviews at UBD Cleantech. The interviews were made with representatives at Volvo Cars Reman, the remanufacturing department for Volvo Cars, and with representatives related to Volvo Cars environmental strategy. At Stena Recycling, there were interviews conducted with representatives managing the relations with car dismantlers and car workshops, and also interviewees connected to hazardous waste. At UBD Cleantech the representatives were related to the remanufacturing process, and to the business marketing management. Both of the representatives at UBD Cleantech had a close relationship with Volvo Cars. All interviews were semistructured, allowing the researcher to make the choice whether the interview should stick to the interviewguide or use new follow up questions outside the original script as follow up questions to the interviewees answeres (6 & Bellamy, 2012).

The flexibility with the use of follow up questions was important as the interview answers could differ widely between interview persons and the interview could take different directions. The interview guide for each interviewee was made with general open - ended questions. Focusing in the beginning on the role of the interviewee and the general view on remanufacturing. This was then narrowed down with more targeted questions related to collection and remanufacturing of more diesel particle filters. Questions were focused on barriers, drivers and possibilities to cooperate for remanufacturing more diesel particle filters. The way of going from a general perspective with open ended questions, still related to the topic, and then narrowing it towards more targeted questions could be described as a "funnel approach" in literature, and is a general recommendation for conducting interviews (Kvale & Brinkmann, 2009).

The interviews varied in length but went on in an interval between 25 minutes to 60 minutes. In two cases, the first at Volvo Cars Reman, and the second at UBD Cleantech, interview persons cooperated to answer the questions under the same interview. The interviews were conducted through phone, skype but also on-site visits and all interviews but the on-site interview was recorded. Following the interviews, all recorded interviews were transcribed from the beginning to the end, to be able to follow the conversation and categorize the findings. Interview guides could be found in appendix 1.

2.4 Interview findings and categorization

After transcribing the interviews, the findings were divided into 5 categories: logistical cooperation, business cooperation, law and regulation, economic incentive and environmental incentives. The findings were presented anonymously to make room for personal opionons, and in some occasions direct quotes were used. The categorization of the findings from the interviews was corresponding with the findings identified from the literature review, in particular the drivers and barriers for remanufacturing in the vehicle industry. The five categories are motivated below.

1) **Logistical Cooperation** sets the fundamentals in the possibility to create a remanufacturing network. This category shares the thoughts of the interviewees view on current logistical cooperations and possibilities for future cooperation involving more actors.
2) **Business Cooperation**, a category crucial for every involved actor. It provides the thoughts of the interviewees on how the involved actors can benefit, what drawbacks there could be or what difficulties they face to establish a functioning remanufacturing process of diesel particle filters.
3) **Economic Incentives**, are closely linked to Business cooperations and Logistical cooperations, but may be the most important factor to enable remanufacturing of more diesel particle filters. This category gives the actors view on how economic considerations play a role in establishing a network to collect more diesel particle filters, but also economic incentives necessary for remanufacturing.
4) **Law and regulations,** could accordingto literature act as a driver and in some cases a barrier for remanufacturing and CE business models. For a functioning network for remanufacturing, it is of interest to see how the actors involved view law and regulation in establishing that network.
5) **Environmental Incentives** remanufacturing is argued to be preferable for the environment, and as a CE business model the environmental benefit is of relevance to consider. This category determines what opinions the actors have when it comes to the environmental implications of remanufacturing more diesel particle filters.

3 Literature review

This literature review gives an overview of the key concepts related to this study. The literature review mainly originates from academic literature, but do also include grey literature. The key concepts presented below are the CE, CE business models and strategies, Remanufacturing, Reverse Logistics, Remanufacturing Logistics, Remanufacturing in the vehicle sector, Drivers for Remanufacturing vehicle parts and Barriers Remanufacturing vehicle parts.

3.1 The CE and the need for CE business models

The need for the CE grows out from resource scarcity, increased price on natural resources, social requirements on more sustainable practices in industries, but also as an economic and socio – political issue (Stahel, 2010). The concept of a CE is based on the biological and technological cycles which includes three principles: preserve and enhance natural capital, optimise yields from resources in use, and foster system effectiveness by minimizing negative externalities (Ellen MacArthur Foundation 2015, p. 14). The CE seeks to rebuild capital, and is practiced through different business models, including recycling, repairing, refurbish, design, maintenance and remanufacturing (Bocken et al., 2016). As mentioned CE involves both the biological cycle and the technical cycle. The biological cycle describes the circular flow of biological material, for example food that are farmed, consumed and then serve the purpose as nutrition or material for energy. and the circular flow of technical material such as a vehicle engine, that occurs from mining and manufacturing, and then at EOL can be reused (Ellen MacArthur Foundation, 2017). The diagram below illustrates the biological and technical cycles in CE.

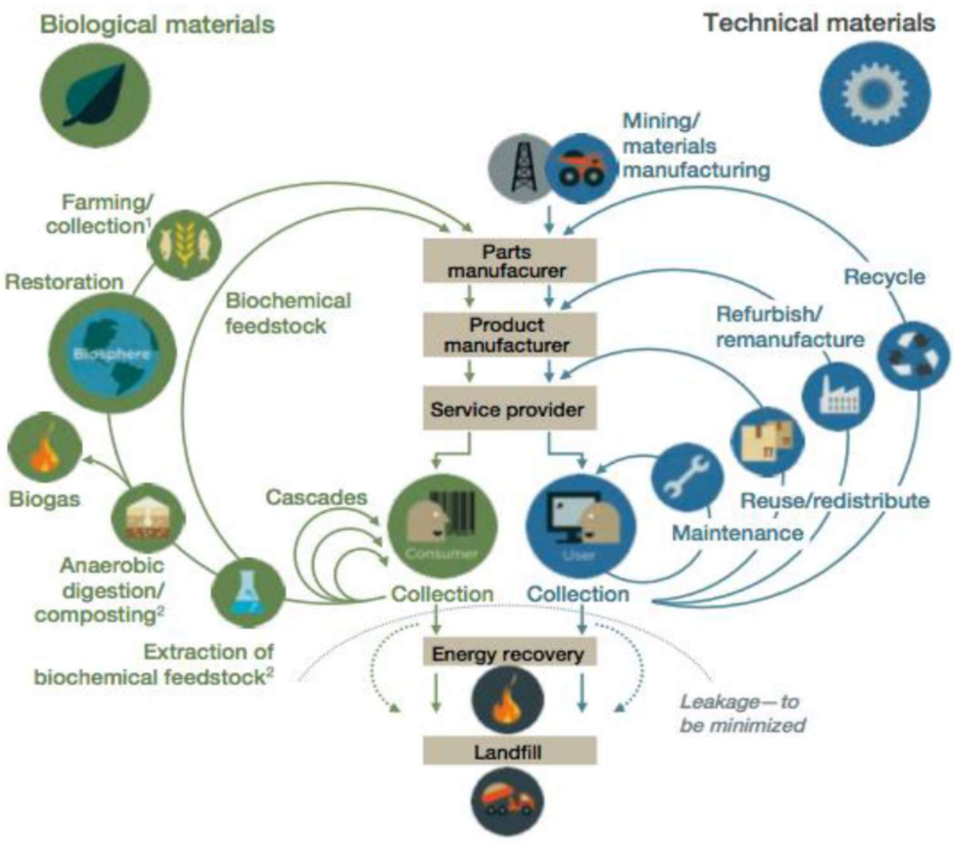

Figure 3-1. The CE, biological and technical cycle.

Source: Ellen MacArthur foundation (2017) https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram

The explanation of Ellen MacArthur Foundation (2015, p.14) corresponds with Murray et al. (2015 p.1) definition of the CE as "an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being". Murray et al. (2015) further argue that CE places emphasis on the redesign of processes and cycling of materials, a process that may contribute to more sustainable business models. Murray et al. (2015) did also link CE to the definition of sustainable development, and argued in their findings that there is a need for CE to be able to meet all three dimensions of sustainable development social, economic and environmental. It was also argued that the CE is concentrating on the redesign of manufacturing and service system, to benefit the biosphere, and through renewal and survival and reduction of finite resources also benefits the humankind. Even if CE is linked to sustainable development, Murray et al. (2015) still see a weak link between the CE to the recognition of the the social aspects in sustainable development, as it is unclear how the concept of the CE will lead to greater social equality. Thus, they argue that the social dimension is missing in the CE.

The CE do often consider the product design important. A product designed for EOL treatment do further include advantages for the manufacturer to control the product through the whole lifecycle, which also makes the CE more desirable than linear economy (Andrews, 2015). Andrews (2015) did further argue that the benefits of CE could also bee seen in involvement of more actors in the reverse supply chain, which creates closer relationships between companies. In the study, it is also argued that CE has the potential to reduce corrupt and unethical practices. This to foster sustainable development through the whole supply chain, by making it much easier to carry out accurate supply chain audits, and to either select ethical suppliers or to encourage unethical suppliers to change their practice (Andrews, 2015). The CE is according to both Andrews (2015) and Murray et al. (2015) argued to be a vector for sustainable development, and a need for changing towards a closed loop economy is urgent, as the take, make and dispose society today depletes our natural resources and pollutes our nature. Further, it has been argued that CE carry benefits such as material savings, reduced supply risks, and business models using CE do also give improved customer loyalty and the development of new revenue streams (Rios & Charnley, 2017).

The advantages of the CE can be many, according to a study made by Ellen MacArthur Foundation (2015) together with the Mckinsey Center for Business and Environment. The study looked at the European economy and the possible impacts of transitioning to the CE. The study concluded that the European economy was extremely wasteful with resources, but new business models incorporating the CE and disruptive technologies have the capability to improve the productivity of resources and at the same time reduce annual costs. If such practices where implemented it could benefit the European economy with up to €1.8 trillion annually by 2030, while at the same time obtain higher employment rates and increased welfare compared to the current path (Ellen MacArthur Foundation, 2015). The benefits of CE are also argued to boost regional job creation since it reinforces the labour-intensive parts (Stahel, 2010; Wijkman & Skånberg, 2015). At the same time CO2 emissions can be significantly reduced. Looking at CO2 levels from 2012, a transition to CE can reduce CO2 emissions by nearly 50 % by 2030 compared to the current path (Ellen MacArthur Foundation, 2015).

As mentioned above, CE and its practical applications to economic systems and industrial processes, take different shapes and contributions from a variety of business models, that all share the idea of closed loop systems (Geissdoerfer et al., 2017). With a lot of different advantages, the concept of CE has also gained attention by policymakers, influencing governments, and intergovernmental agencies at the local, regional, national and international levels. Integrating CE into laws I also becoming more common, and according to Geissdorfer et al. Germany is a pioneer in doing so (Geissdoerfer et al., 2017). Despite all the advantages, CE-based business models can in practice include challenges, as it requires cooperation with additional actors in the supply chain because of the need of reverse logistics of products (Gonzáles – Torre et al., 2010). It is of necessity to involve and cooperate with customers, and in cases other companies to make it as effiecient as possible (Ripanti et al., n.d.). Furthermore, knowledge on how to manage EOL products is important to determine which EOL treatment that suit best for the product, and also design, storing and sorting could be challenges for a functioning CE (Ripanti et al., n.d.) These challenges do make it difficult for the CE in practice. However, Planning (2015) argued in their study that four pillars are essential for a successful CE. Those pillars are referred to be materials and product design, new business models, global reverse networks, and enabling conditions, who are enabled through cooperations and suiting business models (Planning, 2015).

3.2 CE business models and strategies

From a business perspective, a transition to CE and use of CE business models creates several advantages, including: lower material costs and increased resource efficiency, and better competitiveness in markets that require green practices (Rizos et al., 2016). The different ways to practice the CE gives the society and industry different ways of closing the material loop, and reduce the waste and material usage. The different shapes the CE can take includes amongst more industrial symbiosis, focusing on renewable energy, product service systems, product design and EOL management, such as recycling, repairing, refurbish, maintenance and remanufacturing (Rios & Charnley, 2017; Bocken et al., 2016).

Moving towards a CE buisness model do many times require a radical change in current manufacturing strategies, as it is innovative and require new way of thinking of how to do business, compared to the 'linear economy' logic (Bocken et al., 2016). However, in some cases could a CE business model also be an 'add on' to current practices to slow the material loop (Bocken et al., 2016). There are according to Bocken et al. (2016) six different strategies for CE that attempt to slow or close the material loop. The strategies for slowing the loop of resources are access and performance model, extending product value, classic longlife model and encourage sufficiency. Model strategies described to close the loop of resources are extending resource value and industrial symbiosis (Bocken et al, 2016). Table 3-1 below show and explain the business model strategies for CE and gives example of cases or practices for each strategy.

Table 3-1. Business model innovation to slow or close resource loops.

Business model strategies	Definition	Example of cases
Business model strategies for slowing loops		
1. Access and Performance model	Providing the capability or services to satisfy user needs without needing to own physical products	• Car sharing • Launderettes • Document Management Systems (e.g. Xerox, Kyocera) • Tuxido hire • Leasing jeans
2. Extending product value	Exploiting residual value of products – from manufacture, to consumers, and then back to manufacturing – or collection of products between distinct business entities	• Automotive industry – remanufacturing parts • Clothing return initiatives (e.g. H&M, M&S' Shwopping)
3. Classic longlife model	Business models focused on delivering long-product life, supported by design for durability and repair for instance	• White goods (e.g. Miele's 20 year functional life span of appliances) • Luxury products claiming to last beyond a lifetime (e.g. luxury watches such as Rolex)
4. Encourage Sufficiency	Solutions that actively seek to reduce end-user consumption through principles such as durability, upgradability, service, warrantees and reparability and a non-consumerist approach to marketing and sales (e.g. no sales commissions)	• Premium, high service and quality brands such as Vitsoe and Patagonia • Energy Service Companies (ESCOs)
Business model strategies for closing loops		
5. Extending resource value	Solutions that actively seek to reduce end-user consumption through principles such as durability, upgradability, service, warrantees and reparability and a non-consumerist approach to marketing and sales (e.g. no sales commissions)	• Interface – collecting and supplying fishing nets as a raw material for carpets • RecycleBank – providing customers with reward points for recycling and other environmentally benign activities (recyclebank.com)
6. Industrial Symbiosis	A process- orientated solution, concerned with using residual outputs from one process as feedstock for another process, which benefits from geographical proximity of businesses	• Kalundborg Eco-Industrial Park (http://www.symbiosis.dk/en) • AB sugar and other sugar refiners – internal "waste = value" practices

Source: Adopted from Bocken et al. (2016).

As seen in the table, different types of economic models could be used for CE, all with different approaches, ranging from product design (design for durability, repairability, upgradeability), EOL strategies (recycle, remanufacture, repair, and refurbish), cooperations, hire and leasing (Bocken et al., 2016).

3.3 Introduction to remanufacturing

One way to promote the CE is through remanufacturing, a CE business model that have been practiced for a long period of time. The remanufacturing industry saw its rise during the Second World War (Sundin et al., 2008). An increased focus on military production at that time, made remanufacturing a common practice by manufacturers especially in the United States (Sundin et al., 2008). The cost of manufacturing new weapons where high and an efficient way to reduce the cost was to remanufacture old and damaged weapons (Sundin et al., 2008). Remanufacturing has since the second World war flourished into an important business model, as the economic benefits were good and environmental preferable practices were gaining attention (Sundin et al., 2008). Businesses saw opportunities in including environmental conciousness for economic benefits using remanufacturing, and the concept saw its breaktrough in several other industries, including vehicle, furniture and cell phone industries (Sundin et al., 2008). As an environmentally and economically sound way to close the material use and to achieve sustainable development, remanufacturing can also help to comply with legislation (Zhang, Yang & Chen, 2017). The use of remanufacturing has been a way to take producer responsibility by taking care and use of EOL product, which has made it easier for companies to comply with environmental legislation, including legislations such as Waste of Electric and Electronic Equipment (WEEE[1]) directive, and End of Life Vehicle (ELV[2]) directive, and at the same time sustaining economic growth (Sundin et al. 2008). The above-mentioned directives and the extended producer responsibility and other legislations and ethical considerations are argued to be a driver for remanufacturing (Sundin et al. 2008).

Remanufacturing could also be seen as the ultimate form of recycling, as it reuses more of the material put into a product or component than recycling does (Karvonen et al., 2015). Compared to recycling where large amounts of energy is used, less jobopportunities created, is remanufacturing beneficial as it in comparison saves energy, produce less waste and create jobopportunities (Karvonen et al., 2015).

Even though remanufacturing sounds like a business model with mainly advantages, it has its difficulties compared to traditional manufacturing (Sundin et al. 2008; Sabharwal & Garg, 2013). Remanufacturing requires collection of used products from customers, which can complicate the supply chain as it involves uncertainties of the products timing and quality (Sundin et al. 2008). In most of cases to be able to remanufacture a product, it still has to be intact and there need to be a customer demand that could be met, considering the uncertainties in retrieving back products from the customer (Sundin et al. 2008). It is of importance that the collection and supply of cores from EOL products fulfills the demand (Sundin et al. 2008). The reverse supply chain makes the remanufacturing companies' dependent on the customer to return the cores, and this makes logistics and information crucial for successful remanufacturing (Sundin et al. 2008).

Graham et al. (2015) argues that the process of remanufacturing means restoring cores back to useful life, with a product capacity comparable to a new manufactured product. The product capacity could in a best case also be enhanced in its capacity compared to a new manufactured

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[1] Directive 2012/19/EU

[2] Directive 2000/53/EC

product (Graham et al. 2015; Sundin et al. 2008). Remanufacturing involves different stages, that in practice includes inspection, disassembly, component reprocessing, reassembly, and testing of the product to ensure that it meets the desired product standards (Sundin, 2008).

Mähl & Östlin (2007) illustrates the traditional remanufacturing process into five different phases, which is shown in the figure below. The phases are pre-disassembly, disassembly, reprocesseing, reassembly and post-reassembly. New components could be added if needed. The figure does also show the circular flow of cores starting with customers as first tier supplier, through the remanufacturing process and back as a remanufactured product to the customer.

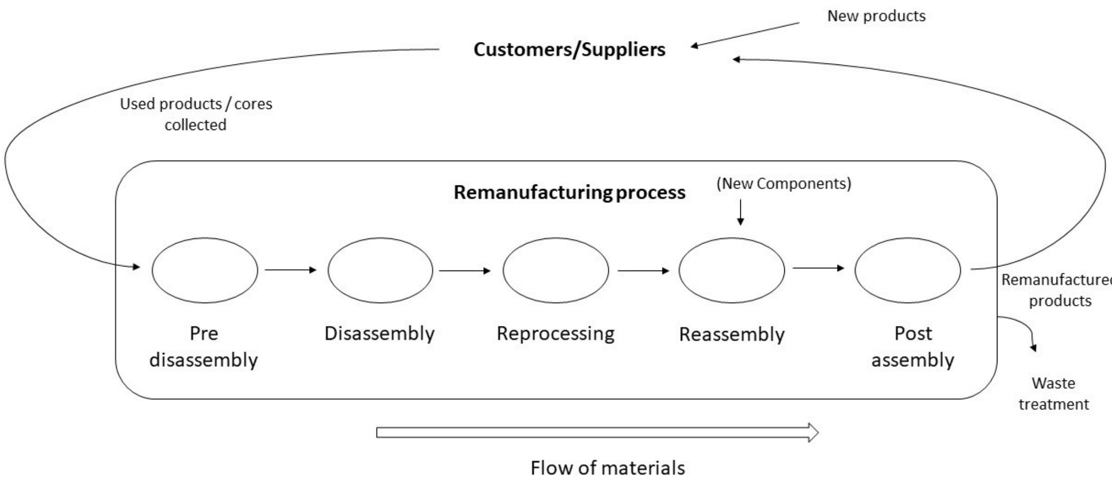

Figure 3-2. The figure illustrates the circular flow of cores and products and a thypical remanufacturing process.

Source: Own illustration adopted from Mähl & Östling (2007)

The motives behind remanufacturing can vary, but remanufacturing practices do often include environmental motives as it reduces the need for raw materials, and reduced waste creation (Seitz & Peattie, 2004). Furthermore, economic growth, and in some occasions increased profitability argued to be motives for remanufacturing (Seitz & Peattie, 2004). The list of motives for remanufacturing could be made longer, including ethical responsibility, meeting legislation and secured spare part supply (Seitz & Peattie, 2004). Remanufacturing is also argued to increase the market share and brand protection (Seitz & Peattie, 2004; Kerr & Ryan, 2001). In comparison to other EOL treatment models remanufacturing is a preferable practice. It is argued that remanufacturing is advantegous to both repair and reconditioning, as the remanufacturing in contrast to repair and reconditioning has the possibility to upgrade the product and assimilates a higher level of quality (States & Kingdom, 2007). Advantages to traditional manufacturing besides the possibility to upgrade the product are energy savings, material savings, and less waste and pollution creation (States & Kingdom, 2007).

The reverse supply chain is as mentioned a crucial part for a successful performance of the remanufacturing system. To be able to satisfy the demand for remanufactured products the question of how and from where to acquire cores is off equal importance as the irregular supply a reverse supply chain can create (Seitz & Peattie, 2004).

When it comes to the cost-effectiveness of a remanufacturing system, it is all dependent on the product, and do not necessarily have to be beneficial (Sabharwal & Garg, 2013). An important factor that needs to be considered when it comes to remanufacturing is the engagement of the original equipment manufacturers (OEM). Usually OEM have resellers that retrieves EOL products or cores, and it is of importance that OEMs engage with remanufacturers for establishing reverse logistics (Matsumoto & Umeda, 2011). Other important factors are consumers' awareness and preferences for remanufactured products, related legislations, and relevant social institutions for a successful and effective remanufacturing process (Matsumoto & Umeda, 2011). Information and cooperation are two essential parts that need to be fulfilled for successful remanufacturing (Matsumoto & Umeda, 2011).

3.4 Reverse logistics

Logistics refers to the part of a supply chain process that plans, implements and controls an effective and efficient flow and storage of products and services and related information from the point of origin to the point of consumption, to meet the customers requirements (Ronald & Dale, 2002). Reverse logistics is the movement of products or materials in the opposite direction compared to traditional forward logistics, in order to create or recapture the value, or for proper disposal (Ronald & Dale, 2002). Reverse logistics do in general start from end users, first consumers, where the products are collected and left back, to be able to manage end EOL products through different decisions, that can include recycling, remanufacturing and repairing (Govindan, Soleimani & Kannan, 2015). The figure below illustrates a simplified version of differences between forward logistics and reverse logistics.

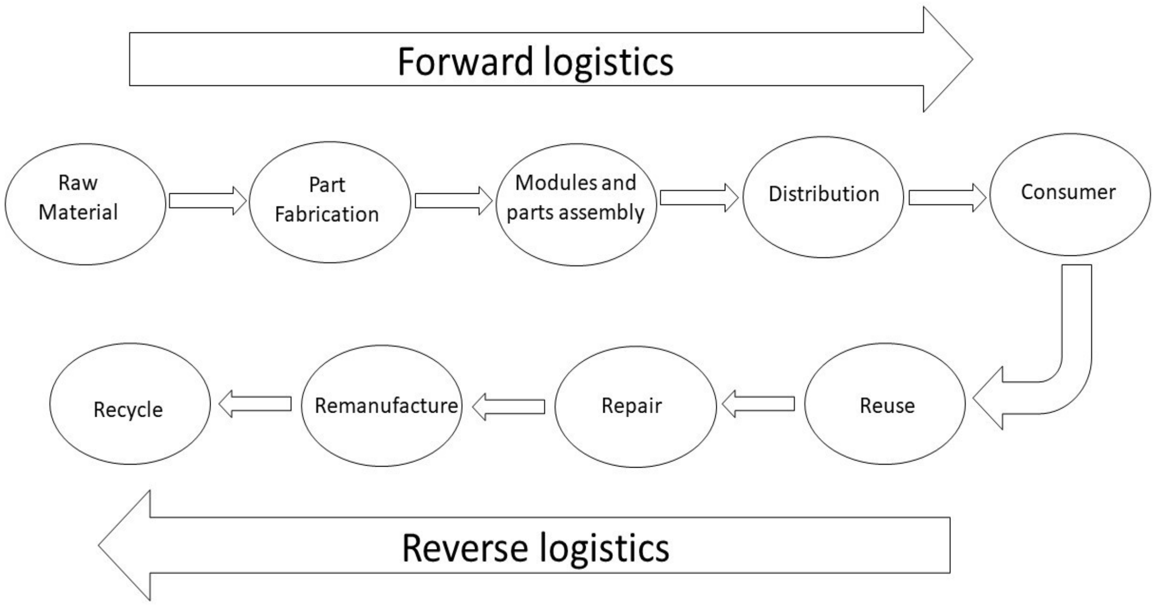

Figure 3-3. Simplified illustration of forward and reverse logistics. It illustrates also how the use of reverse logistics can lead to recapture value of EOL material.

Source: Own illustration based on information obtained from Govindan, Soleimani & Kannan, (2015) & Ronald & Dale, 2002.

Reverse logistics is also referred as green logistics, because of its positive environmental impact by collectiong EOL products (Mao & Jin, 2014). The economic benefits from reverse logistics are widely recognized in different industries, having effective reverse logistics, could improve company's revenue outcomes, and the use of recycling, remanufacturing and repairing can add direct economic value (Mao & Jin, 2014). The economic reason is one reason why reverse logistics should be implemented, as it reduces the use of raw materials, reduces disposal costs, and creates added value for end-of-use products (Rubio & Jimenez – Parra, 2014). Beside the economic reason to implement reverse logistics the legal and social reason is also of interest. In many cases are companies held responsible for the recovery or correct disposal of waste generated by products they manufacture and distribute, and this becomes important especially within the European Union (Rubio & Jimenez – Parra, 2014). Rubio & Jimenez – Parra (2014) also argue the increased social awareness of the need to protect the environment, has led to the demand for environmentally responsible behaviour by companies, particularly when it comes to carbon emissions and waste generation. The benefits of the economic drivers for reverse logistics argued above corresponds with what Chileshe, Rameezdeen and Hosseini (2015) argues in their research. They see that cost savings due to less usage of raw materials is among the main economic drivers for reverse logistics. They do further argue that the main environmental driver is the possibility to reverse negative impacts of manufacturing activities on the environment. As implementation of reverse logistics complies with environmental legislation and makes organizations self-compliant, it also encourages the usage of less virgin raw materials and less energy for transport of goods, at the same time it generates less waste (Chileshe, Rameezdeen & Hosseini, 2015). At the same time, companies implementing the reverse logistics have the potential to improve their image, and it also creates new job opportunities and society could benefit from less health effects because of pollution (Chileshe, Rameezdeen & Hosseini, 2015). Functional reverse logistics are crucial for remanufacturing, and in a study looking at reverse logistics for remanufacturing operations, Dowlatshahi (2005) identifies five strategic factors to enable a successful remanufacturing process. The strategic factors include strategic costs, which refers to the effective use of a company´s current resources to collect and remanufacture material so it can create economic benefits; Strategic quality, which Dowlatshahi (2005) argues to be that the remanufactured product meets the quality of a new manufactured product. This is close linked to customer service, the third strategic factor. Customer services refer to the possibility to meet the customers' expectations with remanufactured products (Dowlatshahi, 2005). Dowlatshahi (2005) do also bring up growing environmental concerns and social awareness related to environmental questions as strategic factors, which together with harsher legislation facilitate and creates the need to treat EOL products and reverse logistics to be a part of manufacturing companies' business. Gonzales – Torre et al. (2010) argued that reverse logistics is necessary for EOL treatment of products, however, reverse logistics can be costly if it is done inefficient, and the costs of reverse logistics are creating hesitation in companies to treat EOL products. But, if an efficient reverse logistics could be accomplished, EOL treatment of products may result in an competeitve advantage with the possibility to enhance and develop the business (González – Torre et. al., 2010).

Despite the fact that reverse logistics is seen as a green practice in that sense that less virgin raw materials are used, and less waste is created thanks to the collection of EOL materials, it is not straight forward and faces several barriers (Chileshe, Rameezdeen & Hosseini, 2015; Rubio & Jimenez – Parra, 2014). The process of reverse logistics requires cooperation with different actors such as cutomers, dismantlers, recyclers and workshops (Seitz & Peattie, 2004). It is also of importance that the OEMs engage in retrieving the used products, so that the right actors can be included and an effective reverse logisitcs established (Seitz & Peattie, 2004). An example that illustrates the importance of close cooperation and relationship can be found in the vehicle industry. For vehicle manufacturers, it is of importance to maintain a relationship with customers so that when an engine fails, the customer return to the retail network for replacement (Seitz & Peattie, 2004). If the customer turns elsewhere, it will be difficult to get access to the cores and in many cases the cores will not be accessed at all, this hinders a closed loop flow of materials, and makes the functioning of reverse logistics difficult (Seitz & Peattie, 2004).

Reverse logistics has been a practice approximately as long as forward logistics, and the main driver the last decades for reverse logistics has been the growing social concern about the environment (Gonzáles – Torre et al., 2010). Still, there are barriers to implement reverse logistics to obtain the environmental benefits (Gonzáles – Torre et al., 2010). A research done 2002, show that many organizations consider the barriers they meet when developing reverse logistics to be greater than the advantages that they would obtain as a consequence of their implementation (Ronald, 2002). When looking at reverse logistics practices and barriers in the automotive industry, Gonzáles – Torre et al. (2010) identifies nine barriers to reverse logistics, divided into internal and external barriers. The external barriers identified are hesitation on the part of the government, customer reluctance, unwillingness on the part of social actors, reluctance on the part of competitors, and the perception of a poorer quality product. And on the internal side which is defined as the organization itself, lack of know-how, lack of top management commitment, lack of information and technological systems, and high costs in financial and human resources (Gonzáles – Torre et al., 2010). Srivastava & Srivastava (2008) argued about three drivers are critical for reverse logistics of parts and products, the drivers are economic, regulatory and consumer pressure. Srivastava & Srivastava (2008) means that there needs to be an economic incentive to retrieve products from customer or resellers, and that regulations are mostly acting like drivers when it comes to management of EOL materials. The economic and regulatory parameters gives an incentive for reverse logistic, with the customer as the most important actor for reverse logistics happening.

3.4.1 Remanufacturing logistics network

Reverse logistics is a crucial part of the remanufacturing process. Reverse logistics is as mentioned the process of moving a product from the consumers markets to the remanufacturer (Chen, 2012). However, when it comes to remanufacturing the process of logistics do not only include the reverse logistics, when product move from consumer to manufacturer, but also forward logistics (Chen, 2012). Through which the product moves back to the market after being remanufactured (Chen, 2012).

Awan & Liu (2011) and Alshamsi & Diabat (2015) argues that remanufacturing logistics network consists of collection centers which could be retailers, but also other organizations that has collected EOL products from the customers. Furthermore, remanufacturing logistics include inspection centers that aim to control the quality of the product, followed by remanufacturing plants to remanufacture the products, and then distribute products to the secondary markets (Awan & Liu, 2011; Alshamsi & Diabat, 2015). Alshamsi & Diabat (2015) did also describe that other EOL treatment methods could be used if products could not be remanufactured, for example recycling. The supply to the remanufacturing plants comes from different suppliers, what suppliers that are connected depends on the actors involved and what kind of products that are being remanufactured (Awan & Liu, 2011; Alshamsi & Diabat, 2015). The supply could be direct to the remanufacturing plant or through the collection centers, furtheremore, is transport required between different logistical connections (Awan & Liu, 2011; Alshamsi & Diabat, 2015).

The figure below illustrates the above described logistics network. Note that the illustration is a simpliefied network system, as every network system are depended on the number of actors involved and their own complexity of the system, as well of the product that aims to be remanufactured (Awan & Liu, 2011).

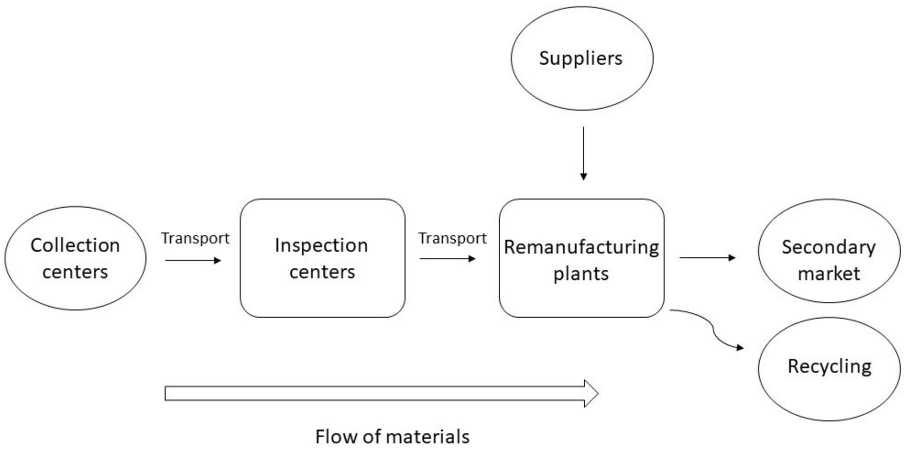

Figure 3-4. Remanufacturing network logistics.

Source: Own illustration adopted from Alshamsi & Diabat, (2015).

3.5 Remanufacturing in the vehicle sector

Remanufacturing in the vehicle sector has been ongoing for a longer period of time, and the vehicle remanufacturing industry has mainly focused on the engine. But other parts that also been common objects for remanufacturing in the vehicle industry include brakes and servopumps (Zhang & Chen, 2015). The car manufacturer Ford, one of the earliest vehicle companies working with remanufacturing, developed an own remanufacturing method called Plasma Transferred Wire Arc (PTWA) coating technology for vehicle engines, which have been a successful way of closing the material loop (Arc & Boagey, 2016). China, with a big and growing vehicle fleet has been researching the possibilities to remanufacture vehicle parts, and vehicle manufacturers see the benefits of remanufacturing. The chinese vehicle manufacturers sees the advantages in economic profitability, brand enhancement and a way to tackle environmental impacts and climate change (Zhang & Chen, 2015; Subramoniam, Huisingh & Chinnam, 2009).

When it comes to meeting environmental requirements and to reduce the pressure on the environment, different directives are pushing the vehicle manufacturers towards greener practices, and to consider the products whole lifecycle. Directives such as WEEE directive[3], ROHS directive[4], Sales of Good Act, ELV directive[5], Ecodesign directive[6], and freedom of information act, are directives that support remanufacturing in the vehicle industry (Subramoniam, Huisingh & Chinnam, 2009).

There are several factors influencing the remanufacturing performance of automotive products. These includes component recoverability, economic incentive, the amount and toxicity of the waste generated through remanufacturing, and these factors in turn are influenced by the properties of the materials used (Yang et al., 2017). To be able to have a high remanufacturing rate, with economic effectiveness and good environmental performance, the design of automotive parts needs to be considered, using materials preferable for remanufacturing (Yang et al., 2017). Yang et al. (2017) argues that materials should be durable, cleanable, restorable, safe for environment and health, and do also include factors such as cost and density as important.

Compared to the remanufacturing process, wherer disassembling, cleaning, painting, repairing, assembling and testing are common, the remanufacturing of automotive parts is more or less the same (Ikeda, 2017). The disassembling methods are the remanufacturers' most important part, and the "know – how" to do it is crucial. This to know how components can be disassembled without breaking, and it is an important knowledge and the main difference to traditional manufacturing when looking at the employees competnecies. (Ikeda, 2017).

China has one of the world's biggest and fastest growing vehicle fleets, which also means that they suffer negative environmental impacts. The growing vehicle fleet has created an urge for the manufacturers to decrease their pressure on the environment. This has paved the path for remanufacturing in the vehicle industry (Xiang & Ming, 2011). Despite the fact, that remanufacturing is in the infancy in China, remanufacturing of vehicle engine has shown a lot of environmental benefits and at the same time opening up new market opportunities. Remanufacturing in the vehicle industry is argued to be the way to solve the negative

[3] Directive 2012/19/EU

[4] Directive 2011/65/EU

[5] Directive 2000/53/EC

[6] Directive 2009/125/EC

environmental impacts, by reducing energy and resource consumption, but also, by minimizing waste (Xiang & Ming, 2011).

Remanufacturing in the automotive sector has also played a crucial role to the growth of the automotive sector, and as an effective strategy for promoting and increasing sustainability it will continuously strengthen its important role in the automotive industry (Saavedra et al., 2013). Saavedra et al. (2013) do further argue that remanufacturing enables automotive components more broadly at reduced prices which also contributes to using less materials and energy during the remanufacturing process.

The engine of the vehicle has been the most common part of a vehicle to remanufacture (Seitz, 2007. Seitz (2007) sees benefits of remanufacturing vehicle engines in the sense that it secures spare parts, it is ethical and morally preferable and it meets legislative requirements, benefits that also could be obtained in remanufacturing other parts.

3.6 Drivers for remanufacturing of vehicle parts

In an article by Karvonen et al. (2015), remanufacturing was argued to be a "win-win-win" situation. This because of the cost savings that enables lower price for the customer to buy remanufactured products compared to new manufactured products. In addition to that could the remanufacturing companies save money, thanks to cost savings in energy use and less money spent on rawmaterials. As a third win was the environmental benefits achieved through the use of remanufacturing, Karvonen et al. (2015) argued specifically of less waste creation, less energy use and less amount of raw materials used. Karvonen et al. (2015) did also see how remanufacturing benefitted to all three dimensions of sustainability, the environmental, social andeconomic dimension. (Ibid) argued that remanufacturing benefitted both the environmental and economic parameter through the save of materials, save of energy resources, it reduces waste and landfill, creates skilled jobs and produces substantial savings for the customers (Karvonen et al., 2015). While the social dimension benefitted from remanufacturing through products becoming more widely available at lower prices, it contributes to conservation of materials and energy, and it provides employment income and income and skill acquisition, which can lead to additional business opportunities (Lund & Hauser, 2010; Karvonen et al., 2015). Further, in the comparison with new manufactured products, Karvonen et al. (2015) argue that remanufacturing has the benefit of reducing pollution, compared to newly manufactured products. Opresnik and Taisch (2015) pointed in their article to the fact that the economic driver is not only limited to the remanufacturer. They argued that the economic driver is also extending to the consumers, since remanufactured products can be sold at a price 20 to 30 % lower than a new manufactured product, and the production costs of a remanufactured product constitutes 35 to 60 % of the original manufacturing costs. Opresnik and Taisch (2015) did further argue the benefits of promoting sustainable consumption, and higher service flexibility as drivers for remanufacturing. The greatest driver for remanufacturing was however seen in the positive environmental impacts. Remanufacturing makes use of EOL material and reduces waste and the use of natural resources (Opresnik & Taisch, 2015; Ismail et al., 2014).

Zhang, Yang & Chen (2017) argued in their study for potential drivers for remanufacturing in the automotive industry to be moral and ethical responsibility, environmental legislation and profitability. The study was made in the Chinese automotive industry, with those three drivers above mentioned as main drivers for developing remanufacturing for vehicle parts (Zhang, Yang & Chen, 2017). Additional drivers for promoting the development of remanufacturing in the Chinese automotive industry, were customer orientation, the development of strategy advantage, secure spare parts supply, asset and brand protection, legislation, competition, warranty, and market share (Zhang, Yang & Chen, 2017). However, as a first step to even get started with remanufacturing, earlier experiences of profitable remanufacturing practices and the right policy orientation, argued to be important incentives (Zhang, Yang & Chen, 2017). Zhang, Yang & Chen (2017) argued that if the right policies were established, promoting EOL treatment of products and pushing companies towards it, using remanufacturing would be more common.

Seitz (2007) concluded from their literature review that moral and ethical responsibility, as well as the commitment to environmental issues, were considered strong drivers for remanufacturing. Seitz (2007) did further include profitability and environmental legislation as drivers. As they argued that efficient remanufacturing practices can generate profitability and that remanufacturing enables compliance with environmental legislation. Seitz (2007) did also argue that reverse logistics and remanufacturing are often in literatur referred to as beneficial, and creates a "win-win" situation, even if it is not that straightforward in reality. Seitz (2007) argued that one motive for remanufacturing of engines in vehicles are securing spare parts supply. This reduces the dependency on raw material suppliers, since vehicle parts as engines are not mass produced any more, which makes the manufacturer more self-reliant. Further, Seitz (2007) also identified customer orientation as a driver this was because remanufacturing often offers the possibility to reach more customers through offering lower costs for remanufactured products. Remanufactured products become more widely available in a reasonable price range opening up for additional business opportunites that stimulates the manufacturer to take care of EOL products (Seitz, 2007).

Ferrer and Whybark (2000) groups the driving factors for remanufacturing into three groups. The three groups mentioned are legislation, prolonged economic life, and strategic opportunities. Looking at legislation as a driver, we can already today see how legislation is pushing towards greener manufacturing methods (Ferrer & Whybark, 2000). As legislation already pushes towards greener manufacturing methods, Ferrer & Whybark (2000) also argued about the possibility of harsher legislation in the future, that could be pushing towards more responsibility put on the manufacturer. Legislation will be a driver for remanufacturing as it will force companies to consider all lifestages of their products, (Ferrer & Whybark, 2000). The second group is prolonged economic life, instead of replacing with new manufactured equipment, remanufactured material can be used, which creates savings and prolongs the products economic value. The third group is according to Ferrer and Whybark (2000) strategic opportunities for remanufacturing. When a company has gained skills in remanufacturing, they can succeed in other markets. One example is the automotive market, that in the beginning was focused to some specific parts, but remanufacturing serves now a broad automotive component market (Ferrer & Whybark, 2000). When it comes to economic benefits, the possibility to make cost savings is argued to be a driver for remanufacturing. Jjust as Srivatsava & Srivatsava (2008), Collet (2013) sees the economic parameter as a driver and especially cost savings. (Ismail et al., 2014; Opresnik & Taisch, 2015)). Ismail et al. (2014) argues in their research the environmental advantage as a driver for remanufacturing. In comparison to manufacturing, remanufacturing has reduced environmental impacts which makes it a preferable practice (Ismail et al. 2014). Even though the environmental dimension is highly emphasized the economic dimension do also show a lot of benefits, benefits that are crucial for a business in their operations. Arndt (2006) shows an example in his article on Caterpillar remanufacturing operations have been profitable, that the company made the remanufacturing business to a separate division. Arndt (2006) do also argue that remanufactured products done well, can cost half the price compared to new ones.

3.6.1 Drivers summarised

The table below show summarised drivers that was identified from the literature.

Table 3-2. Drivers for remanufacturing found in literature

Profitable practice	Legislation	Saves material	Creates income
Waste reduction	Availability of parts in reasonable price range	Creates skilled jobs	Sustainable practices by closing the loop
Energy reduction	Commitment to environmental issues and ethical responsibility	Lead to additional business opportunities	Higher service flexibility and promotes sustainable consumption
Cost savings	Strategy advantage	Securing spare parts supply and prolonged economic life	Promotes extended producer responsibility
Wider customer orientation	Not dependent on raw material suppliers makes manufacturers more selfreliant	Possibility to succeed in other markets	Brand protection

Source: Own table based on the drivers extracted from the literature.

3.7 Barriers for remanufacturing of vehicle parts

There are several challenges to remanufacturing and Sundin & Dunbäck (2013) include lack of control regarding quantity and quality and timing of the returned products as main challenges. Those challenges are argued to be reflected by the uncertain life of a product, product life cycle stage, the rate of technological change, and the dispose behaviour (Sundin & Dunbäck, 2013). These uncertainties together make it difficult to determine the level of return because of a stochastic return pattern (Sundin & Dunbäck, 2013). Stochastic return pattern is explained to be a randomly determined return pattern, creating uncertainties in core availability. Sundin & Dunbäck (2013) argued the importance of a balance in the return of cores for remanufacturing to meet the demand from the customers. An unbalanced supply and demand creates a risk of building up an excessive amount of inventory or low levels of customer service, which will be too costly for a profitable business. An unbalanced supply and demand rate together with above mentioned uncertainties, hinders remanufacturing, and creates direct barriers in developing remanufacturing practices (Sundin & Dunbäck, 2013). Sundin & Dunbäck (2013) further argue that controlling the timing and quantity of products to ensure remanufacturing was crucial. Subramonian, Huisingh & Chinnaman (2009) agree with Sundin & Dunbäck (2013) when talking about the uncertainties in stochastic product returns causing imbalances in supply and demand rates, and adds that this is particularly a barrier for remanufacturing in the automotive industry. Just as Sundin & Dunbäck (2013) do Subramonian, Huisingh & Chinnaman (2009) refer to the high costs of storage space and disposal as two reasons for not developing remanufacturing. Lack of Information and knowledge about reverse logistics and the value of remanufactured goods, are reasons hindering profitable remanufacturing (Subramonian, Huisingh & Chinnaman, 2009).

Matsumoto & Komatsu (2015) found similar barriers, and argued that most of the barriers for remanufacturing seemed to lie in the timing and quantity of returned products, and balance between supply and demand. Futher, did Matsumoto & Komatsu (2015) argue that disassembly of returned products, uncertainty in materials recovered from returned items, requirement for reverse logistics network, complication of material matching restrictions, and the randomness of return pattern as barriers. Matsumoto & Komatsu (2015) argued that for being successful in remanufacturing it is of importance to forecast product returns and demand, in order to continuously have an overview (Matsumoto & Komatsu, 2015). Furthermore, in relation to uncertainty in quantity and return products, the core arrival time was also seen as a challenge for remanufacturing (Matsumoto & Komatsu, 2015; Graham et al., 2015). The core arrival time is crucial for planning and meeting supply needs. Graham et al. (2015) did further argue about the uncertain logistic costs, and uncertainties in core condition, as a barrier for collecting and remanufacturing vehicle parts.

When looking at challenges for remanufacturing of automotive parts in China, three main barriers where identified. Chang, Yang and Chen (2017) talked about counterfeit products disrupting the remanufacturing market, the difficulty in recycling and high cost for obtaining cores, but also high taxes and lack of support from the government. Chang, Yang and Chen (2017) further argued that the interaction between remanufacturing stakeholders also could be a barrier, as it seemed that a lot of companies had a conservative attitude with regard to remanufacturing. Thanks to the believe that remanufactured products had negative effects on sales of new products. The uncertainties in the material management was also what Golinska and Kawa (2011) argued to be a main challenge to remanufacturing of vehicle parts. Golinska and Kawa (2011) listed the uncertainty in timing and quantity of returns, the uncertainty in materials recovered from returned items, the reverse logistic network composition, and the problem of unpredictable routings for materials for remanufacturing operations. Tongzhu et al. (2011) identified different stages of barriers in remanufacturing in the automotive industry in in China. The three stages were, before, during and after remanufacturing. Before remanufacturing, the possibility to enter the remanufacturing industry was seen restricted, due to lack of governmental support (Tongzhu et al., 2011). The lack of governmental support caused difficulties for cooperation between the OEM and remanufacturing companies, and led to low takeback of vehicle parts. What further restricted the remanufacturing in China was lack of subsidies or tax cuts for remanufacturing (Tongzhu et al., 2011). To be able to make it profitable in the Chinese market, subventions and tax cuts was considered important. Without tax cuts or subsidies for remanufacturing, the remanufacturing business saw no economic incentive in engaging in remanufacturing, and it was believed that remanufacturing did not give any competitive edge, as remanufactured products were not given any room for price reductions (Tongzhu et al., 2011). Remanufactured products did also face difficulties in the Chinese market. Tongzhu et al. (2011) argued that remanufactured products were seen as second-hand products in the society, with people having the assumptions of poor quality products, so the demand for remanufactured products was low (Tongzhu et al., 2011). Tongzhu et. al. (2011) summarized the barrirers as policy factors, technical factors and social consciousness. Seitz (2006) found in her research that brand awareness and protection could be a barrier for remanufacturing. It was argued that people connected a brand to new manufactured products, which made people believe that the quality of the brand was low when remanufactured products were used.

A lot of literature brought up the quality and quantity of cores that could be collected for remanufacturing as a barrier, with uncertainties in quality and quantity, the possibilities for remanufacturing were restricted-(Matsumoto & Komatsu, 2015; Graham et al., 2015; Sundin & Dunbäck, 2013). Karvonen et al. (2015) argued the same, and pointed out this as one of the main barriers for remanufacturing. The collection phase, or an organized reverse logistics to ease the possibility for collection of used products, and determine the availability of cores was by Karvonen et al. (2015) argued to be challenging. The collection phase was seen as the first barrier to overcome for even creating a remanufacturing process (Karvonen et al., 2015). Further did Karvonen et al. (2015) argue about technical difficulties to remanufacture and ensure the required quality or costs for remanufactured products. Further were the uncertainties in lead time for returning products a barrier for remanufacturing. The third challenge Karvonen et al. (2015) mentioned was related to the demand for remanufactured products. It was argued that there was a need to ensure customers' acceptance and trust in remanufactured products in order to guarantee a demand.

When looking at remanufacturing of motor vehicle parts compared to manufacturing there are some drawbacks that could act as barriers for remanufacturing. Holbein (2012) argued that remanufacturing tended to be more labour intensive, with numerous tasks, including, disassembly, separation, cleaning, and repair tasks. Holbein (2012) argues that a remanufacturing facility required three times as many employees compared to a manufacturing operation, but on the other hand, remanufacturing required much less investment in machinery and equipment and used much less energy.

US has a big remanufacturing market, and remanufacturing of vehicle parts is the third biggest remanufacturing industry in the US (Holbein, 2012). However, there are three factors affecting the vehicle parts remanufacturing in a negative way, according to Holbein (2012) who describes the factors to be labour costs, transportation costs and scarcity of cores. Other factors that are a challenge for the remanufacturing of motor vehicle parts in the U.S. are, high prices of cores, declining demands for remanufactured goods, environmental regulations, and rising competition from imported remanufactured goods.

3.7.1 Barriers summarised

The table below show summarised barriers that was identified from the literature.

Table 3-3. Barriers for remanufacturing found in literature

Unbalance in supply & Demand	Storage costs	Assumptions of bad quality of product	Transportation costs
Lack of information & Knowledge	Disposal costs	Remanufactured products will affect sales of new products negatively	Cutting competitive edge
Core quality	Customer acceptance of remanufactured products	Labour Intensive	High prices of cores
Stochastic returns	Brand awareness & Protection	Scarcity of cores	Lack of governmental support

Source: Own table based on the barriers extracted from literature.

4 Findings

This chapter provides the interview findings from the interviews made at Stena Recycling Sverige, Volvo Cars, and UBD Cleantech. In total was 9 people interviewed, 3 at Stena Recycling Sverige, 4 at Volvo Cars and 2 at UBD Cleantech. All interview persons were related to the management of diesel particle filters at each company. The interviewees at Stena Recycling Sverige, were close related to car dismantlers, car workshops, and business specialists for hazardous waste. At Volvo Cars two interviewees were related to Volvo Cars Reman, one of them managing the remanufacturing process, and one related to the logistics of remanufacturing. Additionally, two interviews were conducted with staff working with the environmental strategy at Volvo Cars. At UBD Cleantech, two persons were interviewed: one who in charge of the remanufacturing process, and one who was in charge for the business and marketing. Both were closely connected to the business relationship with Volov Cars.

The interviews are presented under five categories; Logistical Cooperations, Business Cooperations, Economic incentive, Laws and regulations and Environmental incentive. The interview findings are presented company wise, to be able to follow the views of each company. The main actors, Volvo Cars and Stena Recycling, are presented under own headings. While UBD Cleantech that work in close relationship to Volvo Cars, was incorporated under Volvo Cars heading. However, the findings point out when UBD Cleantech results are presented.

4.1 Logistical Cooperations

To be able to have a functioning remanufacturing process, reverse logistics and logistical cooperations are crucial for success. Both the current and the possibilities to develop the logistics by involving more actors are critical in enabling remanufacturing of diesel particle filters. The views of the interviewees are presented below.

4.1.1 Volvo Cars

When it comes to Volvo Cars, the interviews stated that they work in a close loop system when it comes to remanufacturing, with an aim to only collect their own parts in the remanufacturing system. Volvo Cars is thereby only working with resellers of Volvo Cars or car workshops related to Volvo Cars. The closed loop system is called different names, known as both exchange system and takeback system. Actors involved in the exchange system or the reverse supply chain consists of different subcontractors, but Volvo cars also mentioned OEMs as an important part. Interviewees told that the OEM are important in the reverse logistics for product remanufacturing because they know their products, and the products' capacity to be remanufactured. Futhermore, by involving the OEM in the remanufacturing process valuable information about the products carachteristics and requirements can easier be forwarded to the remanufacturer.

Volvo Cars Reman have about 2500 Volvo resellers connected to the exchange system and that the exchange system is responsible to manage the logistics and flow of parts for remanufacturing, which includes diesel particle filters. Further, the exchange system starts with consumers returing back cars or products to the resellers or car workshops. This network of resellers, and car workshops reach across the world which enables Volvo Cars to cover a wide range of EOL products out there, such as diesel particle filters. The diesel particle filters that need to be remanufactured are sent from the car workshops to an inventory in Maastricht, the Netherlands. Only diesel particle filters that had a need for remanufacturing was collected, and after being remanufactured, they were returned back to the car workshops. New manufactured diesel particle filters and remanufactured diesel particle filters did not share markets. New manufactured diesel particle filters are used in new manufactured cars and remanufactured diesel particle filters, went back to the car workshops to replace the old damaged diesel particle filters.

The interviewees stressed that new manufactured and remanufactured diesel particle filters, did not in any way share the same market. When it comes to the remanufacturing process of diesel particle filters, interviews at Volvo Cars Reman told that UBD Cleantech, located in Höör are the responsible remanufacturer. Volvo do a forecast of the demand for remanufactured diesel particle filters, and UBD Cleantech can then order the amount of diesel particle filters from Volvo Cars based on that demand. UBD Cleantech orders the diesel particle filters directly from the inventory in Maastricht. One interviewee at UBD Cleantech, who works in close relation to the remanufacturing of Volvo diesel particle filters told that they are only remanufacturing diesel particle filters based on the customers - in this case Volvo cars - demand. UBD Cleantech was not looking to create own streams of diesel particle filters, unless Volvo aimed to do that. All diesel particle filters streams were managed and collected by Volvo Cars. According to the interviewees at Volvo Cars Reman did the remanufactured diesel particle filters do end up in a Volvo Cars original package and then returned to the market.

The exchange system as a closed loop system was something representatives at Volvo Cars Reman argued could create constraints for cooperation with other actors such as Stena Recycling Sverige. They argued the main barrier to be difficulties to sort the diesel particle filters; especially since Volvo Cars only was interested in filters for their own cars. This corresponds to the answers of an interview person at Volvo Cars environmental department who said that it is important to know that the diesel particle filters are usually engine specific, which creates difficulties on sorting as all filters do not suit all engines. It may also be difficult to detect which filters comes from Volvo Cars and which do not, which makes Volvos involvement in this very important as Volvo sits on the information needed to ease sorting. However, both representatives at Volvo Cars and Volvo Cars Reman indicated that Volvo Cars would be interested to cooperate with Stena Recycling Sverige, if both partners can find a way to detect and sort diesel particle filters. All interviewees at Volvo Cars and Volvo Cars Reman agreed upon that, involving more actors to collect diesel particle filters requires more and better communication and information to spread knowledge. The information and knowledge is important to ease sorting and to overcome the logistical barriers that could appear. Another thought from an interviewee at Volvo Cars, was that the interviewee believed that cooperation with car dismantlers for collecting and remanufacturing diesel particle filters would be easier than with Stena Reycling Sverige, as he believed that the cars that reach Stena Reycling Sverige was already to damaged to make use of. However, interviews with representatives at Volvo Cars Reman believed that the streams of diesel particle filters Volvo Cars are missing out on are very small, and if they are missing any, there have to be customers for them too. Volvo Cars representatives could not provide a number for the diesel particle filters that not end up in their remanufacturing process, but that was because very small streams are missing so it has not been considered. The potential for cooperation with Stena Recycling Sverige for detecting streams of diesel particle filters was uncertain according to the interviewees because of uncertainties regarding the quality of the diesel particle filters that reach Stena. The interviewees belived that diesel particle filters that Stena Recycling Sverige gets in contact with, have reached their EOL or are too damaged to make use of. But, one interviewee thought that there could be some old diesel particle filters still valuable for remanufacturing, that could be of interest. But if any cooperations should be created, these filters must be detected before it is started, and then it has to be evaluated if there is any customer demand for these old filters. If it is, there would be an economic incentive for Volvo Cars in collecting those.

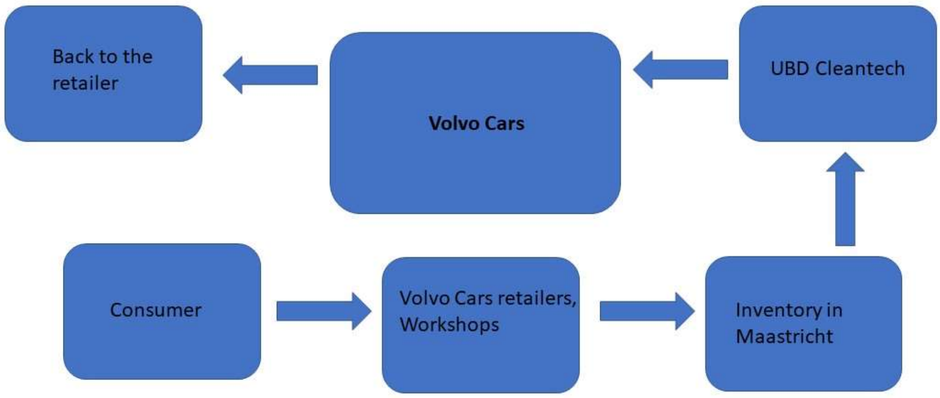

Figure 4-1. Volvo Cars Current logistics for remanufacturing.

Source: Own illustration based on interviews with Volvo Cars.

4.1.2 Stena Recycling Sverige

When it comes to Stena Recycling Sverige, the responses about logistics and cooperation with more actors were similar to Volvo Cars. However, interviewees at Stena told that the most important factor for enabling reverse logistics and collect diesel particle filters lies in the economic incentive. If there is an economic possibility to sort and store the products, the interviewees at Stena recycling did not see any difficulties in collecting more diesel particle filters. This is according to one interviewee based on the possibilities of the current logistical cooperation Stena Recycling have. The interviews revealed that Stena Recycling Sverige is connected to Bilretur, a network with over 100 car dismantlers in Sweden, which all deals with diesel particle filters. Furtheremore are Stena Recycling Sverige connected to several car workshops, like for example Bilia, Hedin Bil, and also Volvo Cars resellers. One example of Volvo car reseller is Helmia, and Stena are about to create additional relationships with more car workshops.

Stena deals with several car parts, which are either sanitized or recycled. The parts range from whole automobile bodies, to smaller parts related to the engine, also parts that are hazardous or include hazardous materials. Interviewees told that diesel particle filters are one of the parts with valuable materials, having a good secondary value, and the filters are mainly collected through the network Bilretur. They further told that the logistical channels to reach diesel particle filters are already set, through Stena Recycling Sveriges relationships, and to develop the logistics further by involving more actors for remanufacturing is based on the remanufacturers economic incentive.

An interviewee that works in close relation to car workshops, said that Stena works to expand the amount of contracted car workshops, in order to retrieve more vehicles and vehicle parts. When it comes to diesel particle filters and their possibility to be remanufactured instead of recycled, he believed that the responsibility was in the hands of the car workshops to sort it. However, there could be a difficulty for functional logistics when it comes to sorting. But the interviewee believed that could be solved through building the right relationships, and that the involved actors could ease the sorting process by providing the knowledge needed and the information needed.

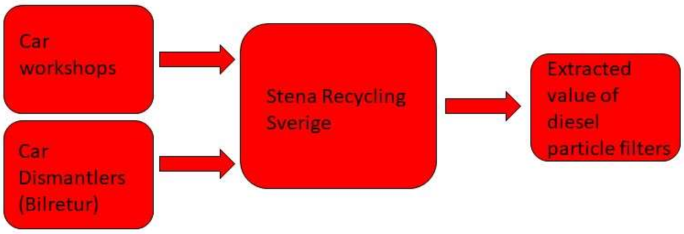

Figure 4-5. Current logistics for Stena Recycling Sverige

Source: Own illustration based on interviews with Stena Recycling.

4.2 Business Cooperations

Building good business relationships are crucial for a functioning remanufacturing process, it is of importance for all involved actors that they agree upon the different requirements the cooperations require. Important for developing functioning business cooperations is the economic value seen for remanufacturing. This part gives an overview of the interviewees' thoughts on the current business cooperation and possibilities for future business cooperations.

4.2.1 Volvo Cars

The interviewees' responses regarding cooperation possibilities with Stena Recycling Sverige and additional actors, varied and the opinions seemed to be twosided. One interviewee saw restrictions in cooperation with Stena Recycling Sverige in retrieving diesel particle filters from them. This because he believed that the cars Stena Recycling Sverige encounters has reached their EOL. Which also in most cases mean that the diesel particle filter has reached its EOL. In that case, the diesel particle filters are more suitable for recycling than remanufacturing. Another restriction the interviewees saw for involving additional actors for collecting diesel particle filters, were the closed system Volvo is working with. Since Volvo only is interested in filters for their own cars, they are interested in those streams and not other streams of diesel particle filters. However, the interviewees also stated that if there are streams Volvo is missing that may be of value, there is an interest in cooperation with other actors.

UBD Cleantech told in the interview that a major barrier they could see for remanufacturing diesel particle filters was the difficulty in persuading the engineers that remanufacturing is a profitable and valuable practice. The designers and department developing the filters was, according to the interviewees at Volvo Cars, not supporting remanufacturing of diesel particle filters. The also agreed that this ia a barrier for developing the remanufacturing business.

4.2.2 Stena Recycling Sverige

Interviewees at Stena Recycling Sverige were more optimistic about cooperation to collect and remanufacture diesel particle filters. One interviewee stated that there is an opportunity for best possible provision of both economic and environmental perspectives, for both car workshops and Stena Recycling Sverige if remanufacturing were used. If the filters somehow could be sorted at the car workshop and such businessrelationship could be created. The only barrier for establish that kind of cooperation, was according to the interviewee, the sorting possibilities out in the car workshops. The sorting possibilities need to be economically feasible to keep the business profitable.

Another interviewee working with EOL vehicles said that one way to increase the value of EOL material is through remanufacturing, and added that he believes that remanufacturing is something car dismantlers aim to do more. With established business relationships with car dismantlers, he told that the channel to arrange it for remanufacturing is already there. Through the creation of the right relationships, he believed that there is no barrier for collecting diesel particle filters for remanufacturing. The interviewee did also add the importance of information and knowledge exchange between the OEM and car dismantler. This to ease the process of sorting and storing diesel particle filters by the car dismantler. The interviewee specified this by saying that it is important that the diesel particle filters are marked correctly with an original number; otherwise the car dismantler will face difficulties in working and sorting the diesel particle filters. The interviewee also stated that another crucial factor that influences the possibility to create business relationships for remanufacturing is that the economic value in remanufacturing diesel particle filters exceeds or meets the value of recycling diesel particle filters. The interviewee argued that the diesel particle filters do have a high value in the recycling stream, and it is important that a remanufacturer has the money to offer a price to at least meet that value, if any businessrelationships for remanufacturing should be created. The value could however vary depending on the material of the diesel particle filter. As a car dismantler, it is preferable to dismantle and work with diesel particle filters just because of the value that is extracted through recycling.

However, Stena Recycling Sverige is a good channel for diesel particle filters, as they buy a lot of them for recycling purposes, and they could choose whether the filters instead should go to remanufacturing. Interviewees at Stena Recycling Sverige points to the importance of a good market demand for remanufactured diesel particle filters to ease the incentive for building business relationships. One interviewee said that if the remanufacturer can create a good market demand for remanufacturing of diesel particle filters, there is of course good opportunities to sell diesel particle filters to the remanufacturer.

4.3 Economic Incentives

The economic incentives are important for accomplishing preferable business cooperations which we also saw in the previous paragraph. It is also an important incentive for enabling remanufacturing and the remanufacturing process. The collection phase includes the logistics, sorting and storing, but there is also an economic incentive for remanufacturing when it comes to material saving. This part will add to the previous paragraph, by evaluating the important economic incentive to enable cooperations between companies involved.

4.3.1 Volvo Cars

Remanufacturing diesel particle filters do create profit and add value to Volvo Cars. One interviewee at Volvo Cars Reman told that reusing materials through remanufacturing is economically profitable. Money is saved in not using raw material, but instead reusing material of value. Also, the energy savings accomplished through remanufacturing are of importance for saving money. Besides those savings, remanufacturing also make it possible to offer high quality products for lower prices. The interviewee further told that the materials reuse through different EOL methods at Volvo Cars is about 85-90% which makes EOL treatment a very important part for Volvo Cars.

The value of remanufacturing was also underlined by UBD Cleantech, where the interviewees stated that a OEM do good business in remanufacturing EOL materials as the net cost for remanufactured products are much lower than for manufactured products. The interviewees said that remanufactured products are preferable as it lives up to the quality of a new manufactuered product but are much cheaper. The cost for a remanufactured diesel particle filter could vary depending on the model and shape, but the interval was between 1500-2500 Swedish crowns (SEK) or 150-250 Euro.

The representatives at UBD Cleantech did further mention that approximately 15000 diesel particle filters were remanufactured yearly from Volvo Cars, but they could se a declining trend 2017 compared 2016 concerning the amount of remanufactured diesel particle filters. Representatives at Volvo Cars Reman did not know why the number was declining. One interviewee at Volvo Cars Reman mentioned that it could be because filters are improving when it comes to quality, so the need to remanufacture diesel particle filters are not as high as before. Despite the declining trend, UBD Cleantech saw, that remanufacturing of diesel particle filters had a good economic profitability in all trade routes, this due to the much higher price for new manufactured diesel particle filters. The price differences were something Volvo Cars pointed out, when representatives stated that the price for remanufactured diesel particle filters was much lower than new manufactured. No price examples were given by Volvo Cars, but interviews at Volvo Cars reman was extra careful in pointing out that the markets for remanufactured and new manufactured diesel particle filters was two different markets, and did not affect or compete with eachother.

Interviewees at Volvo Cars did also tell that the interest of making use of EOL products are high and of importance because of the economic value that they hold. A representative at Volvo Cars told that remanufacturing, is a crucial way for company growth, now and for the future as the price of virgin material constantly increases. Products that are of high interest right now when it comes to remanufacturing are electric products, such as batteries and electronic components in general.

For Volvo Cars, one important incentive for engaging in remanufacturing of diesel particle filters of elder cars is the high cost to manufacture new diesel particle filters. By instead collecting old ones, Volvo Cars could make savings compared to manufacture new filters, but also earnings in selling the remanufactured diesel particle filter. This incentive is according to representatives at Volvo Cars Reman stated to be one of the most important economic incentives for engaging in remanufacturing of diesel particle filters.

4.3.2 Stena Recycling Sverige

One representative at Stena Recycling Sverige argued that the economic incentive for remanufacturing diesel particle filters lies in the possibilities to store and sort the diesel particle filters already out in the car workshops or car dismantlers. The interviewee argued that the optimal logistics would be if the diesel particle filters are sorted there, but for that to happen, the economic incentives for sorting and storing needs to be met. In general, saw the interviewees at Stena Recycling the economic incentive as the most important one for enabling remanufacturing. The need for economic value in remanufactured products as well as logistics and storing, were all dependent on the economic incentive. Stena Recycling Sverige did earn a lot of money with recycling of diesel particle filters, depending on the material content could the earnings vary, but it was stated that Stena Recycling were given approximately 1000 SEK (approximately 100 euro) per diesel particle filter.

4.4 Law and Regulations

Law and regulations are important factors for enabling a remanufacturing process. The possibility to collect and remanufacture diesel particle filters must be promoted by law and regulations, or at least not face regulatory obstacles. This part aims to show the interview responses when it comes to the influence of law and regulation to collect and remanufacture diesel particle filters. The interviews aimed to find out whether law and regulation could be a driver or a barrier.

4.4.1 Volvo Cars

Volvo Cars do always seek to remanufacture EOL vehicle parts to a quality similar to those of new manufactured products. An interview person related to products requirements stated that remanufacturing is one way for Volvo Cars to take responsibility of their products. Remanufacturing EOL products makes it possible for Volvo to in good way reuse products, comply with laws and offer products that fills the same requirements and must meet the same regulations as new manufactured products. ELV directive[7] is one of the directives that support EOL treatment of products, for example, the vehicles material should be designed and made in such way that it could be recycled or remanufactured. The ELV directive is a driver for remanufacturing. Interviewees also said that, since Volvo Cars is operating across the world,

[7] Directive 2000/53/EC

EOL vehicles and EOL vehicle parts are collected all over the world. This means that there are different regulations and laws controlling these; but still, most of the regulations and laws are promoting EOL treatment of vehicles and vehicles part, which is also beneficial for remanufacturing diesel particle filters. Remanufactured diesel particle filters do also have the same requirements and are subject to the same laws as new manufactured products. Which do show for the customer that remanufactured products have an equal quality compared to new manufactured products. UBD Cleantech interviewees could not see any restricting laws for collecting and remanufacturing diesel particle filters, and told that they could only see that laws were positive to remanufacture diesel particle filters.

4.4.2 Stena Recycling Sverige

Interviewees at Stena Recycling Sverige related to the relationship with car workshops, and stated that because of law and requirements, the cooperation for treating EOL vehicles with other actors such as car dismantlers and car workshops has been strengthened over the years. The car workshops and car dismantlers are today working more proactively with environmental questions as they are pressured by authorities, which has lead to establish good cooperation so that the EOL vehicles could be managed in the best possible way. Considering the above mentioned perspectives, the same interviewee believed that the laws and regulations are drivers for remanufacturing, as well for other EOL methods Another representative at Stena Recycling Sverige answered when asked if law and regualtions could be a driver or a barrier for remanufacturing, that he could not se anything that is holding remanufacturing back when it comes to law and regualtions.

Further, representatives at Stena Recycling Sverige tell that laws require diesel particle filters to be dismantled, which aslo ease the logistical process. No law or regulation is hindering an expanded network, involving more actors to collect and remanufacture diesel particle filters.

4.5 Environmental incentive

Remanufacturing as a CE business model for slowing the loop, is referred to be environmental preferable. Environmental protection is often seen as an important parameter to consider when it comes to EOL treatment of products. Remanufacturing as a EOL model do consist of a lot of environmental advantages. This part provides the interviewees views of the environmental incentive of remanufacturing.

4.5.1 Volvo Cars

Environmental advantages obtained from remanufacturing was according to interview persons at Volvo Cars reman considered to be coherent to the economic advantages remanufacturing gives. What could be won economically through reuse, material savings and less waste creation are also what benefits the environment. One of the interviewees told that the possibility to reuse materials in products through remanufacturing is about 80-90 % of what the product holds, which also is the biggest environmental advantage. With Volvo Cars working within the exchange system, they do involve in collecting EOL material and reduce the waste from Volvo cars. Another interviewee at Volvo Cars, related to the development of environmental strategies, stated that remanufacturing is one step for Volvo Cars to be sustainable and promote greener business strategies. The interviewee further told that Volvo Cars have a long history of “green” activities such as developing the lambda sond, and are as a heavy material industry continuously looking to develop green practices and expand their responsibility towards the society and environment.

When it comes to collection and remanufacturing of diesel particle filters, the same interviewee refers to CE business models in general. Because of increasing raw material prices, he believed that remanufacturing and other circular business models were of relevance as a solution to use cheaper materials. The collection and engangement in CE will then also contribute to environmental benefits. A interviewee specialized in the products specifics and product design at Volvo Cars thought that remanufacturing was something that should increase genereally, because of the environmental requirements from society and government, and because of the environmental benefits it contributes to.

4.5.2 Stena Recycling Sverige

At Stena, who are working with recycling as a CE business model, taking care of the environment is already incorporated to their strategy. One representative related to the management of EOL vehicles at Stena Recycling Sverige told that environment is a driver for both recycling and remanufacturing, but the greatest driver is still the economic incentive. If the business with remanufacturing would turn out to not be profitable, the environmental driver is not reason enough to remanufacture instead of recycling. The same interviewee also told that car dismantlers that Stena Recycling is cooperating with are aiming to make their profile "greener" so there is a high interest for them to decrease the environmental impact. That's why they also would consider remanufacturing as an alternative to treat EOL vehicles and give the parts new life.

Another interviewee connected to the relations with car workshops argued that car workshops are also establishing themselves as more sustainable. The interviewee stated that different directives for environmental compliance pushed them to be more sustainable. The interviewee believed that car workshops looked for best possible solutions for both the environment and the economy which can make remanufacturing to an interesting alternative.

5 Analysis and discussion

This chapter seeks to analyse the interview findings in relation to the findings in the literature review. The concepts that are considered in the chapter are concepts of drivers and barriers for remanufacturing in the vehicle sector, but also the concept of reverse logistics. The chapter starts with presenting common drivers from literature and interviews for remanufacturing of diesel particle filters, then additional drivers appearing in only interviews, followed by drivers found only in literature, are presented. The same goes with barriers for remanufacturing. Lastly in this chapter, the logistics will be analysed by looking at what current logistics are there and what reverse logistics require to be successful according to literature.

5.1 Analysing drivers for remanufacturing of diesel particle filters

The drivers for remanufacturing were manifold both in literature and in the interview findings. Karvonen et al. (2015) stated remanufacturing to be a win-win-win situation, with products available at a lower price range, companies earning more money, and at the reduction of energy and raw material usage. Volvo Cars related saw it a similar way, when they stated that they saved money through energy and material savings, and earned money by offering high quality remanufactured products. Volvo Cars saw both environmental and economic benefits from remanufacturing, and did state that waste reduction, reduction of material use and energy savings were drivers for remanufacturing. The possibility to remanufacture good quality products was also seen as a driver. UBD Cleantech stated that the quality of a product was comparable to the quality of a new manufactured product, but also, that the remanufactured product had a much lower price. This relates to what Arndt (2006) argued in their article that well done remanufactured products can cost half the price compared to new manufactured products. The interviewees at UBD Cleantech told that the cost for remanufacturing of a diesel particle filters varied between 1500-2500 swedish crowns. UBD Cleantech argued further, that this was economically profitable in all trade routes because of the much higher costs for new diesel particle filters. Volvo Cars did not provide any costs for manufacturing new diesel particle filters, and no price for remanufactured diesel particle filters was mentioned. But Volvo Cars agreed with what UBD Cleantech stated, that the remanufactured diesel particle filter had a much lower price. However, Volvo Cars also told that in reality comparing prices between manufactured and remanufactured diesel particle filters were not important, because remanufactured and new manufactured diesel particle filters did not compete in the same market.

The environmental part is important in CE and a driver for remanufacturing. Remanufacturing offers several environmental advantages, and one of them, according to Seitz (2007), is the company's commitment to environmental issues, and taking ethical and moral responsibility. Stena Recycling Sverige argued that the environmental benefits were the main driver for the car workshops and car dismantlers for practicing remanufacturing instead of recycling. Volvo Cars representatives did believe that remanufacturing is a CE model that should be used more, because of societal and governmental pressure faced today, and because of its capacity to reduce the impacts on the environment. Another driver besides the economic and environmental drivers is the legislative driver.

Ferrer & Whybark (2000) see legislation as a driver and believes that legislation will push even more corporations towards taking responsibility of EOL products, and that will benefit remanufacturing. This is also what Volvo Cars says; that legislation is positive for EOL treatment of products, and directives such as EOL vehicle directive is pushingin the right direction. Remanufacturing is one way to comply with laws and requirements, and representatives at Volvo Cars points specifically to the ELV directive as positive for remanufacturing. At Stena Recycling Sverige did the answeres follow the same path. They could not see any hinder of remanufacturing diesel particle filters, rather the opposite, as both car workshops and car dismantlers aim, thanks to harder regulations and requirements, to find the best possible way to treat EOL products.

There is no discussion that the literature considers the economic parameter as the greatest driver for remanufacturing. Benefits such as cost savings, cheaper products, and profit are some benefits that are brought up (Srivatsava & Srivatsava, 2008; Collet, 2013; Zhang, Yang & Chen, 2017). Volvo Cars consider cost savings through remanufacturing as one of the most beneficial parts in engaging with remanufacturing. For Stena Recycling Sverige, it is argued that if the remanufacturer can show a market demand, and has the money to offer, building relationships for remanufacturing diesel particle filters are no problem.

The greatest driver for Volvo Cars to collect and remanufacture diesel particle filters are cost savings, but also that there is only a small number of cars out in the market that need reparation and remanufactured diesel particle filters. The small amount of vehicle that need diesel particle filters was not enough and economically preferable to manufacture new filters, which made remanufacturing of diesel particle filters a valuable practice for Volvo Cars.

5.1.1 Drivers derived from interviews but not in literature

Volvo Cars did see a driving force for involving in additional cooperations for remanufacturing and EOL treatment of diesel particle filters, if streams that currently not are collected had a value in form of a customer demand. We could also se another driver for them for working with remanufacturing expressed in interviews. It was the interest for taking their responsibility towards the society. In literature, did Karvonen et al. (2015) talk about moral and ethical responsibility which this societal driver could be linked to. But, it differs in the way Volvo Cars express it. Volvo seeks more to take their responsibility as a heavy material indstry, by reducing their impacts on the society through remanufacturing, for slowing the material usage and show that they take their societal responsibility as a big car manufacturer. Volvo Cars did also express the companys approach of being environmentally friendly as a driver for remanufacturing.

Stena Recycling Sverige on the other hand, did not engage in collecting vehicle parts for remanufacturing today. However, Stena Recycling Sverige stated that they could see an ambition in the car workshops and car dismantlers to priorotirize the best EOL solution for vehicle parts this so they could meet environmental requirements and profile themselves as "green". The best EOL solution for diesel particle filters were stated to be remanufacturing, and thus Stena Recycling Sverige argued that the incentive for remanufacturing was strong enough to engage car workshops and car dismantlers in the remanufacturing logistics.

In both Volvo Cars and Stena Recycling it could be seen that the economic incentive and environmental incentive are the underlying drivers for remanufacturing. But it was also the willingness to take social responsibility and engage in the best possible EOL treatment for diesel particle filters. Drivers that maybe still are coherent with environment and economy, but the author would say that the drivers show an additional will to do the right thing and could then be characterized as sub drivers for the economical and environmental incentive. Sub drivers named social responsibility and best solution approach for EOL vehicle parts.

5.1.2 Drivers found in literature but not interviews

The literature showed additional drivers that functions as a vector for remanufacturing that did not come up during the interviews. Drivers that should be considered for the actors involved in this case. One driver observed from literature and not seen in interviews was the driver of strategy advantage.

In the Chinese automotive industry remanufacturing was seen as beneficial, as it made it possible to offer products at reduced price, and profile the companies as "green", and offer a wider product availability by reaching more people, which gave the companies a strategy advantage (Zhang, Yang & Chen,2017). Volvo Cars already practicing remanufacturing of vehicle parts, could, if they choose to try to close the loop of diesel particle filters even more, show more social responsibility but also be less dependent on suppliers of raw material as they secure spare parts supply. Remanufacturing more diesel particle filters could widen the product availability by reaching out with more high-quality products to more people. This may offer good business opportunities that could benefit both the environment and the profitability and can result in a strategy advantage. Securing spare parts supply and be more selfreliant by collecting and remanufacturing EOL vehicle parts are argued to be drivers by both Seitz (2007) and Zhang, Yang & Chen, (2017). Prolonged economic life through remanufacturing is by Seitz (2007) argued to be a driver. Volvo Cars could as have mentioned, achieve a strategy advantage by taking more environmental responsibility and gain additional revenues through remanufacturing more diesel particle filters, this could also enhance the work for sustainable development. According to Karvonen et al. (2015) is remanufacturing of vehicle parts, beneficial for sustainable development.

Karvonen et al. (2015) also argued that remanufacturing of vehicle parts does create skilled jobs. The creation of jobs could stimulate GIAB godsinlösen Nordic AB, UBD Cleantech, Volvo Cars and Stena Recycling Sverige to establish a cooperation, to collect and remanufacture more diesel particle filters.

5.2 Analysing barriers for remanufacturing of diesel particle filters

There are also barriers for remanufacturing diesel particle filters, and a common barrier that could be seen were the barrirer of information and knowledge.

Sorting or the logistics of collecting used products to determine the availability of them do Karvonen et al. (2015) see as a first barrier for even creating remanufacturing possibilities.

Both Stena Recycling Sverige and Volvo Cars representatives argued that sorting could be a difficulty, and it requires involvement of OEM to inform and spread the knowledge. Information that were argued necessary were information about the products, information to recognize a useful filter, knowledge about the brand of the diesel particle filter and the serial number. If the communication was managed in a good way and efficiently, logistical barrirers in sorting could be overcome. This is also what Subramonian, Huisingh & Chinnaman, (2009) argued. They saw information and lack of knowledge of value in remanufacturing goods as a barrier. The engagement of spreading knowledge through information is important for all involved actors. For enabling cooperations and remanufacturing of more diesel particle filters.

Interviewees at Volvo Cars talked about uncertainties when it comes to the quality and condition of diesel particle filters when they reached Stena Recycling Sverige. Also, as mentioned in interviews at UBD Cleantech, a diesel particle filter can not be remanufactured if the substrate is damaged. Uncertainties in take back of products, uncertainties of quality of products were argued to be a barrier (Golinska & Kawa, 2011; Sundin & Dunbäck, 2013; Graham et al., 2015).

These uncertainties may be the reason Volvo Cars are hesitant to enter into new business relations for remanufacturing. Other difficulties that was seen from both Stena Recycling Sverige and Volvo Cars, was the issue of sorting diesel particle filters. There is an interest from Volvo Cars, if the fraction of diesel particle filter for Volvo Cars, could be separated and sorted.

The main barrier expressed by Stena Recycling Sverige, was the economic incentive. Representatives at Stena Recycling Sverige did argue the importance of economy to enable sorting and storing of diesel particle filters at the site of car dismantlers and car workshops. High storage costs are something Subramonian, Huisingh & Chinnaman (2009) argue to be a barrier for not developing remanufacturing. Stena argued the same when telling that there need to be an economic value in remanufacturing diesel particle filters. Stena, did also argue that the channels for logistics were already established, and all that was of interest was the price the remanufacturer could pay to realize the logistics. Uncertainties in logistics cost are argued to be a barrier by Graham et al. (2015). In the investigated case, it was not argued to be a barrier, but what the actual costs could be needs to be revealed, and if there is a risk for any additional costs to appear. If the there were a cost of sorting them and storing them given, it would be much clearer for the actors to see if this was hindering collection of more diesel particle filters or if it could be enabled. However, the cost uncertainties were not brought up by any actor.

5.2.1 Barriers derived from interviews but not in literature

Since remanufacturing was a process Volvo Cars already works with, they also had a system to collect diesel particle filters, called the exchange system. This is a closed system, only working with retailers of Volvo cars, and car workshops. Interviewees at Volvo Cars Reman saw this closed system as a restriction, and a barrier for further develop their remanufacturing system. Because of, that the system covered the whole world, it was argued that only very small amounts of diesel particle filters were not collected. Further on did Volvo Cars Reman representatives also argue that the small number of diesel particle filters not collected, or those Stena Recycling Sverige got in contact with, could be filters of old cars, or very damaged filters. If so, collecting and remanufacturing these filters maybe did not match a customer demand. These uncertainties together also seemed to create a barrier in the attitude of Volvo Cars to further develop business relations for collecting and remanufacturing additional diesel particle filters.

Another uncertainty that could be seen as a barrier was that an interviewee at Volvo Cars told that they are looking more for other products that are of interest when it comes to EOL treatment. Electrical products, such as batteries and electric components were of high interest for Volvo Cars, which may indicate that there is a priority towards other vehicle parts than diesel particle filters.

Stena Recycling on the other hand did not express any particular barriers for remanufacturing diesel particle filters. The economic incentive seemed to be the most interesting driver, and the remanufacturer had to be able to match the price given for recycling of diesel particle filters, but the development of reverse logistics for remanufacturing should also have enough money to sort and store diesel particle filters.

UBD Cleantech believed the main barrier for expanding the network for collecting more diesel particle filters for remanufacturing is connected to the OEM and the engineers designing the filters. They stated that they met strong opposition from the engineers developing diesel particle filters in Volvo Cars, who hindered them for remanufacturing more diesel particle filters. UBD Cleantech stated that the engineers did not value the benefits from remanufactured products, as they preferred to work with new manufactured diesel particle filters.

However, the main barrier for involving in cooperation for remanufacturing more diesel particle filters, came from Volvo Cars. Volvo Cars did not see a incentive in collecting more diesel particle filters, because they saw that they already had a good system to collect their filters, covering a big part of the market. The small streams of diesel particle filters that were not collected had uncertainties whether it could add economic value, and was because of that not of interest. The barrier came from the belief that the filters that were not collected may be from old cars, and may then be diesel particle filters that do not have any customer demand. The customer demand needed to be investigated first, if cooperation for collecting more filters is to be made possible.

The market for remanufactured diesel particle filters were only focused on cars with a need to replace their old diesel particle filter and not new cars. This made the market quite small, with a low demand. Additional arguments to not engage in further collection of diesel particle filters was that the streams out there seemed to be of low value, and since a remanufactured diesel particle filter did not compete with a new manufactured diesel particle filter, was the incentive to expand the current exchange system Volvo Cars had low, and Volvo Cars seemed satisfied with the collection of diesel particle filters they had today.

5.2.2 Barriers found in literature but not interviews

There were different barriers identified in literature that was not mentioned or considered barriers in the interviews. Tongzhu et al. (2011) argued about different stages of barriers occurring, and one barrier for even starting with remanufacturing was lack of governmental support. This study made in China, showed that lack of governmental support, caused difficulties for cooperation between OEMs and remanufacturing firms. This is a barrier opposite to what interviews stated, none of Stena Recycling Sverige, Volvo Cars or UBD Cleantech could see any barriers when it came to laws and regulations. Stena Recycling Sverige even stated that as long as the economic incentive from the remanufacturing company is there, they could not see any other barrier. Volvo Cars, explained that remanufacturing was viewed as positive even by local authorities when it came to regulation, and different directives. UBD Cleantech did not see any other restrictions than the relevant actors' willingness to cooperate. However, it was not mentioned if there was any economic support from the government for remanufacturing either.

Brand awareness and protection was argued in literature to be a barrier. Zhang, Yang & Chen (2017) argued that remanufactured products was precieved as second-hand products, and did not have the same quality in peoples' eyes, affecting the brand, as the brand was connected to new products. Seitz (2006) argued that people connected a certain brand to a certain quality, and remanufactured products could damage that view of people and in turn damage the business. In the interviews, this was not brought up anywhere. Comments from Volvo Cars, did rather show on the opposite, as they were aiming to take both social and environmental responsibilities. Remanufactured products were an additional business idea for Volvo Cars, that is profitable thanks to material and energy savings. Also, remanufactured diesel particle filters held the same quality as a new manufactured diesel particle filter, according to both Volvo Cars and UBD Cleantech. However, remanufactured diesel particle filters are sold in a secondary market, not competing with new manufactured diesel particle filters, which makes the quality parameter, between remanufactured and new manufactured diesel particle filters irrelevant.

Additional barriers mentionedin the literature was unbalances between supply and demand, randomised return patterns (stochastic returns), and uncertainties in logistic network composition (Golinska & Kawa, 2011; Matsumoto & Komatsu, 2015; Sundin & DUnbäck, 2013). These barriers were not really expressed as difficulties by any actor. Rather,Volvo Cars expressed uncertainties regarding the demand of diesel particle filters for older cars.

5.3 Logistical compositions and requirements for effective reverse logistics

As Volvo Cars already have their remanufacturing process, the reverse logistics for diesel particle filters are already set. The exchange system is organized through the Volvo reatailers that is connected to car workshops. The car workshops are contracted to Volvo Cars and the collection of diesel particle filters is done through them. After the collection are the diesel partilce filters sent to Volvo Cars inventory in Maastrich, the Netherlands. Volvo Cars do in turn do a forecast on how much diesel particle filters that need to be remanufactured, and do then send the filters to UBD Cleantech, that is remanufacturing them. After being remanufactured the diesel particle filters are sent back to Volvo Cars, which in turn send the diesel particle filters to the retailer or car workshops that need them. The literature described a remanufacturing logistics network with first a reverse logistic network, where the products travel from the customer, through collection centers, via inspection centers, to remanufacturing plants and then out through forward logistics to the secondary market (Alshamsi & Diabat, 2015). That is exactly what Volvo Cars are practicing today, retailers are the collection centers, an inspection and sorting is done in the Maastricht inventory, then to UBD Cleantech, and last out to the secondary market.

The composition of the reverse logistics Volvo Cars has makes it a closed system. However, to open up for collection of more diesel particle filters, additional actors need to be added and the logistics need to be expanded. Here is mainly the interest to add more collection centers for diesel particle filters. What could be understood from the findings was that Stena Recycling Sverige, but also the car dismantler network called Bilretur, do come in contact with a lot of diesel particle filters, and are the main actors that could create additional value to Volvo Cars exchange system. However, the incentive to add them need to be investigated first, through researching the quality and age of the diesel particle filters, and the customer demand for the diesel particle filters Stena Recycling Sverige and Bilretur may hold.

What was also discussed was the storage and sorting of the diesel particle filters, since the network Bilretur do manage a lot of vehicle parts and from different brands, the need to enable some kind of additional storage may be there. This could create, that there need to be a storage for diesel particle filters, before ending up in Maastricht. However, if this is an economic burden for the remanufacturer it could be a positive effect on job creation. As reverse logistics is argued to create more job opportunities (Chileshe, Rameezdeen & Hosseini, 2015). Dowlatshahi (2005) argued thatharsher environmental legislation pushes companies to engange with producer responisibility, and the use of reverse logistics for EOL products was a way to comply and to show responsibility towards society and environment. This could create an incentive for Volvo Cars, that in interviews argued that social responsibility is of value, to expand their reverse logistics network for diesel particle filters.

For a functional reverse logistics to collect more diesel particle filters for remanufacturing, are already established business relationships important. Bilretur and the car workshops that Stena Recycling Sverige, already had business relationships with, are actors to further reverse logistics with. It is also of importance that Volvo Cars, sees the value of those actors, to establish cooperations to ease the process of detection and sorting but also to determine the customer demand for the filters. The uncertainties in the customer demand and the quality of filters makes Volvo Cars hesitate to engage and further develop their exchange system, an explanation for this hesitation could be found in the literature. Seitz & Peattie, (2004) argued in their article the importance of close relationships between customers and OEM for effective reverse logistics. If the customer turns to someone else than the retail network that OEM is related to, it creates hesitation for the OEM to get access to cores as the value to get access to those cores may not be high enough. Without any relationships built, can the uncertainties in the quality of the cores and additional costs to cooperate, hinder the OEM to engage in engaging in relationships with other actors (Seitz & Peattie, 2004).

6 Conclusions and recommendations

This chapter reflects on the research questions by discussing barrirers and drivers occurring both in the literature and from the interviews. It does further suggest what future research should look at, to realize cooperation for remanufacturing more diesel particle filters in the Swedish market between the companies involved. But, do also consider other companies that may be of interest to expand the network for collection of more diesel particle filters.

1) *What barriers do the companies currently face in establishing cooperation for collection of more particle filters?*

Barriers were expressed by all the interviewees in the study. The main barrier may have been expressed by Volvo Cars. Volvo Cars argued that they covered a lot of the diesel particle filters out there that could be covered, and hesitated to collect more as they did not see value in the small streams of diesel particle filters that was not collected. At the same time did Volvo Cars already have a closed and organized system for collecting diesel particle filters of their own cars, a system they seemed to be satisfied with.

When it came to sorting and storing, both Stena Recycling Sverige and Volvo Cars expressed difficulties which could act as barriers for remanufacturing. Stena Recycling Sverige argued that sorting and storing is a difficulty, however, the economic incentive could ease and promote a preferable sorting and storing process. Stena Recycling Sverige did further state that another barrier in relation to this, was the demand for remanufactured diesel particle filters, it was necessary to determine if there is a demand for the diesel particle filters to enable a logistical process. Volvo Cars, also argued about the importance of OEMs engaging in the logistical process, by spreading information and knowledge to ease the sorting and storing. Volvo Cars did further state the importance to evaluate what kind of filters Stena Recycling Sverige got in contact with, in order to determine whether the filters have a customer demand. Both Stena Recycling Sverige, and Volvo Cars saw customer demand of the diesel particle filters that currently not are remanufactured as important for enabling remanufacturing of more diesel particle filters. Further, did Volvo Cars state age, and the quality of the diesel particle filters, to also be important to determine, for remanufacturing more diesel particle filters. Age, quality and customer demand was currently barriers for developing a cooperation for remanufacturing diesel particle filters.

UBD Cleantech, did see the greatest barrier for expanding remanufacturing of diesel particle filters in the engineers. UBD Cleantech stated that the engineers were in big opposition of remanufactured products, and valued new manufactured products more. This made it difficult for UBD Cleantech to further engage in remanufacturing of diesel particle filters.

Listed in the table below are the main barriers identified by this research for developing cooperation for remanufacturing more diesel particle filters.

Table 6-1. Main barriers identified for cooperation for remanufacturing more diesel particle fitlers.

Sorting and storing	Uncertainties in quality of diesel particle filters
Uncertainties in customer demand	Strong opposition from engineers that are designing new manufactured diesel particle filters
Volvo has already a developed closed system for collecting diesel particle filters	The remanufacturers economic incentive to enable the remanufacturing process

Source: Own table based on the findings in this study.

Some of the barriers expressed in the interviews did also correlate with what literature said. The literature mentioned uncertainties in quality of the product to hinder remanufacturing of vehicle parts. What were also mentioned in the literature were unbalanced supply and demand, and customers will and acceptance of remanufactured vehicle parts.

2) *What drivers for enabling cooperation for remanufacturing more diesel particle filters were identified?*

Drivers were also expressed by all involved companies. Volvo Cars expressed cost savings and social responsibility as two crucial drivers for remanufacturing diesel particle filters. While Stena Recycling Sverige, saw the car dismantlers and car workshops engagement in becoming "greener" through finding the best solutions for EOL treatment of products, where remanufacturing was seen as the best EOL method for diesel particle filters.

Further, Volvo Cars express the environmental benefits of using remanufacturing and also the companys approach towards being environmental friendly as drivers.

UBD Cleantech argued just as Volvo about costs, but was pointing more towards a much cheaper price for remanufactured diesel particle filters than new manufactured diesel particle fitlters as a driver for remanufacturing. Volvo Cars did also see energy savings and material savings as drivers for remanufacturing.

All companies in this study saw law and regulation as positive for remanufacturing. Listed in the table below are the main drivers identified by this research for establishing cooperation for collecting more diesel particle filters for remanufacturing.

Table 6-2. Main drivers identified for cooperation for collecting more diesel particle filters for remanufacturing

Best solution for diesel particle filters	Benefitting the approach Volvo Cars has towards environment	Law and regulation
Car dismanlters and Car Workshops will to become greener	Cost savings	Energy savings
Social responsibility	Cheaper products	Material savings

Source: Own table based on the findings in this study.

The drivers listed above appeared from the interview answeres. But some of them did also appear as drivers for remanufacturing of vehicle parts in the literature. The economic value of cost savings, and cheaper products, was widely argued to be a driver in the literature review. Likewise, was material savings, energy savings and law and regulations argued in the literature to be drivers for remanufacturing in the vehicle sector.

3) *Suggestions for future research*

To further research the possibility to collect more diesel particle filters for remanufacturing through cooperation between companies at the Swedish market, the drivers and barriers identified from this study needs to be considered and evaluated. What is important to take a closer look into in future research, is the streams of EOL diesel particle filters that are not currently being remanufactured. This to be able to determine the quality of those filters, and to evaluate if there is a customer demand for them.

To get a picture of the whole situation, it could also be of interest to study other OEMs of vehicles. Volkswagen is another big vehicle player at the Swedish market, that could be of interest to research, to see how their system works, and what possibilities there may be for them to cooperate with additional actors to collect remanufactured diesel particle filters.

Further, it is of necessity to consider other actors than just Stena Recycling Sverige. Such examples could be car dismantlers and car workshops, both independent and those who are already connected to Stena Recycling Sverige. Car workshops and car dismantlers were argued by Stena Recycling Sverige, to be the first channel for these diesel particle filters. For example, could interviews be conducted with the car dismantler network Bilretur, but also with different car workshops that Stena Recycling Sverige already had relations to. Involving these actors would cover a bigger spectrum of the market, and the research will come closer to what actually happens to the diesel particle filters after being removed from the cars. This may also help to give a picture of the sorting and storing of remanufactured diesel particle filters. This will make it easier for the remanufacturer and involved OEMs to get a good overview of what diesel particle filters that are out there and currently not being remanufactured. With a clearer picture, some of the uncertainties from the OEM may be resolved and may lead to an established cooperation to collect diesel particle filters. A practical research, to investigate the procedures and practices of sorting diesel particle filters out in the workshops, but also to uncover what diesel particle filters are out there, to enable remanufacturing of more diesel particle filters, could also be of interest.

What also could be of interest to research, is the design of new manufactured diesel particle filters. If the diesel particle filters could be designed for remanufacturing, the incentive to engage more actors in collecting diesel particle filters at EOL would be much greater. What could be considered in such research is the OEMs possibility to design for remanufacturing, and the willingness to do it to further promote remanufacturing of diesel particle filters.

Another interesting thing to research in this case is the support from the government. It was argued in the literature that lack of support from government in China, made manufacturers to hesitate remanufacturing. It could be of interest to se if there is any support provided by the government that benefits remanufacturing, or create an incentive for remanufacturing. What could that support then be, and is it enough to stimulate OEMs to engage more in remanufacturing?

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Appendix 1

Intervjuguide

Volvo Cars

Hej! Jag vill börja med att introducera mig själv och varför jag gärna vill genomföra denna intervju idag. Jag heter Nikola Stojmenovic och är en mastersstudent vid Internationella miljöinstitutet, Lunds Universitet. Jag arbetar just nu med mitt examensarbete, som syftar till at titta närmre på möjligheten att samla in och återtillverka dieselpartikelfilter för personbilar. Projektet involverar företagen GIAB godsinlösen Nordic AB, Volvo Cars samt Stena Recycling Sverige och pågår fram till september. Det är därför jag kontaktar dig som är Purchase Planner på Volvo Cars.

Jag har ett intresse att få lite bakgrundskoll på erat arbete med materialinsamling och kommer börja intervjun lite mer generellt innan jag specifikt går in mer på dieselpartikelfilter.

- Vilka material tar ni in?
- Hur går ni tillväga vid insamling av material?
- Tenderar det till att vissa material samlas in mer än andra? Varför?
- Hur ser den omvända logistiken ut vid insamling av material?
- Vilka aktörer involveras?
- Hur fungerar samarbetet vid insamling av material?
- Hur jobbar ni med återtillverkning och återvinning idag?
- Vad avgör om ett material går till återvinning och ett annat till återtillverkning?
- Vad har Volvo Cars för Policy kring insamling och återtillverkning och återvinning av material?
- Ser du att vissa material skulle kunna samlas in till högre grad?
- Vilken potential ser du det finns att ta in mer material för återvinning/återtillverkning?
- När det kommer till dieselpartikelfilter för personbilar: hur arbetar ni för att få tillbaka filtren efter att dessa förbruktas, i syfte att återanvända dem?
- Om, ja, hur går ni tillväga? Vilka procedurer finns för att ta in dessa filter?
- Några specifika samarbeten?
- Vad ser du för möjligheter och hinder för insamling av dieselpartikelfilter?
- Vad ser du för möjligheter och hinder för ett samarbete med andra aktörer för att samla in och återtillverka fler dieselpartikelfilter?
- Ekonomisk lönsamhet?
- Logistiska möjligheter/hinder?
- Lagar?
- Samarbete?

Intervjuguide

Volvo Cars

Kan du berätta mer om din roll på Volvo Cars?

- Hur arbetar Volvo med cirkulär ekonomi idag?
- Vilken potential ser man i att främja och arbeta med cirkulär ekonomi i framtiden?
- Ur miljösynpunkt, ekonomi samt social hållbarhet?
- Hur har arbetet med miljöfrågor förändrats över tid?
  - Vilka drivkrafter finns för att kontinuerligt förbättra sin miljöprofil?
  - Vilka barriärer upplevs för att arbeta med miljöfrågor?
- När det kommer till återtillverkning av bildelar hos Volvo, hur prioriterat är detta område?
- Var riktas prioritet i återtillverkning idag?
- Hur har arbetet förändrats över tid? (Samarbeten, volymer som återtillverkas osv)
- När det gäller bildelar, hur prioriteras dessa, dvs är vissa delar mer prioriterade än andra? Och hur sker insamlingen?
- Vilken bakgrundskoll har du på arbetet med dieselpartikelfilter?
- Som jag förstått det är det ett slutet system man arbetar i när det gäller återtillverkning på Volvo Cars, man ser helt enkelt till sina bildelar, hur ser ni på Volvo Cars på möjligheten att knyta an fler aktörer i värdekedjan för att samla in ytterligare delar till Volvo bilar för återtillverkning?
- Miljö?
- Ekonomi?
- Forskning?

Intervjuguide

Volvo Cars Corporation

Hej!

Jag är just nu i slutfasen av mitt mastersprogram Environmental Management and Policy, vid Lunds Universitet. Därav skriver jag nu mitt mastersarbete som syftar till att titta på möjligheterna att samla in och återtillverka dieselpartikelfilter. Ett samarbete med Giab godsinlösen Nordic AB, Volvo Cars samt Stena Recycling Sverige. Som egenskapsexpert med bland annat koll på funktionen kring dieselpartikelfilter finner jag det högt intressant att göra en intervju med dig, för att höra lite mer kring funktionen på produkter och då specifikt dieselpartikelfilter.

- Jag skulle vilja börja med att höra lite mer om din roll på Volvo Cars?
- Har du koll på de flesta delar som Volvo bilarna använder?
- Finns det stora skillnader i kvalitet bland de förtag som sysslar med återtillverkning av bildelar? Är det något som hindrar kapaciteten på en återtillverkad produkt jämfört med en nyproducerad?
- Hur ser lagar och regler ut avseende detta? vilka regler befrämjar respektive hindrar återtillverkning?
- Hur är efterfrågan av återtillverkade produkter jämfört med nytillverkat?
- Vad gäller dieselpartikelfilter, vad har de för funktion?
- Vad innehåller dem?
- Vilket skick bör de vara i för att kunna återtillverkas?

- Vilka specifika standarder och lagar bör nya så som återtillverkade dieselpartikelfilter uppfylla för att kunna användas?
- Hur ser du på funktionaliteten hos ett återtillverkat dieselpartikelfilter jämfört med nyproducerat?
- Uppfyller den samma levnadslängd som ett nytillverkat?
- Hur ser du på lönsamheten i att återtillverka dieselpartikelfilter?
- För återtillverkning av dieselpartikelfilter, vad anser du vara det viktigaste?
- Vad skulle enligt dig vara ett argument som talar för att återtillverka mer dieselpartikelfilter?
- Vad ser du som en barriär eller motargument för återtillverkning av dieselpartikelfilter?

Intervjuguide

Stena Recycling

- Kan du berätta om vad du gör på Stena Recycling Sverige?
- Hur ser insamlingen av bildelar ut?
  - Logistik?
  - Lagring?
  - Sortering?
- Är det några bildelar som prioriteras utöver andra?
  - Vad avgör om en bildel ska till återvinning?
- Mr berättade att dpfer hamnar i samma hög som oljefilter, ser du några möjligheter till att separera dessa två produkter?
- Ser ni någon potential att knyta till er fler leverantörer av dieselpartikelfilter? produktområdet
  - Hur ser ambitionerna ut att samla in mer dieselpartikelfilter i framtiden?
  - Vilka drivkrafter för insamling av dieselpartikelfilter finns?
  - Vilka barriärer för insamling av dieselpartikelfilter finns?
- Då ni kommer i kontakt med mycket partikelfilter, hur ser ni på möjligheten att samarbeta med GIAB godsinlösen Nordic AB (jobbar med återtillverkning) samt Volvo Cars för att återtillverka dieselpartikel filter? produktområdet
  - Vad skulle krävas för att det ska vara ekonomiskt lönsamt att återtillverka istället för att återvinna?
  - Logistiska lösningar, ser du som får in partikelfilter från verkstäder, någon barriär eller möjligtvis drivkraft vad gäller logistik?
  - Ser du andra barriärer eller drivkrafter? (Lagar, samarbete osv)
  - Mer allmänt: hur ser ni på möjligheten att arbeta med fler aktörer i värdekedjan i framtiden för att prioritera återtillverkning framför återvinning?

Intervjuguide

Stena Recycling Sverige

Hej! Jag vill börja med att introducera mig själv och varför jag gärna vill genomföra denna intervju idag. Jag heter Nikola Stojmenovic och är en mastersstudent vid Internationella Miljöinstitutet, Lunds universitet. Jag arbetar just nu med mitt examensarbete, som syftar till att titta närmare på möjligheten att samla in och återtillverka dieselpartikelfilter för personbilar. Projektet involverar företagen GIAB godsinlösen Nordic AB, Volvo Cars samt Stena recycling Sverige och pågår fram till september. Det är därför jag kontaktar dig som är ansvarig för ELV affär på Stena Recycling Sverige.

Jag skulle vilja börja intervjun, med att få lite bakgrundskoll på ert arbete med insamling och återvinning av bildelar idag, för att sedan gå in mer specifikt på dieselpartikelfilter:

- Hur ser du på insamling samt återvinning/återtillverkning av bildelar i Sverige?
  - Hur arbetar ni med insamling av bildelar och återvinning idag?
  - Tror du att återtillverkningen av bildelar kommer att öka i framtiden?
- Vilka drivkrafter ser du att det finns till att samla in bildelar för återvinning?
  - Tenderar vissa bildelar att vara mer ekonomiskt lönsamma än andra?
  - Vilka?
  - Ser ni skillnader mellan olika bilmärken avseende exempelvis:
    - Hur mycket som samlas in, återtillverkas, och återanvänds?
    - Intresset för att återtillverkning hos biltillverkarna?
- Vilka barriärer/hinder finns, som sätter stop för insamling/återvinning, eller begränsar insamling/återvinning?
  - Lagar? Logistiska? Ekonomiska? Lagringsutrymme?
- När det kommer till insamling av bildelar, hur går ni tillväga?
  - Vilka leverantörer/ Företag jobbar ni med?
- Om vi tittar närmre på dieselfilter för personbilar, hur ser insamlingen ut för dessa?
  - Ungefärlig siffra på antal filter som tas in för återvinning årligen?
  - Anser du denna siffra vara optimal eller ser du möjlighet i att samla in mer filter?
- Hur ser logistiken ut för insamling av dessa filter?
  - Finns det lagar som möjliggör/ begränsar insamlingen? Ekonomiska begränsningar?
- Hur ser lönsamheten ut för återvinning av partikelfilter?
  - Om ni får bättre betalt - per filter - för att samla in och skicka dem till återtillverkning, jämfört med att återvinna dem, är detta intressant för er? JA!
  - Vad krävs för att realisera ovanstående? Vilka är de större utmaningarna? Krävs det stora ändringar av rutinerna?
- Om du ser till logistik, ekonomi samt lagar, vad tror du om möjligheterna för att samarbeta med andra aktörer för att samla in och återanvända partikelfilter?

Ytterligare frågor att ställa:

Stena:

Var hamnar dessa filter när de kommer till Stena?

Sorteras dem eller blandas dem? Fungerar det olika på olika anläggningar?

Finns det något specifikt pris på återvinningen av filter?

Hur mycket partikel filter får stena in årligen? Någon uppskattning?

Volvo:

Vilket skick bör filtren vara i för att kunna återtillverkas?

Hur ser efterfrågan ut på diesel partikel filter?

Vad är priset för ett nytillverkat diesel partikelfilter?

Vad kostar det att tillverka ett nytt diesel partikel filter?

Används återtillverkade filter i nyproducerade bilar? (Tänkte då de läggs tillbaka i originalförpackning)

Hur mycket återtillverkade dieselpartikel filter säljer Volvo årligen?

Har ni idag någon koll på volymen av diesel partikel filter ni inte får tillbaka som ej går till återtillverkning? Uppskattning av hur mycket diesel partikelfilter ni säljer som inte kommer tillbaka i era led för återtillverkning?

Generellt vilken syn har kunderna på att köpa återtillverkade diesel partikel filter?

Vad är priset för kunden för ett återtillverkat filter jmf med ett nytillverkat?

UBD:

Vad kostar det att återtillverka diesel partikel filter?

Hur mycket filter återtillverkar ni ungefär årligen från Volvo? Ser ni några trender?

Hur ser lönsamheten ut när det gäller återtillverkning av diesel partikelfilter generellt?