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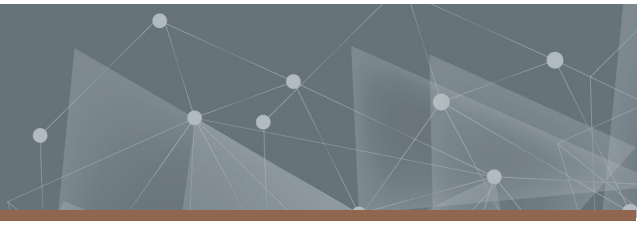

Circular Economy in the Service Market

Waste Management in Distribution Centres

Master's Thesis in the Master's Degree Programs Supply Chain Management and Quality and Operations Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

The demand for sustainable products and services is increasing. Circular economy has become a renowned concept, commonly applied when considering how to reduce the impact of a company's business on the limited global resources and reduce the waste generated. An important part of this is how to reduce the waste generated. The increased level of environmental awareness in society adds another level of expectations on a business that is already very complex, namely the service market in the automotive industry. The service market within the automotive industry is characterised by unpredictable demand, high numbers of SKUs and fast response times. For a long time, the target has been to take better care of the waste generated, but now the efforts needs to be extended to also include waste prevention.

The aim of this thesis is to explore how an automotive manufacturer can work with circular economy within its service market logistics and more specifically, within their distribution centres. This study has analysed a case company called AutoCo and their operations in service market logistics. The result is based on qualitative data gathered both from the case company through interviews and observations, as well as externally from experts through a benchmarking study with other companies.

The result showed that scrapping of parts and excessive use of packaging material are the key drivers to waste within distribution centres. These drivers result in cardboard, plastic and metal becoming the largest and most difficult waste fractions to handle. There is a potential to standardise the data collection in order to better understand and compare the waste fractions between distribution centres. This standardisation would help to set and follow up on targets and to work systematically to reduce waste.

It was found that many companies have a targets to reduce waste but what separates the industry top performers from the others are that their targets are either measurable or that the concept of circular economy exists not only in their logistics departments, but that it is incorporated in all functions of the companies.

In order for an automotive company in the service market to better manage their waste it was found that the packaging can be improved and that standardisation in operations, such as use of filling material, entail a potential to remove some of the waste. Furthermore, in order to achieve actual waste prevention it is essential that the whole company works together from design to delivery. The design of a part can enhance its reuse and prolong its life which prevents scrap.

Keywords: Service market logistics, circular economy, waste management, distribution centre operations, waste hierarchy, packaging, sustainability, automotive industry

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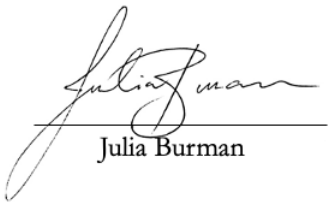
Furthermore, we would like to extend a big thank you to all of the interviewees, both employees at the case company and external companies, for showing interest and participating in this study. Without your knowledge, time and insights, this master thesis would not have been possible.



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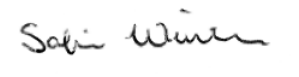

Sofie Winther

Gothenburg, Sweden
June 3, 2021

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Word List

CDC: Central Distribution Centre

SDC: Support Distribution Centre

RDC: Regional Distribution Centre

Cardboard packaging: All types of wood-fibre based paper packaging, both well-papp with liner and fluting layers as well as carton with solid paper.

Commercial packaging: Also known as primary packaging. "packaging which is in contact with the product, and the one that consumers usually bring home" (Pålsson, 2018).

Transport packaging: Also known as secondary packaging. "Transport packaging, also called distribution or logistical packaging, is used to transport products from the place of origin, such as a factory or farm, to the destination" (Sarkar et al., 2019).

Stock Order: Order coming from a CDC or RDC to dealer with standard inventory that will be kept at dealer for sale.

Refill Order: Order from CDC to RDC or SDC. Similar to stock order but fills up inventory levels at SDCs or RDCs.

Day Order: Orders sent by SDCs out do dealers. More urgent orders, always sent the same day as ordered. Ordered by dealer when need occurs.

VOR: Vehicle off road, meaning a vehicle is out of service and need to be repaired. Also the name of the most urgent order class.

1
Introduction

Circular economy is becoming a renowned concept within sustainability work. Companies are adapting to the concept in order to reduce the impact they have on the environment and the limited global resources. The main objective of circular economy is preventing waste and can be applied to all manufacturing industries, including the automotive industry. This study revolves around the concept of circular economy and how this can be applied within the service market of an automotive company. The service market works to deliver the right part, at the right time and to the right cost. The distribution of spare parts is enabled with the help of distribution centres. The distribution centres are important facilities that holds the inventory and ensure fast deliveries to customers. This is also where a substantial amount of waste is generated and where key actions can be implemented.

This chapter will present the content of this report starting with the context in which it is set. Thereafter the study's theoretical and practical relevance is presented. Finally, the aim and the research questions are presented together with the outline of the report.

1.1 Service Market Characteristics

The service market is according to Gaiardelli, Saccani, and Songini (2007) processes and activities "taking place after the purchase of the product and devoted to support customers in the usage and disposal of goods". After sales services include spare part distribution, customer care, accessories sale and technical support while service market support includes secondary market transactions and product recovery processes (Durugbo, 2020). However, over the years the definition of service market has also expanded to include more than the physical product. Advances in remote communication, including embedded system technologies, electronics and model-based diagnosis has changed the way in which vehicles can be diagnosed and maintained (You, Krage, and Jalics, 2005). Having these real-time information flows enables companies to gather knowledge about their customers and gain understanding of their individual needs which allows companies to expand their traditional offerings (Genzlinger, Zejnilovic, and Bustinza, 2020). This means, for example, that potential breakdowns can be discovered before the vehicle actually breaks down, so called preventive maintenance (You, Krage, and Jalics, 2005). Therefore it can be said that the customer buys mobility rather than a product through the service agreement, also referred to as servitization (Genzlinger, Zejnilovic, and Bustinza, 2020).

The service market is characterised by unpredictable and erratic demand which can be difficult to forecast (Cohen, N. Agrawal, and V. Agrawal, 2006; Dekker et al., 2013). There are also requirements on high quality as well as fast response times and prompt deliveries of the needed spare parts (Cohen, N. Agrawal, and V. Agrawal, 2006). The requirements of fast deliveries have shaped the structure of service market networks, resulting in that companies have to "deploy parts, people and equipment at more locations than they do to make products" (Cohen, N. Agrawal, and V. Agrawal, 2006).

The need to meet the demand for fast response time, high quality products and environmental awareness in operations puts high pressure on companies supply chain and distribution centre operations. Distribution centres, hereafter called DCs, are defined as "a warehouse and the business based there, that stores a manufacturer's goods temporarily, before they are transported to stores or customers for sale "(Cambridge Dictionary, 2020a). The activities performed within a DC includes, but is not limited to, receiving, put-away, storage, picking, sorting, packaging, shipping and return handling (Kembro, Norrman, and Eriksson, 2018). DCs play an important part of aligning product demand with supply over different echelons in the supply chain. Decisions regarding the design, location and management needs to be decided in order to create an adequate supply chain (De Koster, Johnson, and Roy, 2017). Ishizaka et al. (2020) states that warehousing facilities hold a significant potential for reducing social and environmental impact and therefore needs to be considered in order to create sustainable supply chains, this will be further discussed in section 2.1.

1.2 Theoretical Relevance

In 2016 the first global initiative to reduce emission of greenhouse gases was taken as 197 countries signed the Paris Agreement (UN Framework Convention on Climate Change, 2017). Participating countries formulated key actions to achieve the agreed targets and waste reduction was deemed to be one of the important factors (UN Framework Convention on Climate Change, 2017). Waste is not just an indirect contributor of greenhouse gases through landfill, reduction of waste also means reduced need for using new raw materials and energy usage, which also leads to reduced emissions (Intergovernmental Panel on Climate Change, 2007). These agreements have resulted in increased regulations for companies (UN Framework Convention on Climate Change, 2017). Waste reduction is a way for a company to avoid cost that comes from handling and disposing waste. It is also something that usually is demanded in order to comply with the local and global regulations (Lewis and Slack, 2017). These regulations includes reporting on waste generated within operations as well as how much is set out to the market e.g. packaging material (UN Framework Convention on Climate Change, 2017).

According to the waste management literature, organisations should focus on preventing waste to the greatest extent possible, then proceed to increase reuse and

recycling before there is no other option but to dispose (United Nations, 2013). This is also known as part of creating circular economy (Kirchherr, Reike, and Hekkert, 2017). Some researchers highlight the importance of packaging as a main contributor to both direct and indirect waste within a supply chain (Ajwani-Ramchandani et al., 2021; García-Arca, Garrido, and Prado-Prado, 2017). Other researchers discuss the importance and implications of excess inventory and obsolete products in their end-of-life phase as this becomes both large volumes of waste as well as can be problematic to dispose (R. E. Crandall and W. Crandall, 2003). Both packaging and obsolete products play an essential role in service market operations. Besides regulations and global agreements, companies are also facing an increased demand from stakeholders to increase their sustainability awareness and waste management is seen as one key action in this regard. (Smith and Ball, 2012). This study will delve deeper into the specific area of circular economy within distribution, and more specifically the DC operations of a company within the service market. Previous literature has investigated the single factors of packaging, obsolete products and circular economy, but this report will add to the research by applying and analysing the issues within the service market context.

1.3 Practical Relevance

This thesis will be based on the assignment of a manufacturing automotive company, in this report called AutoCo. They own and operate their own service market logistics for their products which are mainly trucks and construction equipment. The company offers spare parts for all their products and promises delivery within 24 hours in case of break-down, internally referred to as Vehicle Off Road (VOR). Today they manage over 700'000 different articles with their 100'000 employees and approximately 40 distribution centres (DCs) around the world. Their global presence and rapid response times are creating a demand for a distribution network with DCs close to the customer.The DCs are of varying sizes depending on their function. AutoCo operates six central distribution centres (CDCs) that ship to both other CDCs as well as regional or support distribution centres (RDCs or SDCs). This is visualised in figure 1.1 together with the flow of focus in this study. RDCs ship both stock orders and more critical day orders whereas SDC only ship day order. The only region with solely SDCs, in addition to two CDCs, is Europe. Other regions mainly have CDCs and RDCs. Direct waste, which means waste that is disposed by AutoCo's DCs, is measured and generated at each facility where it is disposed. There is also indirect waste, which means waste that is generated by AutoCo in terms of e.g. packaging, while being disposed by dealers.

AutoCo delivers their parts through dealers, some of which are owned by themselves and some that are privately owned. Out of the 700'000 registered articles, a CDC can hold up to 100'000 different ones and at a dealer there can be between 8'000-12'000 articles. The parts can be sold either over the counter or sold and installed in the workshop. This means that there is both a great variety of articles as well as large volumes. In order to operate in the service market there are multiple departments involved, including for example the commercial packaging department,

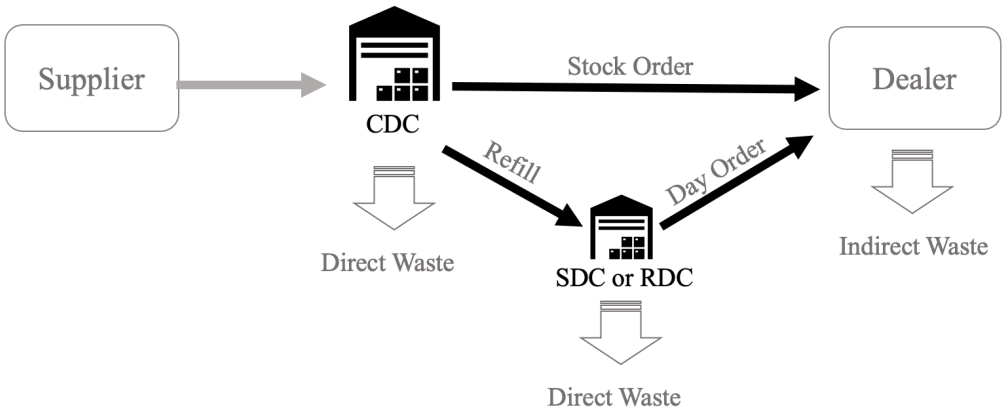

Figure 1.1: A simplified view of the case company's service market distribution chain and the order types. Direct waste is generated at the company owned DCs and the waste from parts sent to the dealers is counted as indirect waste generated by the case company.

dealer inventory management department and service market logistics department. These have to collaborate as the decisions regarding spare parts are complex in many aspects, including deciding which parts should be held where in the distribution network and at what volumes. Furthermore, AutoCo's end-products last for a long time. Today they serve trucks and other vehicles of which some were designed over 30 years ago. This means that their ability to serve the market is designed to cope with long product life cycles, where decisions taken in product design today will impact on the service market for the coming decades.

The department that operates the distribution of spare parts is called Service Market Logistics, hereafter called SML. They, just as AutoCo overall, has sustainability targets within three different areas. These are waste management, energy consumption and reduction of CO_2 emissions. CO_2 emissions from transportation has been the priority to reduce as it contributes to the majority of the service market logistics's greenhouse gas emissions and extensive work has been done. Also related to reduction of energy consumption a lot of work has been done. In order to continue the development towards sustainable operations the mission is now to reduce the waste created, as this indirectly contributes to greenhouse gas emissions. All DCs have a person assigned to report data on how much waste that has been generated each month. This data also contains information about how the waste has been handled, the categories are recycled, incinerated, put to landfill or treated by a contractor. The level of recycling has been increasing for the past years but so has also the reported quantity of waste in terms of weight. As AutoCo are aware of the importance to prevent waste rather than only recycle, further discussed in 2.4, they would like to understand how they can prevent waste throughout their distribution chain, primarily in their distribution centre operations. Furthermore, the company wants to understand what is best practice within waste prevention in order to focus their efforts and be better prepared to meet new regulations.

1.4 Aim

Waste prevention is the first step in circular economy where the overall target is to reduce waste and limit the indirect emissions of greenhouse gas emissions. With increased stakeholder demands and increased regulations on environmental sustainability there are multiple reasons to increase the understanding for how waste can be reduced in a distribution chain. This report will define a distribution chain as starting in the operations at the CDC and end with the outbound goods sent from RDCs and SDCs. When addressing this scope, at how to prevent waste through the distribution chain, dealers will also be affected by reductions further up in the chain. With these starting points the aim of this report is formulated as follows,

This thesis aims to investigate and evaluate how a company within the service market can prevent waste from their distribution centre operations.

1.5 Research Questions

In order to fulfill the aim of this report and analyse what can be done to prevent waste, it is essential to understand the current situation, the desired state as well as what measures to take to get there.

Firstly, it is necessary to map the current state and define what generates waste. Therefore, the first question is formulated as,

Research Question 1 What type of waste is managed by DCs?

Secondly, once it has been established what type of waste is managed within distribution centre operations, improvement potentials can be identified and the focus can be shifted to understand what is a desired state and target. Therefore the second research question is defined in a way that enables exploratory research that helps the case company understand their desired end-state. It is stated as,

Research Question 2 What needs to be considered when setting targets for waste reduction?

Lastly, after having understood the current state and desired end-state, the third and final research question will follow naturally by considering how to close the gap between the two. The third question builds upon the two first ones and will synthesise the findings in order to fulfil the overall aim of the report. Therefore, the third research question is formulated as follow,

Research Question 3 What are the key actions to prevent waste or reuse waste from DCs?

1.6 Structure of Report

This report is divided into the following chapters: introduction, theoretical framework, method, results, discussion as well as conclusions and recommendations. Their contents are briefly described in Table 1.1.

Chapter	Content
Chapter 1 **Introduction**	The scope of the report with its aim and research area. A presentation of the case company as well as the theoretical and practical relevance of investigating the topic.
Chapter 2 **Theoretical Framework**	The previous research within the area is presented as well as the current regulations and relevant theories within the subject is reviewed.
Chapter 3 **Method**	The methods used; observations, interviews, data collection and benchmarking are presented.
Chapter 4 **Results**	The results from the study are presented.
Chapter 5 **Discussion**	Each research question is discussed with regard to the results and in relation to the theoretical framework.
Chapter 6 **Conclusions and Recommendations**	The final conclusion for each research question as well as recommendations to the case company is presented.

Table 1.1: The structure of the report and content of each chapter.

2
Theoretical Framework

This chapter will present the theoretical framework on which the study is based. First, the increasing sustainability focus and importance for companies is described. Secondly, the external regulations and specifically the greenhouse gas standards are reviewed. The third section narrows down further towards the topic of the report and describes the key concept of the study, circular economy. Lastly, the sustainability work within DCs is described.

2.1 Sustainability Work in a Corporate Setting

Today's global society is characterised by an increasing demand for products and services. At the same time, higher demands are placed on companies to produce their products in a more sustainable way using less energy, less material and generating less waste (Smith and Ball, 2012). According to the Brundtland report, sustainable development can be defined as "meeting the needs of the present without compromising the ability of future generations to meet their needs" (United Nations, 1987).

The social pressure and legal requirements on sustainability have become internalised within the automotive industry as companies need to transform into sustainable businesses (Wolff et al., 2020). The transformation causes many new requirements for companies such as learning how to define sustainability, assign responsibilities as well as making the required investments in time, money and other resources (Whitelock, 2019; Wolff et al., 2020). Additionally, a company's sustainability targets, no matter if voluntary or demanded, can be difficult to measure and is related both operations and environmental cost structure, making sustainability efforts complex to achieve without causing operational inefficiencies or the opposite to desired environmental impact (Halati and He, 2018; Whitelock, 2019).

From a promotional perspective, the increased popularity of green products and services has led to more companies wanting to promote themselves as environmentally conscious (Furlow, 2010). In order to do so, firms are increasingly engaging in green advertisement and actively communicate their environmental efforts as well as setting targets higher than required (Arouri, El Ghoul, and Gomes, 2021; Delmas and Burbano, 2011). This is done similarly to how companies manage their Corporate Social Responsibility (CSR) work, and the critics' discussion to green advertising is similar to the ones of CSR whether it actually has an impact (Arouri, El Ghoul, and Gomes, 2021). The issue related to green advertising is called greenwashing and

means that some companies are actively choosing to mislead consumers about the environmental benefits of a product or the environmental practices of the company (Delmas and Burbano, 2011; Rahman, Park, and Chi, 2015). Two behaviours that characterise greenwashing is poor environmental performance and positive communication about it (Delmas and Burbano, 2011). Companies can therefore be said to choose to highlight positive environmental attributes while trying to conceal negative ones (Rahman, Park, and Chi, 2015).

In order to meet the global regulations and the demand from stakeholders, much of the efforts revolve around finding the financial linkages between sustainability and financial performance (Black, 2019). Many companies therefore apply the "Triple Bottom Line" concept (Lewis and Slack, 2017). This means not only looking at the bottom line of profit but develops the definition of success to include two additional dimensions - the social and environmental bottom line (Lacoste, 2016). The social bottom line is measured by "the impact of the operation on the quality of people's lives". The environmental bottom line measures to what extent a firms activities negatively affect the natural environment. The topic is important since a company's activities may have an evident impact on the environment in terms of air pollution and creation of hazardous waste but can also include less evident impact like contribution to the global warming. Some suggestions of how operations can affect the environmental bottom line include, but are not limited to degree of recycling of materials and waste generation (Lewis and Slack, 2017). By pursuing more environmentally friendly products and operations, firms may gain a competitive advantage since they will not risk suffering penalties from non compliance with regulations and waste disposal (Smith and Ball, 2012).

2.2 Global Sustainability Regulations

The increased sustainability consciousness by the public sphere is mirrored in the increase of environmental regulations companies need to adhere to (UN Environment, 2019). One of the most fundamental global initiatives taken is the Paris Agreement, which aims to keep the global temperature increase below two degrees Celsius (Bengtsson, 2021). The agreement, which is signed by 197 countries and came into force November 2016, is the first real act to prevent global warming and align nations efforts towards a common goal (UN Framework Convention on Climate Change, 2017). Nations involved in the agreement developed Intended Nationally Determined Contributions (NDCs) as action plans for how to reach the target of reduced carbon emissions (Powell, Chertow, and Esty, 2018). These targets take into account the capabilities of the participating nations in order to require more of the developed countries than of the developing (Liu et al., 2020). One of the main sources of CH_4 is landfill and how to manage and reduce waste is therefore one important NDC for many countries (Bogner et al., 2008; UN Framework Convention on Climate Change, 2017). If waste is properly managed it creates an essential reduction of Greenhouse Gas (GHG) emissions as it reduces the need of raw material and energy for creating new material (Intergovernmental Panel on Climate Change,

2007).

Due to the COVID-19 pandemic, started in 2019 and lasted for over 18 months, the European Union provided financial support to many affected industries. To fund these recovery packages the non-recyclable plastic tax was increased to the current cost of €0.8 per kilogram (Baumgarten, 2020). This was not the first implementation of plastic taxes, as they have been in place since 2018, but an increase of them. The impact that these taxes will have on industries is still unknown.

2.3 Greenhouse Gas Standards

When discussing reduction of emissions, a common way is to use the framework developed by the Greenhouse Gas Protocol, abbreviated to GHG Protocol (GHG Protocol, 2013). Their framework is an emission accounting standard used by corporations, institutions and nations in order to assess their carbon footprint (Green, 2010). The initiative was created by the World Research Institute and the World Business Council on Sustainable Development and has been adapted by certification authorities such as ISO (Patchell, 2018).

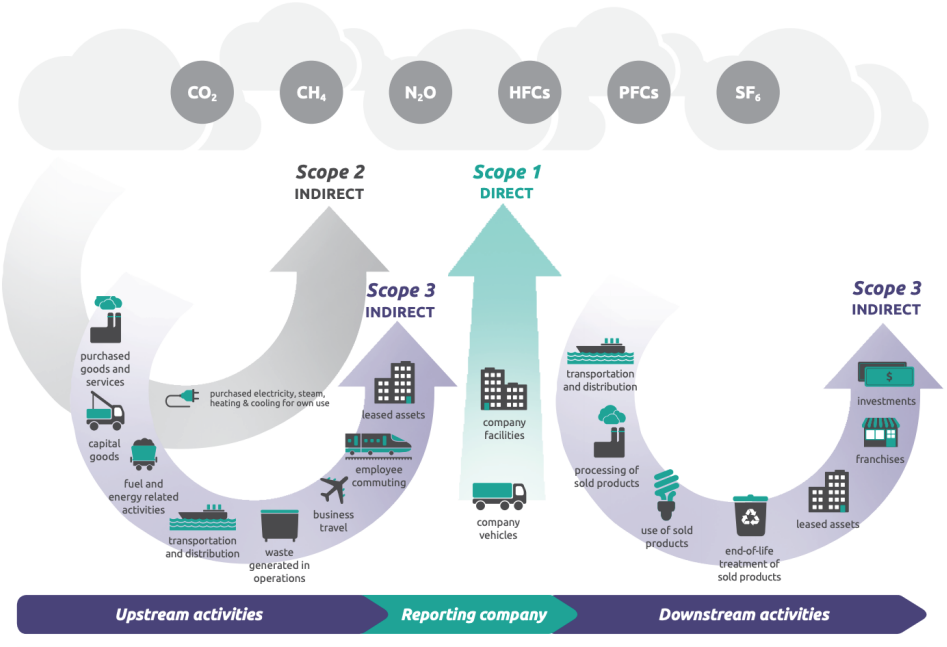

Figure 2.1: The three scopes as defined by Greenhouse Gas Protocol (GHG Protocol, 2013).

It has also been an important framework to describe and understand the emissions a company creates both directly and indirectly throughout its supply chain. Described and illustrated by GHG Protocol (2013), see figure 2.1, Scope 1 emissions are those that a company or institution is the direct owner of, hence something they own is generating the emissions. In Scope 2, all indirect emissions generated by the

purchased electricity the company utilises is included. Scope 3 includes all other indirect emissions, both up-stream and down-stream in the value chain. Waste generated both in the operations as well as on the market is included here. This scope therefore also includes the end-of-life disposal of products.

2.4 The Circular Economy Concept

Circular economy is argued to be one of the most important sustainability concepts (MacArthur et al., 2013). At first, it involved strategies of how to find the equilibrium between environment and the economy and how to involve natural resources as part of the economic system (Boulding, 1966; Pearce, Markandya, and Barbier, 1989). Kirchherr, Reike, and Hekkert (2017) provide the definition used in this report which is based on a review of multiple authors definitions and concepts. They state that the wording circular economy is most commonly used when describing activities revolving around reduction, reuse and recycling of products and material. In the European Unions circular economy action plan, one of the key aspects is how to create circular economy in order to prevent waste (European Comission, 2020).

Waste is defined as "unwanted matter or material of any type, especially what is left after useful substances or parts have been removed" (Cambridge Dictionary, 2020a). In line with this definition the common perception of waste is that it is something that has to be disposed and addressed as an issue, but it can also be seen as a source of value as per United Nations (2013). The UN promotes the triple bottom line as a way of seeing waste management as creating value. First, regaining otherwise lost value through recycling and providing work opportunities is an economic profit. Second, health and poverty issues can be lessened through proper waste management as it provides job opportunities and, hence the social aspect is addressed. Third, when waste is managed correctly, negative consequences of pollution and greenhouse emissions can be avoided. This reduces the impact on, for example, air and water, employee and community health as well as the impact on flora and fauna (United Nations, 2013).

Originating from circular economy is the framework and concept of the waste hierarchy, used by the European Union, United Nations and many other organisations (European Commission Directive 2008/98/EC, 2008; United Nations, 2013). The framework, see figure 2.2, puts waste prevention and reuse as primary targets within circular economy, before recycling or other disposal methods. As per the United Nations (2013) the goal of the framework is not to manage waste well or comply with regulations, but to optimise the use of the world's limited resources and reduce the need to extract and manufacture new products and materials, hence getting closer to circular economy. They explain that the hierarchy follows the progress of material and products throughout their life-cycles and frames the important decisions and priorities. First, every material or product starts with being designed and manufactured. In this phase there is a possibility to prevent potential waste through designing for minimised use of excessive material and enable recovery of resources in

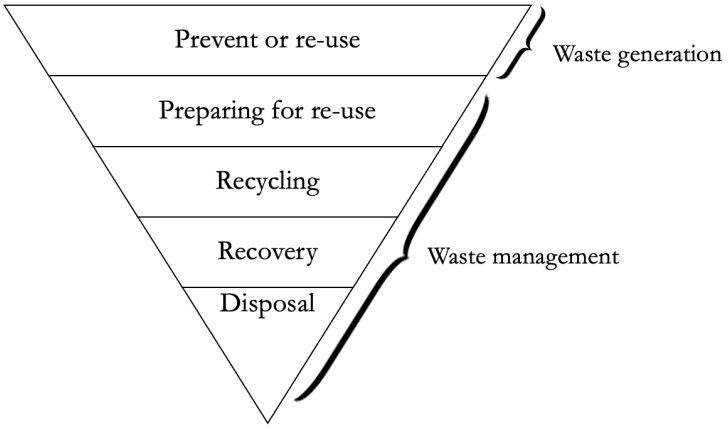

Figure 2.2: Waste Hierarchy adopted from EU directive 2008/98/EC.

the creation process. The design should also consider how the material or product can be reused and have an extended applicability. Thereafter the handling of the material or product is important in order to limit the usage of it and to handle it in a way so that its useful life is maximised. As for the bottom section of the waste hierarchy, recycling and disposal refers to the way the material or product proceeds into being waste and how it is managed, primarily recycled, in order to limit the use of new material (United Nations, 2013).

Ultimately all material has to be disposed, either through incineration or as landfill and the only actual way of preventing this is to not produce the material in the first place (Zink and Geyer, 2019). Landfill is strictly regulated in Europe and as many countries try to move away from this there is an increase of waste-to-energy, i.e. incineration. Incineration, with or without energy recovery, is not without issues. Even if energy is recovered in the burning process there are still external costs in the terms of pollution that affect the environment (Rabl, Spadaro, and Zoughaib, 2008). Additionally, incinerators can be very different and the actual external cost vary. In the European Union there is a directive in order to regulate the incineration process and reduce the environmental and human impact of the emissions (European Commission Directive 2000/76/EC, 2000). EU does not recognise energy from incineration as renewable energy. Many organisations, some funded by EU, is working to promote reduction of incineration and prevention of waste, such as Gaia (2021) and Zero Waste Europe (2021). The waste hierarchy have received a lot of attention from an environmental perspective as applying the approaches of re-manufacturing and recycling are "shown to result in great reductions with regard to both material efficiency and global warming" (Diener and Tillman, 2015).

Building upon the waste hierarchy, the European Union has set up specific regulations in order to target some sources of waste, two of them are the Waste Directive (European Parliament, 2018) and the Waste from Electrical and Electronic Equipment (WEEE) Directive. The first directive has set up targets for countries to achieve by 2025 and 2030 in terms of recycling of packaging material, see table 2.1.

The directive states that "By 31 December 2025, at least 65% by weight of all packaging waste must be recycled." By 2030, the total recycling of packaging must be 70%.

Material	2025	2030
Plastic	50 %	55 %
Wood	25 %	30 %
Ferrous metals	70 %	80 %
Aluminium	50 %	60 %
Glass	70 %	75 %
Paper and cardboard	75 %	85 %
All packaging material	65 %	70 %

Table 2.1: Recycling targets as per European Parliament (2018).

In order to improve the recycling of electronic equipment which contains multiple rare and valuable metals, the EU also has the second directive aimed for WEEE (European Parliament, 2012). This directive takes stance in the rapid increasing amount of WEEE which is currently the most growing waste fraction. The directive has the objective to prevent WEEE, increase efficient sourcing of material as well as increase recovery of material. The directive requires accurate collection and treatment of WEEE by EU members and enforces strict regulations on waste export. This means preventing the waste to be exported to low-income countries due to the increased transport emissions and lack of transparency in the disposal process.

2.5 Waste Management in DC Operations

Within a DC several activities take place. According to Kembro, Norrman, and Eriksson (2018) DC operations includes the activities receiving, put-away, storage, picking, sorting, packaging, shipping and return handling. In order to make DC operations efficient and effective, several design aspects and resources needs to be taken into consideration. This includes physical layout, storage opportunities and handling equipment such as different types of forklifts for put-away and picking (Kembro, Norrman, and Eriksson, 2018). How operations should be designed are affected by a range of order characteristics including order size, assortment, lead time pressure and workload variation (Boysen, Koster, and Füßler, 2021).

One challenge for DC operations in a service market context is that firms need to support both current and previous product versions (Cohen, N. Agrawal, and V. Agrawal, 2006). The DCs therefore needs to be able to handle a high number of SKUs (Andersson and Jonsson, 2018). According to Cohen, N. Agrawal, and V. Agrawal (2006), firms that engage in the service market needs to handle approximately 20 times the number of SKUs compared to the manufacturing function. Having this many SKUs comes with a risk of obsolesce due to difficulties in forecasting as well as specific product characteristics (Cohen, N. Agrawal, and V. Agrawal,

2006; Dekker et al., 2013).

The most prominent performance metric in the service market have traditionally been up-time (Cohen, N. Agrawal, and V. Agrawal, 2006). However, the increasing awareness of sustainability issues among governments, businesses, consumers, and society at large is pushing many industries to take on environmentally conscious policies, for example in their end-of life management (Subramoniam, Huisingh, and Chinnam, 2009). Therefore, companies nowadays have to cope with high requirements on quality and fast deliveries, while also facing requirements to handle the service market operations, including delivery, return, repair and disposal of failed components in an environmentally safe fashion (Cohen, N. Agrawal, and V. Agrawal, 2006). Two particular sources of waste within DC operations are packaging and obsolete products or excess inventory.

2.5.1 Sustainable Packaging Logistics

Transferring goods between different actors and sites within the organisation are referred to as inter organisational activities. The environmental impact of these activities has previously received relatively little attention but as the society becomes more aware of sustainability these issues are receiving increasing focus (White, Wang, and Li, 2015). One of the issues that are receiving attention are inter organisational packaging issues. In line with the definition of waste in 2.4, many companies sees their products as the value delivered and the packaging as an unwanted must with short useful life (Ajwani-Ramchandani et al., 2021; Pålsson, 2018). Packaging have generally had three purposes - to enhance product life span, facilitate stackability and to protect the contents from damage (White, Wang, and Li, 2015). Pålsson (2018) adds to this and describes four performance areas or targets for packaging which are minimising product waste, increasing logistics efficiency, being value adding and minimising packaging material. Traditionally the focus has been on the primary packaging within the organisation and not between organisations. However, it has now been acknowledged that packaging material results in waste for both the producing company and its customer (White, Wang, and Li, 2015).

As mentioned in 2.3, waste has both indirect and direct consequences on emissions, this also includes packaging. Packaging production and packaging waste has direct impact on greenhouse gas emissions in its creation and disposal, but even greater are the indirect emissions (Pålsson, 2018). Indirectly, packaging impacts logistics and transport efficiency and maintains the quality of the product, hence reducing scrap and further waste. Wu and Dunn (1995) have mapped the logistics decision in the supply chain and its correlating environmental impact. Some of the stages they mention are inbound logistics, outbound logistics and after-sales service which are relevant when discussing DC operations, see table 2.2. Wu and Dunn (1995) stress the importance of managing returns well when operating within after-sales services.

Due to the issues related to the use of packaging, multiple nations and regions re-

Logistics Decision	Environmental impact areas	Role of packaging
Inbound Logistics	Consolidation, selection of transport mode, selection of transport provider, materials handling, warehousing and backhaul management	Appropriate unitisation, stackability, handleability, volume efficiency, and weight efficiency features
Outbound Logistics	Same as inbound logistics, and the distribution network and packaging system selection	Appropriate unitisation, stackability, handleability, volume efficiency, and weight efficiency features.
After-sales service	Management of returns	Weight and volume efficiency, stackability, and unitization

Table 2.2: Table adopted from Wu and Dunn (1995). Environmental impact and the role of packaging in different logistics decision areas.

quire reporting of waste to market generated by the business, often as a result of the nations' commitment to the Paris Agreement (UN Framework Convention on Climate Change, 2017). For example in the UK, if an organisation or business either produces, uses packaging or sells packaged goods companies have to follow certain rules. These rules mean that one must work to "reduce the amount of packaging produced in the first place, reduce how much packaging waste goes to landfill and increase the amount of packaging waste that's recycled and recovered" (Environment Agency, 2014). For many organisations it is a complicated task to adhere to the waste reporting requirements as it implies that it is necessary to continuously record all packaging materials that are received and used by the company accurately (White, Wang, and Li, 2015). Therefore, it is important that waste measures are incorporated as part of a company's sustainability targets in order to gain control and be able to minimise the amount of packaging material and packaging waste (White, Wang, and Li, 2015).

Packaging design is a key action to prevent material and products to become waste (García-Arca, Garrido, and Prado-Prado, 2017). With the same prioritisation of importance as the waste hierarchy figure, see figure 2.2, packaging design should consider how to reduce material consumption, how to enable reuse and how to avoid losses or damages of goods (García-Arca, Garrido, and Prado-Prado, 2017). When it comes to reuse, returnable packaging is one method encouraged due to its cost and environmental benefits (Baudin, 2004; García-Arca, Garrido, and Prado-Prado, 2017). The method is most commonly used among local suppliers through milk runs as return freight is an important aspect. If an extra freight needs to be booked, the sustainability aspects of increased emissions need to be considered in relation to the gains of recovering the material (Baudin, 2004).

Elaborating further on the idea of returnable packaging, Baudin (2004) describes the three main advantages of returnable packaging. First, the cost advantages of

returnable containers in a return system is greater and increasing over time the more the packaging is used. There is also the possibility to charge the suppliers for utilising the returnable packaging. Secondly, the quality of the packing is and must be better for it to last through many transports, making each transportation safer for the goods. Third and foremost, there will be less waste that needs to be recycled, incinerated or put in landfills. On the other hand, there are aspects that need to be considered when implementing returnable packaging. The actual impact of creating the containers, which are usually made out of hard plastic or wood, can have an impact equal multiple usage of one-way packaging. Hence number of usages need to be considered when evaluating potential environmental benefits of it before making the investment. The returnable packaging may also be subject to some kind of standardisation which can lower the fill rate in transportation. As previously mentioned, the return flow needs to be evaluated and in place to such a degree that the additional transportation required is not consuming the environmental benefits that the reduction of waste generates.

No matter the life-span of packaging, it can no longer be reused but has to be recycled if possible or else disposed (Ajwani-Ramchandani et al., 2021). Circular economy puts emphasis on the importance of recycling, but this is only possible for some types of material as some, such as plastics, aluminium and steel, can contain hazardous material not suited to be recycled (Geueke, Groh, and Muncke, 2018). It is not solely the recyclability of the packaging material that has an impact on whether the packaging will be recycled or not, the available recycling methods, price of raw material, local policies and education also plays a role (Tallentire and Steubing, 2020).

2.5.2 Management of Excess Inventory and Obsolete Products

Spare parts often carry a high risk for obsolesce due to their specific characteristics and companies frequently face the challenge of offering competitive service contracts while at the same time having the correct balance between holding too much inventory and risk for stock-out, as neither of them are preferable (Dekker et al., 2013). Having a proper inventory balance is important since lack of spare parts may be connected with a high cost of downtime for customers (Andersson and Jonsson, 2018). An important aspect of a proper inventory balance is accurate forecasting, it may otherwise result in excess inventory (Toelle and Tersine, 1989). Excess inventory, also called obsolete inventory, is when there is more stock than necessary of a product which are in the state that it is no longer useful (Cambridge Dictionary, 2020b; Oxford English Dictionary, 2020). Excess inventory is created through demand variation, supply variation or internal variation. Excess inventory can be said to exist when it is not *"the right quantity of the right goods at the right place at the right time"* (R. E. Crandall and W. Crandall, 2003). When the balance is not accurate, management have to decide what to do with the excess inventory.

An approach to avoid excess inventory is the life-cycle model which includes various phases. The first one is the create/prevent phase. It is in this phase decisions that may lead to excess inventory are taken. This includes decisions stemming from operational execution, tactical planning and strategic objectives. However, it is also this phase that offers most opportunities to take decisions that prevent, or at least reduce, the impact and amount of excess inventory through for example demand planning (R. E. Crandall and W. Crandall, 2003). The second phase is the identify/classify phase. While the planning phase deals with identifying causes for excess inventory, the identify/classify phase deals with recognising which type of excess inventory a company has. This includes but is not limited to excess inventory due to age, obsolesce or abnormal amounts. To identify these categories an information system is normally required and used (R. E. Crandall and W. Crandall, 2003). The third phase, also referred to as the analyse/value phase regards being able to make a realistic estimation of the value of the excess inventory and how to report it. Lastly, it is in the disposal/recycle phase decisions regarding which method for handling excess inventory that is the best are taken. The method chosen must match the characteristics of the inventories incurred (R. E. Crandall and W. Crandall, 2003). Excess inventory can be reduced or disposed of by (1) returning it to the supplier, (2) modifying it for use in another product, (3) using it as spare parts, (4) selling it, (5) donating it, or (6) scrapping it (R. E. Crandall and W. Crandall, 2003).

3
Method

In this chapter, the research approach and methods used to answer the research questions will be presented. First, the research approach and process will be described. Secondly, the methods that have been used to gather the data will be presented and lastly the research quality of the study will be discussed.

3.1 Research Strategy and Approach

This study serves to explore the waste streams of AutoCo, identify what needs to be considered when setting targets for waste reduction and to finally conclude in what key actions are needed to prevent waste or reuse waste from DCs. The research approach is adapted to fulfill this purpose.

Often a distinction is made between two types of research strategies, quantitative and qualitative research. Quantitative research is said to emphasise quantification in the collection and analysis of data rather than emphasising words, whereas qualitative research on the other hand tends to emphasise words rather than paying attention to quantification in the collection and analysis of data (Bryman and Bell, 2013). This thesis will follow mainly a qualitative strategy including interviews, primary and secondary data, observations as well as a benchmarking.

There are mainly three available research approaches to choose from, namely i) inductive, ii) deductive and iii) abductive (Bryman and Bell, 2013). For this report an abductive approach was taken which is a combination of a deductive- and inductive approach. A deductive approach entails a process in which observations and findings are built on the foundation of theory whereas an inductive approach emphasises that theory is the outcome of research, i.e. "the process of induction involves drawing generalisable inferences out of observations" (Bryman and Bell, 2013). An abductive approach was deemed suitable as it allowed the researchers to apply an iterative approach by going back-and-forth between data and theory to gradually increase the understanding (Bryman and Bell, 2013; Patel and Davidson, 2011). This iterative approach was suitable as the research questions were built upon each other, allowing the researchers to go back to theory when interesting topics came up during the interviews and the benchmarking. The flexibility to be able to respond to new insights are one of the main benefits raised by Maxwell (2005).

For this thesis, the insight and findings are derived from data collected from one

single actor in the automotive service market. A study conducted at a single company focusing on its specific settings and properties could, according to Eisenhardt (1989) and Gerring (2004), be called a single case study. A case study can be an appropriate research methodology when the aim is to obtain multiple perspectives on a single organisation. In a case study, interviews are combined with direct observations and information from the case company which is helpful when trying to understand a particular process or phenomenon (Cooper and Schindler, 2014). For this thesis, a case study of a company operating in the automotive service market has been conducted. This included internal interviews with key personnel at the company, external interviews with other companies, a virtual site visit as well as a literature study have been performed due to the complexity of the research topic.

3.2 Research Process

The research process of this thesis followed an iterative rather than a linear approach as stated above. Figure 3.1 shows an overview of how the research project was conducted together with descriptions of what each phase consisted of.

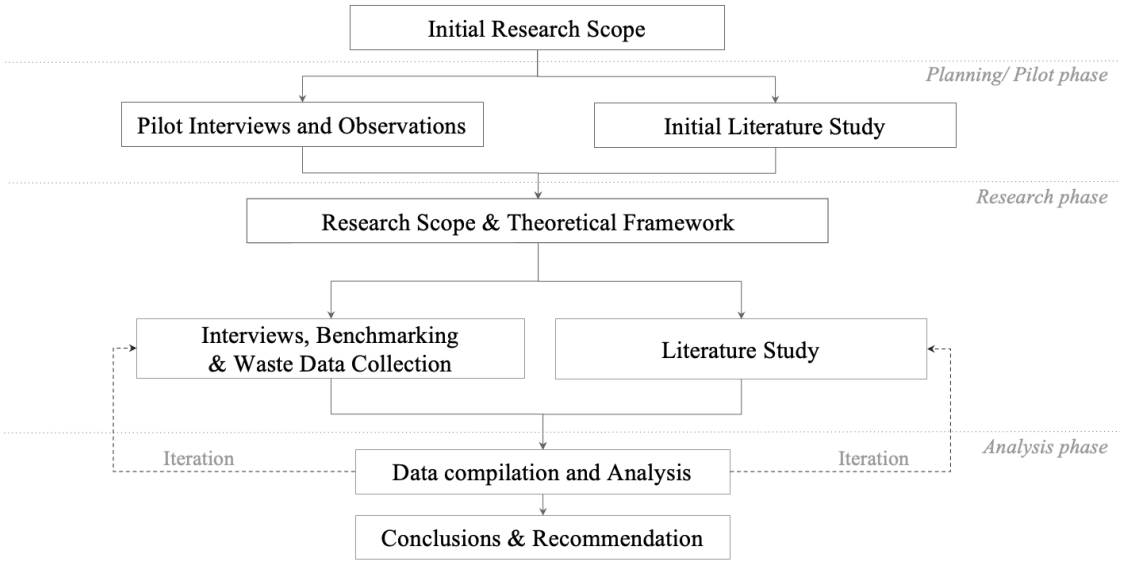

Figure 3.1: The process of how the study was conducted.

As the thesis was carried out in collaboration with a case company, there was initially a set topic for what the thesis and investigation should be about, to investigate how AutoCo can get closer to climate neutrality. However, the exact scope of the study had not be set in advance. Therefore, the first step was to create an initial research scope. Here, a review was made regarding what would be interesting aspects to investigate related to the research topic. The initial research scope was discussed with the supervisor at the case company to identify potential delimitations and the

current situation at the company.

The planning phase consisted of two separate parts; initial interviews with AutoCo's employees and a direct observation as well as an initial literature study. The literature study was conducted to create knowledge and understanding of the research scope chosen. Simultaneously, a direct observation was made to understand the case company's DC operations and interviews were conducted with key personnel at the case company. The interviews were primarily conducted to create an understanding of AutoCo's current work with sustainability and what parts of the organisation are involved in the DC operations.

Once a more solid knowledge base had been created, the actual problem definition could be done and the aim was formulated. Based on the information that had been obtained up until this point it was agreed that the report would only focus on one of the targets set by the company, namely waste management as it could be considered that it was the target that had recieved the least attention so far. With the set scope and aim a review of existing literature on the subject was conducted in order to create a theoretical framework. This resulted in three research questions that were found interesting to investigate in order to fulfill the aim of the thesis.

During the research phase, the majority of the data were collected from the sample chosen. According to Bryman and Bell (2013) convenience sampling is a non-probability sampling method used when the whole population of interest is not accessible and, in this case, a predefined network can be utilised. After reviewing the existing database at the case company, see section 2.3.1, it was found that the European region had the highest level of recycling and most certified landfill free DCs. As the European region is the most regulated market with the European waste legislation (UN Environment, 2019) this is not surprising. There are regional differences that makes each DC have different possibilities to manage the waste. In Europe these differences are considered to be less than compared to other regions in the world with less waste infrastructure. In order to answer the purpose of this study the sample chosen was therefore solely DCs located in Europe, see 3.1.

In order to provide the reader of an understanding for the size of each DC, they have been categorised into three different categories by the researchers. These categories are based on number of shipped order lines annually. A small DC has at the most 200'000 shipped order lines, large DCs has over 1'000'000 shipped order lines and medium DCs lies in between.

As this is a total of two CDCs and eight SDC it was considered possible and manageable to include all as objects of investigation. From these DCs the qualitative data was be retrieved through interviews and data sheets. One of the two CDCs located in the European region is the largest of all of AutoCo's six CDCs worldwide. The operations conducted, all material used and all waste generate at any DC will also exist at this CDC. The SDCs are not representative for the other DCs outside of the region as most DCs are either CDCs or RDCs. The difference between them

DC	DC Size
CDC Belgium	Large
CDC France	Large
SDC Italy	Medium
SDC Sweden	Medium
SDC UK	Medium
SDC Spain	Medium
SDC Poland	Small
SDC Finland	Small
SDC Romania	Small
SDC Austria	Small

Table 3.1: Sample of DCs of which data was collected and interviews where held.

is that the supporting DCs only manage day orders while regional DCs manage both day orders and stock orders. This is one of the limitations of this study as the result will be applicable to the regional DCs to some extent, but not exhaustively cover their operations and aspects of waste prevention.

In the research phase AutoCo's extensive network was utilised to reach the correct persons. For the interviews the right persons were selected with the help of the thesis supervisor at AutoCo. Through the supervisor, the researchers were also able to get in touch with one of the companies for the benchmarking. The other companies were contacted directly by the researchers via email. The benchmarking process was initiated once the internal interviews were concluded in order to be able to ask questions relating to the same topics that came up during the internal interviews. The benchmarking resulted in interviews with representatives from five different companies. In parallel with the data collection, a literature study was performed to build knowledge.

The third phase of this thesis, called the analysis phase, entailed data compilation and analysis. The compilation and analysis formed the basis for the conclusion and recommendations which were discussed together with case company representatives and supervisors in order to verify and prioritise suggested actions. The data collected from the DCs was compared against each other and against their individual size. The majority of the analysis was done based on an average for the past three years of waste data in order to find patterns dependent upon the DCs operations and not the yearly variations of shipped order lines or scrap orders. The benchmarking result was analysed as a comparison between the companies and waste targets analysed in terms of feasibility for AutoCo.

3.3 Data Collection and Sources

This study primarily used publicly available information and the knowledge held within AutoCo. To capture the current waste streams secondary data from the DCs was collected which displayed the waste fractions. In order to gain a deeper understanding, employees across the organisation were interviewed, both operators at DCs to overall sustainability managers. In order to map the current performance within sustainable DC operations a benchmarking study was done. This included both review of annual reports as well as interviews.

3.3.1 Secondary Data

Secondary data is data collected by other researchers or organisations and can be used for both qualitative and quantitative data (Bryman and Bell, 2013). There are both advantages and disadvantages of analysing secondary data (Boysen, Koster, and Füßler, 2021). A positive aspect is the saved time and cost as the collection phase is avoided and the data can still be of high quality and gathered over a long time which opens up for longitudinal analysis. The negative aspect is the level of details, how the data was gathered and the purpose of gathering might require adjustments to how it is used. Furthermore, the quality of the data cannot be guaranteed. The secondary data that has been used for this report are general literature, annual reports and waste data gathered by the different DCs.

Waste data

The case company currently measure their waste totals and disposal methods in terms of how large percentage that is recycled, incinerated, put to landfill and treated by contractor. This is reported by all DCs monthly and is collected, via a larger system of AutoCo, in a database and published in a dashboard. As it is not possible to view any more details than the main headlines in terms of what disposal method that has been used for handling the waste in the larger system of AutoCo, more specific waste data from each DC was collected. The waste data was used to answer the first research question and indicate for which waste categories it could be of interest to take action and work with as a part of research question number three.

The waste data differs between the sites, mainly in terms of how many waste categories the DC are reporting and how they label the waste. Some DCs make quite general reporting while some perform a more granular data collection for their own development purpose or for local regulation compliance. The data that was collected was later compared to the data that had been reported into the larger data system of AutoCo to ensure that the total amount of waste added up to the same number.

Once all the data had been collected and verified, an analysis was performed where waste categories were compared in order to gain an understanding of what is driv-

ing waste within the DC operations. The comparisons were made both within each DC respectively as well as between DCs. This was done by calculating how large percentage of total waste some of the most prominent waste categories like metal, cardboard and plastic accounted for in relative numbers. Then the percentages per waste fraction was compared across the DCs.

In order to compare the waste generated at each DC and normalise the result with the size of the DC, a measurement called waste per order line, WPO, was created. It measures the amount of waste in kilos in comparison to the number of shipped order lines from the DC annually based on the following equation.

$$\text{WPO} = \frac{\text{Total Waste}}{\text{Total Shipped Order Lines}}$$

This measurement was created in order to see whether the waste generated in each of AutoCo's DCs in Europe were proportional between the sites and to their size or if some sites generate more or less waste per outbound order line. For this report, the WPO and the percentages of waste were calculated for the years 2018-2020 which was also the years that the researchers received data of. The reason for calculating an average instead of doing it for each year was to get a more representative picture and ensure that individual events during these years did not have as great an impact on the result. Thereby the sites could be compared more fairly.

When collecting the data, some difficulties were encountered that required manual adjustment by the authors. As the DCs decide by themselves what waste categories they collect the waste in, it resulted in different types of categories from all DCs. In order to make a comparison the data had to be sorted in standardised categories of metal, plastic, cardboard, paper, wood and other. This was at times complicated. For example, one of the DCs did not have any metal reported but had one category named *scrap*. As it had been verified by key personnel at AutoCo that scrap parts normally are made of mostly metal and partly plastic and/or electronic waste, this category was therefore moved to the metal headline by the authors. The DC was already reporting plastic as a separate waste category.

3.3.2 Primary Data

Primary data is data collected for the sole purpose of the research (Bryman and Bell, 2013). For this study it was found essential to get primary data from the DCs. This was done through interviews and observations. For the benchmarking the data could have been collected only with secondary data, such as publicly available annual reports. Interviews where held anyway with the benchmarking companies as it was found important to get specific information about waste and DC operations which the annual reports did not provide in detail. This section will describe the interviews and observation method while benchmarking will be further described in

section 3.3.3.

Interviews

For this study, employees from various functions of AutoCo has been interviewed. The interviews were conducted in order to gather data needed for understanding the research topic and the challenges related to it but also to understand what AutoCo is currently doing in terms of sustainability in their DC operations. The interviewees were selected using a combination of convenience and snowball sampling. Convenience sampling is beneficial due to the degree of accessibility and snowball sampling allows the researcher to via the already selected group of relevant people find and establish contact with other people who are relevant to the topic (Bryman and Bell, 2013). The interview process for this thesis was three-folded, including initial interviews, internal interviews and external interviews.The initial interviews were conducted during the planning phase and aimed to acquire general knowledge about AutoCo's operations and the work that is currently being done within the area of the research topic. The internal interviews aimed at acquiring more specific knowledge about AutoCo's waste streams and how the company are working with them at various sites and departments. Lastly, external interviews were held in order to obtain knowledge about what other companies are working with in relation to waste management and their targets for it.

Initial Interviews

During the planning phase, initial interviews were held with selected employees at AutoCo. The interviews lasted between 30 minutes to one hour. See table 3.2 for detailed description of interviewees. The interviewees had knowledge within different areas of the service market resulting in seven interviews covering several steps of the service market distribution chain. The interviews were exploratory in their nature but revolved around the research topic, waste management, and how the department or DC are currently working with it. As respondents did not hold the same position and would therefore be able to contribute with different views on the topic.

Function/DC	Position	Length
RDC South Africa	Security and SHEQ Manager	50 min
CDC Belgium	Environment and Dangerous Goods Coord.	25 min
SML	Environmental Excellence Leader	60 min
CDC Brazil	Environmental Specialist	55 min
Commercial Packaging	Packaging Engineer I	55 min
Commercial Packaging	Packaging Engineer II	60 min
Commercial Packaging	Packaging Engineer III	30 min

Table 3.2: Conducted interviews in exploratory planning phase

The interviews conducted were semi-structured and loosely based on some core questions as defined by Waller, Farquharson, and Dempsy (2015). This mean that the interviews followed a general template, see A.1, which was adapted before each interview based on the interviewee's responsibilities. The template acted as a starting point for the interview and was followed as far as possible (Bryman and Bell, 2013). As most of the questions were open ended the order needed to be changed at times, partly because the interviewee had answered certain questions in previous answers, but also due to follow up questions.

Internal Interviews

Once the focus area of the study, waste prevention, had been selected the second part of the interview process, internal interviews were conducted. This was done as part of the study's research phase. The interviews in this phase was done with two different groups, employees at the DCs in Europe as well as with central functions of AutoCo and one of the DCs' waste contractor. The interviews held with the representatives from the DCs was conducted in order to gain more specific knowledge about AutoCo's waste streams and how they are handling them at the different sites and how they are working with waste prevention. For the DC interviews see table 3.3 below.

DC	DC Size	Position	Length
CDC Belgium	Large	Packaging Engineer	55 min
CDC France	Large	Logistics Manager	30 min
SDC Italy	Medium	General Manager	55 min
SDC Sweden	Medium	VPS Coach	90 min
SDC UK	Medium	General Manager and Business Admin. Manager	55 min
SDC Spain	Medium	Administration	60 min
SDC Poland	Small	Acting General Manager	E-mail
SDC Finland	Medium	Director of SDCs in Europe	25 min
SDC Romania	Small	General Manager	65 min
SDC Austria	Small	Office Support	45 min

Table 3.3: Summary of interviews with DCs in sample

The interviews in this phase were also semi-structured but the core questions were not changed between interviews. Two separate templates were created in order to be consistent in the questions asked. This was done in order to be able to compare and generalise the results from the interviews. The questions in the DC interviews were more specific than in the planning phase and had a higher degree of structuring. This was done in order for the questions to be perceived in a similar way by the interviewees (Olsson and Sörensen, 2007). However, the format for the interviews still left room for changing the order of the questions and asking follow-up questions, hence also these interviews was to be considered semi-structured.

The interviews with central functions were held continuously during the research

phase to gradually increase understanding in areas where it was perceived to be a knowledge gap. For these interviews there was no specific template to follow but rather explored specific target areas of interest, very similar to the way interviews where conducted in the planning phase. In order to get a more nuanced view on the waste disposal a waste contractor was also interviewed. This was SDC Sweden's waste contractor Stena Recycling. For more details about the interviews with central functions and waste contractor see table 3.4.

Function	Position	Length
SML	Environment excellence Leader	30 min
SML	Senior Excellence Manager	60 min
SML	Senior Project Manager	30 min
SML	Head of Dealer Inventory Management	35 min
Quality & Environment	Head of Environmental sustainability	30 min
Commercial Packaging	Packaging Engineer	25 min
Waste contractor	Key Account Manager	30 min

Table 3.4: Summary of interviews with relevant central functions and the waste contractor.

Prior to the interview, the respondents received a set of questions from the template via email in order for them to get an idea about the subject and to have some time to prepare for it. The interviews were held remotely via Microsoft Teams and lasted between 25 and 65 minutes. During the interviews the interviewees were asked to provide input regarding other employees or actors that would be interesting for further interviews, hence creating a snowball sampling.

External Interviews

In addition to the interviews held with employees at AutoCo, external interviews were held with selected companies for the benchmarking. In the benchmarking interviews the questions were more exploratory in their nature, allowing the interviewees to speak more freely about their waste management work, i.e. they had a lower degree of structuring. The purpose of this approach was partly to increase the interviewee's willingness to cooperate and partly increase the opportunities to obtain interesting and essential information that might otherwise be lacking due to researchers' preconceived notions (Olsson and Sörensen, 2007).

The benchmarking interviews followed a similar approach as the DC interviews, where the interviewees recieved a set of open-ended questions in advance, prior to the interviews. The interviewees for the external interviews had a higher spread of what positions in the company they held compared to DC interviews, see section 3.3.3 for further details. Hence the interviews tended to focus more on the areas that they had the most knowledge and interest in. Therefore the content of the interview varied to a greater extent.

Observations

During the study, one direct observation has been made. The direct observation was made with the purpose to gain a better understanding of the warehouse structure and the activities performed at the DC as well as in which processes waste is generated. Direct observation means that the observation takes place in the natural environment (Olsson and Sörensen, 2007). The observation that was carried out was unstructured, which means that it was carried out for exploratory purposes in order to obtain information about the situation (Olsson and Sörensen, 2007). Like Yin and Retzlaff (2013) states, observations can be an invaluable way of collecting data as one sees it with one's own eyes and perceives with one's own senses not filtered by what others have reported to one or what the author of any document has seen. This was something that the authors also perceived as seeing the activities live increased the understanding for the DC operations. The observation was conducted thorough a virtual tour by the production system coach at one of the case company's SDCs.

During an observation, the observer can be participatory or non-participant and known or unknown (Patel and Davidson, 2011). During the observation, it was not possible to act as a participating observer since the tasks performed in the DC are of a physical nature and the tour was held remotely via Microsoft Teams. However, as the main purpose was to see and understand the processes in the DC as well as gain an understanding for where waste is created this was not seen as a limitation. Before the observation was carried out, it was made clear to those being observed that the observation was going to be recorded. The advantage of recording the observation is that it can be seen by the researcher several times, which enhances the accuracy of the interpretation of what was observed (Olsson and Sörensen, 2007). In addition to the observation that was conducted, the researchers also received pictures of different parts of DC operations, especially how the goods are packed on various sites in order for the researchers to gain a better overall picture of whether the process looks the same at the different sites.

3.3.3 Benchmarking

Benchmarking has been an established quality tool since the late 1980's and is used for creating operating goals and productivity initiatives based on best-industry practices (Camp, 1992). Benchmarking is also described as a strategic management technique that includes comparing a firm's performance against best-performers in the same industry (Shetty, 1993). One commonly used definition provided by Camp (1992) is benchmarking as a continuous process of measuring something, such as a product, service or practice, against the company's toughest competitor or those renowned as industry leaders. More recent benchmarking literature includes expanding and applying the tool to *strategies* and *systems*, hence not only including the process and activity oriented usage (Yasin, 2002).

This study utilised Camp´s benchmarking process. Camp (1992) focuses on the importance of knowing your operation and its strengths and weaknesses, know the

industry leaders and competitors and learn from the best and gain superior advantage. It is also possible to benchmark against a whole industry, an organisation or another internal function. In this study it will solely be a benchmarking against other companies. Camp (1992) breaks the benchmarking process down further in his 10 step framework for benchmarking of which this study will apply a simplified version of, see figure 3.2. The steps are as follows, (1) identifying what is to be benchmarked and (2) identify comparative companies was included in the planning phase for this study. The benchmarking factors and comparative companies were decided together with AutoCo. The benchmarking factors are waste targets, waste measurements and actions to prevent waste. The comparative companies were chosen as companies that have some type of DC operations. This was possible to fulfill and it was more easy than expected to get an interview with the contacted companies. Therefore, the sample of companies included in the benchmarking consisted of both companies with a mature level of sustainable DC operations as well as companies with similar preconditions and service market as AutoCo.

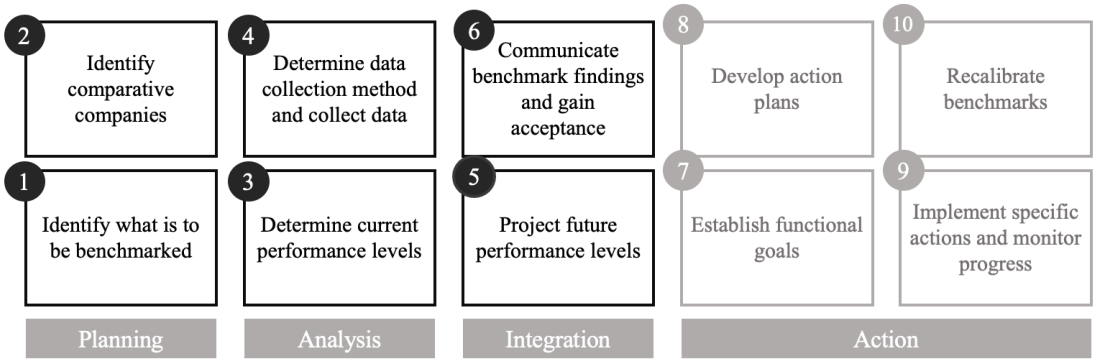

Figure 3.2: Camp's 10 step Benchmarking Process

In the second phase, which Camp calls the analysis phase, the steps of (3) determine current performance levels and (4) determine the data collection method were executed. To determine the current performance levels the preexisting data from each DC was used in order to not expand the scope of the study. As mentioned, it was possible to get interviews with multiple companies. Therefore, in addition to collecting public information from databases and annual sustainability reports, interviews with representatives from the benchmarking companies were also conducted. This study proceeds until (5) project future performance levels and (6) to communicate findings. These two final steps are part of the discussion and conclusion of the study where future feasible performance levels are projected as well as the main findings will be communicated.

When reaching out to the benchmarking companies the contact person from their respective sustainability reports were emailed. In the email the project was introduced as well as the fact that it is done in collaboration with AutoCo. After describing the scope it was asked if the person responsible for sustainability in the DC operations could be interviewed and topic questions were included to provide further

understanding of what the interview would revolve around. These topic questions were *How do you measure waste? What has been done in order to prevent waste?*, and if applicable, *How is scrap managed?*. The outcome of these emails was a high response rate where only two companies responded that they did not have the availability to participate and one company found itself too different to be a good subject for benchmarking. One of the companies that did not have the availability was Nike, but due to their excellence in sustainable DC operations they were included without being interviewed. Instead, their detailed sustainability reports were reviewed and the online material was sufficient to include them in the benchmarking. In the end, there were six companies included in the final set of benchmarking companies, see Table 3.5.

Company	Interview	Position of Interviewee
IKEA	Yes	Packaging Development Leader
HP Inc	Yes	Prev. Director of Environment
Husqvarna	Yes	Director Development Projects
Access Solutions*	Yes	Director Global Innovation Management & Director of Sustainability
ICA Group	Yes	Sustainability Coach & Packaging and Traceability Responsible
Nike	No	-

Table 3.5: Summary of companies reviewed as part of benchmarking
**Access Solutions is an alias for a company that chose to be anonymous.*

IKEA are famous for their sustainability work and was the first company contacted. They quickly provided contact details for the Packaging Development Leader. As expected, the interview resulted in answers to the questions and good examples of potential ways to reduce waste from packaging. The HP contact was provided from AutoCo as they had had previous collaboration. The previous interaction has revolved around an overall exchange of sustainability ideas. The benchmarking provided more information of external CSR, meaning projects not immediately connected to HP's core business, as for example funding plastic recycling projects in the Caribbean. The main ideas were not specifically around distribution but gave more insight into how to create circularity of material and parts. Husqvarna and Access Solutions were interviewed in order to make a comparison with companies with similar operations and industrial products, also managing spare parts. The last benchmarking interview was held with the Swedish retailer and wholesaler ICA. That interview was held with both a sustainability coach and a packaging responsible manager which provided insights into very complex and well developed logistics operations.

3.3.4 Literature Study

A literature study was made, both in the initial phase and also later on in the research phase. In the initial phase the focus was to gather information about the

research topic to gain a basic understanding of the research field and the issues related to it. This is in line with research presented by Creswell (2009) who states that that the literature study informs the researcher about other studies and their results related to the current research topic. In the initial stage literature from primarily Chalmers Library and Google Scholar was used together with scientific reports. Keywords in this phase included aftermarket services, triple bottom line, waste management, energy consumption, warehouse operations and greenwashing.

In the following phase, more in-depth literature searches were made based on the material that had been collected so far through interviews and guided tours. For this part of the report some of the main goals were similar to the ones presented by Creswell (2009), namely to create a framework for the study, relate the study to the current literature on the topic as well as establishing why the study is important within its field.

3.4 Research Quality

To ensure the quality of the study, several aspects were taken into consideration. For qualitative research, Bryman and Bell (2013) have suggested to assess the aspects of reliability and validity into the research in order to ensure a sound result.

3.4.1 Reliability and Validity

Reliability can be said to be the degree of which the result from a calculation or measurement can be considered accurate. Validity refers to whether the measure of the study is measuring what is intended to be studied. Both concepts can be divided into external and internal aspects.

Reliability can according to Bryman and Bell (2013) be divided into external reliability and internal reliability. External reliability deals with the degree to which a study can be replicated while internal reliability deals with the extent to which the researchers agree about what they have heard or seen if there are more than two researchers performing the study (Bryman and Bell, 2013).

Similar to when conducting any other kind of data gathering, reliability of respondents cannot be guaranteed (Bryman and Bell, 2013). Considering the issue of greenwashing, discussed in section 2.1, this must be taken into consideration when reviewing the information other actors present about themselves and their work with sustainability. To ensure the reliability of the interviews, both researchers were present and after each interview a reconciliation was made to verify that the topics discussed had been perceived in the same way. Cross-checking in this way is one of the methods used to ensure reliability presented by Creswell (2009). The interviews during the planning phase were not transcribed nor recorded as the purpose was mainly to get an understanding for the DCs and the operations performed. During

the research phase the interviews were recorded and transcribed in order to capture all details and ensure that the information was correct. The material selected to be included in the report was sent to the interviewees for their consent that everything included was correct.

When reaching out to interviewees the idea was to contact people with the same type of position at each DC, preferably the general manager. This was not always possible and in a few interviews the administrator of the DC was interviewed instead. It was also discovered that depending on the size of the DC the general manager was to a different degree involved in the daily operations. The smaller the DC, the more insight the general manager had in the operations. This may have impacted the reliability as the people interviewed had different types of involvement in the daily operations and therefore provided different levels of details. This issue also occurred when reaching out to benchmarking companies as they choose who to forward the interview request to. The interviewees in the benchmarking therefore had an even greater variety of positions. This was taken into account in the analysis of the results from the benchmarking where ideas and inspiration on ways of working with waste management were taken and compared based on the interviews whereas the actual targets were compared using the data from annual reports. The interviewed people held different positions and the interviews were semi- structured. This made the interviews somewhat steered towards what the interviewed person worked with and found interesting to discuss. This had to be considered in the analysis phase when comparing the interviews and trying to make generalisable conclusions.

Validity is the aspect of whether the concept under investigation truly is measured by the chosen indicators (Bryman and Bell, 2013). Validation can be divided into several different aspects, two of which are internal and external validity. Internal validity is about how well the study agrees with reality, i.e. whether or not there is a good match between the theories that are developed and the researcher's observations (Bryman and Bell, 2013). The external validity is about the degree of generalisability and whether the results can be applied on other contexts than the particular setting of the conducted study. External validity is particularly an issue for qualitative researchers who tends to take on case studies with small samples (Bryman and Bell, 2013). This will be further discussed in section 3.4.3.

Two validity strategies that were used for the study was triangulation and member checking which are two of the most frequently used methods for validation (Creswell, 2009). Triangulation means using different methods for data gathering to both verify that the information is correct and to identify various perspectives of the research subject. When the interviews were conducted further on in the study, member checking was also used, i.e. the information obtained during the interviews was sent back to the respondents. This means that the respondents were able to verify that the information provided during the interview had been correctly interpreted and that they felt that the information presented was accurate (Creswell, 2009).

In terms of data gathering and to answer the first research question, what waste is

managed at the DCs, the DCs were asked to submit their waste data for the past three years. These were all measured in kilos. This can be problematic in terms of validity as metal compared to cardboard paper is much heavier and makes the data skewed. Waste does not necessarily have to be problematic because it is heavy, but could be difficult to handle if there are large volumes or if it is hard to find a waste contractor that wants to take care of it. In order to cope with this problem, additional questions were added to the interviews. The DC employees that were interviewed were asked what was the most problematic waste to manage and why. Sometimes the answer was waste which was problematic due to its volume, at other times the waste which was considered the most difficult to dispose.

3.4.2 Ethics

In order to assure a professional research study, ethical issues need to be addressed (Bryman and Bell, 2013). According to Bryman and Bell (2013) there are four aspects that need to be considered when conducting research: harm of participants, consent, deception and privacy.

Harm of participants is also referred to as beneficence. It essentially means that the research should take any potential risk for harm into account before conducting it. Harm includes both physical, psychological, emotional and legal harm and the basic rule for this criterion is that the benefits of the research must outweigh the potential harm of it (Waller, Farquharson, and Dempsy, 2015). For this study only the last three mentioned criteria were relevant as no physical contact or participants outside of their comfort zone were interviewed.

Lack of informed consent is when uninformed observations are made or presented with a false motive (Bryman and Bell, 2013). In order to avoid reactivity of participants under observation, some kind of covert research might be necessary. This study was conducted with a genuine presentation of what the purpose of the interviews and observations was and there was no risk of reactivity changing the participants' answers. Lack of informed consent is closely related to what Waller, Farquharson, and Dempsy (2015) refer to as respect which means providing the research participants with enough information about the research project that they are able to do an informed choice of whether or not they wish to participate in the research. In other words this means respecting the dignity, right and self-determination of others. This is also similar to the third aspect Bryman and Bell (2013) presents which is deception. This means a researcher shall not present a study as something else than what it truly is. This study, as mentioned had no need of covering the motive and was rather a collaboration with the participants. For the interviews conducted as part of the benchmarking it was clear both in the initial email to the companies as well as during the interviews that the study is done with and for AutoCo.

Invasion of privacy and lack of integrity is when human integrity and values are not considered. This must be avoided, one case being respecting confidentiality and anonymity when agreed or seen as necessary (Bryman and Bell, 2013; Waller,

Farquharson, and Dempsy, 2015). Therefore, the researcher must be fair, honest and respectful when performing the study but also when reporting the result of it (Waller, Farquharson, and Dempsy, 2015). In this report, confidentiality at a company level is adhered to but as no personal data is processed there will be no real need of anonymity of participants. Since their personal details is not relevant for the study only work titles are presented.

3.4.3 Relevance

Relevance and external validity means to what extent the study is generalisable in a greater context. This study is based on one case company's setting which gives the results some limitations. However, by incorporating the benchmarking additional perspectives are considered. Through the benchmarking, questions and issues were tested on the interviewed representatives in order to understand if the issues that AutoCo has are generalisable in a greater context. Due to the spread of industries among the benchmarking companies it can be stated that some of the issues could be seen as general across industries while others where confirmed as only relevant for the automotive service market. The conclusions of the study will have the same spread, with some of the actions generalisable for all companies operating distribution centres and some actions solely applicable for companies within the automotive industry.

4
Results

In this chapter the empirical findings derived from the planning and research phase will be presented. First, the identified central functions that have an effect on the DC operations will be presented. This will be followed by the results obtained from the data collection and interviews with all European DCs. Finally, the results from the benchmarking are presented.

4.1 AutoCo Departments

In this section the different departments within AutoCo that have an effect on the sustainability within the distribution chain will be described. The information is extracted from both exploratory interviews in the planning phase as well as the complementary interviews during the research phase.

4.1.1 Service Market Logistics

The Service Market Logistics (SML) department are mainly responsible for the provision of AutoCo's spare parts. The department is divided into regional functions and two overarching functions. These two functions are Operations Excellence and Supply Chain Optimisation. It is within Operations Excellence the central control of the flow from CDC to SDC to dealers lies. Environment and Quality within Operations Excellence is the main responsible function for tracking sustainability performance in the DCs. SML have defined their own sustainability targets derived from AutoCo's overall sustainability target. These targets lies within three areas; use of materials and creation of waste, use of energy and CO_2 emissions from freight transports. So far a lot of focus has been put on transportation and energy. The overall targets within these areas are CO_2 neutrality, zero waste to landfill and 100% recycling. The results from the waste reporting that is done show that the DCs are getting closer to the targets and that more waste is recycled, but the results also show that the total amount of waste is increasing. Besides the internal reporting run by SML there are national reporting requirements in many countries where the amount of waste to the market, meaning excess material ending up at the dealers', must be measured. Besides tracking the recycled amount of each DC, initiatives for circular economy is tracked to a limited extent. There are directives for the DCs to follow, one being to try to apply the waste hierarchy model and strive for "Reduce, Reuse and Recycle" within the DCs.

4.1.2 Dealer Inventory Management

Dealer Inventory Management, DIM, is a department positioned under Supply Chain Optimisation. The main purpose of the DIM department is to optimise the inventory levels at both DCs and dealers. One part of AutoCo's service offering to its dealers is to take full responsibility of the replenishment process of parts. At the moment AutoCo is responsible for the replenishment process for over 3000 of its dealers globally. From AutoCo's perspective this is done in order to ensure that appropriate stock levels are being held at the dealers to guarantee a high service level through an internally developed replenishment system.

The system entails that AutoCo's inventory planning department decides if a product should be ordered, when it should be ordered and how many pieces of the items that should be ordered. Whether the product should be ordered or not is calculated from a picks table consisting of the parameters price and frequency of picks for a specific part. When and how many parts that should be ordered is based on a stock level table derived from the parameters price and order point, i.e. it is the number of stocked parts that triggers the system to order more. For parts that are sold more seldom a fixed order point is set while for more frequently sold items a safety stock level is set based on lead time. The picks table and stock level table are set differently by brand and by region and country.

The system is partly automatic and partly manual as the system is designed to evaluate what the dealer needs to have in stock based on its consumption. That means that when a dealer is about to run out of a fast moving item the system will automatically order more. More rare items need to be ordered automatically since they are too expensive to have lying on a shelf. In order for the system to work the dealer commits to buy genuine AutoCo parts and provide AutoCo with current stock levels and sales data, so that customer demands generates what is ordered from central or regional warehouses. By doing this the dealer warehouses are refilled with corrects parts, at the right time and in the correct quantity. In return, AutoCo commits to ensure better parts availability, a healthy stock and time savings for the dealers due to increased automation of the ordering process. The performance attributes of the system include customer satisfaction, capital tided up and efficiency of the ordering process.

AutoCo also have the obligation to carry out initial stock cleansing and regular buybacks in order to maintain a satisfactory inventory turnover rate at the dealers' warehouses. Whether the parts are to be taken back is a complex decision made with multiple rules and systems. When there is a decision that something shall be taken back from dealers it results in a so called take-back initiated by AutoCo which means that the part are to be relocated or scrapped. The term dead stock is sometimes used here, which means that a specific part is considered to be dead if it has not been sold for 12 months. AutoCo can then decide whether the part should be put back on the shelf to later be relocated to another dealer that has demand for it or if the part should be scrapped. If the part is to be scrapped AutoCo decides if they want to scrap it at the DC or let the dealer scrap it on site. Currently the

department is working on some improvements to the system, which includes using machine learning in order to optimise dealer refill by not pushing parts to the dealers. This means that parts that is predicted to become dead stock never will be send out to the dealers.

Another source of scrap is returns from the dealers, which has a similar process as the take-back decisions taken by AutoCo. Returns from dealers originate either from parts that were ordered incorrectly or that are faulty. It is up to the manager of the DC that sent out the product to then decide if they want it back or if the dealer should scrap it on site. If the part is taken back and defined to not be of value anymore it will be scraped. The decision to scrap products takes into account the financial transactions that have been done during the life span of the part. No environmental factors are considered neither in the decision of inventory placement or when scrapping. Both the return process and the take-back process generates waste both in terms of packaging material and scrap parts.

The department has started looking at if scrap parts can be taken back to be re-manufactured. By doing this AutoCo can take advantage of the material that is already used in existing products instead of extracting new material, which is one of the processes that contributes a lot to the environmental impact. However, this is currently only done for a very small portion of the assortment which is mainly heavy and complex parts such as engines. One example is one type of engine that is taken back and re-manufactured to 90%, the final 10% that is left leaves flexibility to finalise the product into up to 8 different articles. This enables central storing in the distribution network and late customisation once the demand occurs. Currently this is solely done with high value, complex parts and products. If the product is not complex, there will be no opportunity for late customisation in the same way.

Currently DIM is performing an overall end-to-end project in order to enhance the forecasting and movement of spare parts. The result of the project will be a new IT platform that optimises the dealer inventory processes. Even if it is not the target of the project, it will have an effect on scrap orders and products as the overall system will be optimised. The project will also enable a better overview of current decision models and enable further refinements on how decisions are being taken in terms of inventory and location. This means aspects such as CO_2 emissions and scrap costs can be further developed.

Overall the challenges of serving a market where some sold products are very old makes the inventory management even more complex. AutoCo has supplier contracts where they want to have guaranteed delivery over a long period of time. This is becoming more and more challenging as technology advances. The more technically complex the parts become and as the amount of electrical components increases, the more niched the suppliers become which results in a decreased supplier base. This makes it harder to replace suppliers and ensure parts availability over a longer period of time. This means it becomes difficult to change the supplier of a part during the lifespan of the products as there might not be as many suppliers.

Additionally, the increased customisation, which is part of AutoCo's value proposition, drives the number of articles that needs to be managed.

4.1.3 Commercial Packaging

Commercial packaging is considered an extension of the product and has the purpose to both protect and market the product. The department with the same name, Commercial Packaging, is the department at AutoCo that defines which packaging the spare parts are in need of. The decision takes quality as well as cost and to some extent also environmental impact into consideration. To fulfill the different parameters continuous dialogues are held with both suppliers and the purchasing department. The commercial packaging department reviews the packaging decisions as a team in order to ensure that the right packaging decision is taken. The department objective is that as little packaging material as possible is used to the lowest price possible. Additional aspects such as shelf-life length is also considered. The decision is complex but quality is the most important parameter as it is crucial to ensure that the parts arrives in good condition to the dealers. The decision to whether or not to use a commercial packaging is taken mainly based on the product characteristics. This could be that it needs protection due to for example being fragile or risk for rust. Commercial packaging is not required to hold for transportation but should always have a transport packaging as well.

Previously the focus was more on the cost side but now the department also measures its CO_2 emissions through an internally developed tool in order to be able to compare different packaging options. The most common commercial packaging material includes wooden crates which are usually used as one-way packaging, blue branded cardboard boxes, brown cardboard boxes, plastic bags and rust protection bags.

The commercial packaging department has a database with all parts that SML provides its DCs and dealers with. For the commercial packaging the department has mainly four different suppliers of packaging material, so called preferred packaging suppliers. These are useful for high volume products. If they would not have a suitable packaging or if the volumes are too small the department will source new packaging from the suppliers for that specific part. Other demands on the packaging material apart from keeping high quality, being cost effective and having as low environmental impact as possible, is that it has to be a neutral packaging, so called brown box, or one containing the logo of AutoCo. Within these restriction, commercial packaging are working towards reducing the amount of packaging material while also reducing the environmental impact from it. During internal pre-studies it has been identified that an unnecessary large amount of packaging material ends up at the dealer.

The department works to pursue the environmental goals set for the company as a whole but also has an unspoken internal goal of reducing the amount of plastic

used for commercial packaging. Commercial Packaging has also worked a lot to try to harmonise the packaging for similar products, which means that it should be one packaging decision for all similar parts. The department has started this work by implementing it for similar parts from the same supplier. To pursue the environmental goals the commercial packaging department have taken initiatives to guide suppliers to use materials that are not harmful to the environment. For example, previously wood crates were more frequently used for certain parts, especially heavy ones, but now the department are working on replacing these with cartons of corrugated cardboard as these have become better and stronger. An ongoing pilot project is to see whether or not cardboard boxes for large products, such as door panels, can be replaced with jiffy bags that are completely degradable. This will reduce the amount of packaging material and also has the benefit of less air being shipped between the sites. Lastly the department is also looking into how they can limit the use of staples to close the boxes as this makes them more difficult and time consuming to recycle.

4.1.4 Transport Packaging

There is a difference between commercial and transport packaging. Transport packaging is solely used in the transport in order to protect the part while commercial packaging is seen as an extension of the actual product. Wooden crates can be used for heavier products. These products are usually packed in the wooden crate the whole way throughout the distribution chain. In those special cases the wooden crate is considered both a commercial packaging and transport packaging. AutoCo has a returnable packaging pool which is part of the transport packaging solution. Unlike commercial packaging, the transport packaging does not have a dedicated department. Instead this responsibility falls on each DC to decide how they pack the outbound goods.

The packaging pool consists of return packaging boxes that are used for all type of flows, both from DCs to dealers and in between DCs. When dealers are ready to send back the packaging they disassemble the packaging pool material and register it as ready for pick up. Approximately 60% of the sales are shipped in pool packaging but when looking at total shipped packages a minor part is pool packaging compared to consumable packaging, i.e cardboard. This is due to the fact that the pool packaging are large in volume and is only registered as one parcel. The smaller orders all go by consumable packaging. The pool packaging is not without cost so there is constantly work being done to prevent packaging getting lost and not returned. The replacement cost for pool packaging can add up to a substantial number over the year. If the packaging is kept within the system it can hold for over 20 years. Currently environmental factors are mostly considered in the development phase when business cases are presented but no environmental measure is incorporated in the tracking of the daily operations. Transport packaging is an area that has historically not received a lot of focus at AutoCo. Instead it has been up to each supplier and DC to send the goods in a way that they believe is convenient

for them and most suitable for the part.

AutoCo has recently created a project team aiming at investigating the use of transport packaging in the first step of the supply chain at SML, the one between suppliers and CDC. Here, the main focus is to see whether the goods can be packed properly at the supplier in order to reduce the amount of repacking needed at the CDC, i.e. to see whether the transport packaging from the supplier can be used in the next step of the supply chain. The initiative was pilot tested on approximately 300 new parts and the project has now moved on to also include selected products of higher volumes. The task for the project team is to write transport packaging instructions to the suppliers. Here one of the suggestions that are investigated are if the internal packaging material from the packaging pool can be used already from the supplier. However, this would not currently be possible due to shortages of volumes of boxes from the packaging pool.

4.2 Waste Contractor Stena Recycling

A waste contractor is an actor that offers recycling solutions and collects all the conceivable residual material that arises from both operations and production. After collection, the material is refined through sorting and processing and can thereafter be used as raw materials for new products. In this way, recycling can become a sustainable business for companies while maximising the reuse of the earth's finite resources. In the case material cannot be recycled it can be burned and used for creating new energy.

One of these waste contractors are Stena Recycling who are utilised by SDC Sweden. The company has been in the business for over 75 years with the goal to optimise their customers waste management (Stena Recycling, 2021). Stena Recycling gathers all types of waste, for example paper, cardboard, plastic, metal, wood, electronics and mixed waste. Depending on the type of waste, it is taken care of in different ways as the materials have different properties. Metal, paper and cardboard for example can be recycled into new materials and sold to steel mills or paper mills respectively, whereas wood for example are energy recycled.

Depending on the material, the products can be recycled several times. Metal is durable and can be melted down and recasted unlimited amount of times. Cardboard and plastic have a more limited number of times it can be recycled as the quality of the fibres in the material eventually become so poor that they cannot be used again. Plastic can be recycled and become new products approximately five times. The corresponding value for cardboard is roughly seven to ten times. Wood is not recycled, but is rather reused in its original condition through reselling it to actors who are in need of, for example, wooden pallets and otherwise the wood is energy recycled.

In order to be able to recycle the waste, Stena Recycling mentions that it is impor-

tant with as clean waste flows as possible. This means that all types of material goes into separate bins, for example, parts cannot be glued together or contain various materials. Therefore, in order to be able to recycle the material in a proper way, it needs to be sorted. This is preferably done at the company generating the waste, otherwise some other party in the distribution chain has to do it to make the waste recyclable. Many workplaces in the industry are old and not built to facilitate sorting bins and the surface where the bins stand also costs money which could have been used for other purposes within the organisation. Sorting the waste is also usually outside of the work description of employees and means that it takes time from their main tasks.These are general observations and are not solely applicable to AutoCo.

For some materials there are technologies that makes it very easy to separate the waste while for e.g. plastic there are no good sorting machines and most of the sorting is done by hand. Plastic is perceived to be the most complicated waste to handle at the moment due to the fact that different kinds of plastic cannot be merged and it is of outermost weight that the plastic in each bin are of the same type and colour and does not contain staples or similar. In order to be able to recycle plastic it follows a rule called the 98/2 rule meaning that 98 % of the plastic needs to be clean while the other two percentages may contain labels or being contaminated in some other way. Plastic is also difficult to handle as there are limited volumes of it. Many companies are requesting recycled plastic but in order for it to be available the plastic also needs to reach the waste contractor. In general a lot of the plastic that Stena Recycling receive come through the combustible waste as it has been sorted incorrectly. Larger volumes of each plastic would make it both easier and more profitable to handle. According to the interview all plastic if sorted properly are recyclable, it is just a matter of the price.

According to Stena Recycling it would be beneficial to try to coordinate the waste flows from different actors in order to achieve larger volumes. If the volumes are not large enough, for plastic in particular, they are normally sent to other countries which have better technology to handle it. This results in long transports that are costly which makes it more profitable for the companies generating the waste to put it in combustible waste.

Stena Recycling perceives that there is an increased awareness and that many companies want to become better at waste management. One way that the contractor guides its customer, in this case AutoCo, is by performing pick analyses. This means that the waste contractor provides feedback to the customer company of what can be improved to facilitate recycling. Here it has been identified that there are opportunities for improvement regarding sorting, especially for plastic. However, the Stena recycling is also aware of that this is not easy to implement and improving the sorting process can be difficult as it is hard to distinguish between different kinds of plastic. Just a couple of errors can destroy the value of the additional efforts that are being made to sort it. One key action that Stena Recycling have identified for AutoCo to cope with this issue is to reduce the number of plastic variants. This is

however not something that AutoCo can change on their own, it requires cooperation with other actors, for example its suppliers in order to ensure that they receive the requested type of plastic.

4.3 DC Waste Management

In this section, key findings derived from the data collection and interviews with representatives from each DC is presented. The first part, gathering of waste data, refers to the collection of pre-sampled data by the DCs that is not reported to any central function within AutoCo but only kept locally at the DC. The data was to the majority recorded by the waste contractor used by that DC. After the waste data collection each DCs operations will be presented which is based on the interviews conducted with each DC. Figure 4.1 shows a summary of the data collected from each DC.

DC	Size	Fractions	Filling material	Dealers	Largest waste stream
CDC Belgium	Large	23	Mixed	500+	*Scrap/Packaging
CDC France	Large	8	Mixed	500+	Metal
SDC Italy	Medium	6	Reuse or plastic	**500	General waste
SDC Sweden	Medium	8	Reuse	-	Metal
SDC UK	Medium	7	None	120	Cardboard
SDC Spain	Medium	7	None or reuse	**300	Wood
SDC Finland	Small	6	Reuse	40	Cardboard
SDC Poland	Small	8	Shredded reuse	-	Metal
SDC Romania	Small	4	Shredded reuse	17	Metal
SDC Austria	Small	7	New material	79	Mixed waste

Table 4.1: Summary of Results from DC Interviews and Data Gathering
** CDC Belgium's data displays scrap as largest waste driver, but in interviewed it is packaging that is percieved as main driver.*
*** DC with boating spare parts that has many small service centres as part of dealer totals*

4.3.1 DC Waste Reporting

Based on the existing waste data collected by the DCs it can be seen that one CDC categorises its waste into 23 different fractions. For the other CDC and the SDCs the waste is categorised into between 4 and 13 categories. The four categories that all the SDCs have in common was plastic, general waste, metal and cardboard. In addition to these four categories common waste categories is wood and glass. For some of the SDCs, waste categories are broken down even further. For example, instead of having a general category called cardboard the DC is dividing the waste into

office paper and cardboard, thereby creating two waste categories instead of one. In general, waste is reported for all categories on a monthly basis. One common exception is metal, which for smaller SDCs only is emptied and reported once full, which can be up to two to three years between. In addition to data regarding waste fractions, the number of shipped order lines out from the DC was also obtained. In general there has been a decrease in shipped order lines for the given time period of 2018-2020.

The largest waste fractions varies between the DCs. For the majority of them, metal or cardboard is the largest waste fraction but since each DC define their own fractions it is difficult to compare. One thing that is unique is that one DC, SDC Spain, reported that wood was the largest, but reported in the interview that it was plastic that is the most difficult to recycle. Both these answers differed from the other DCs.

4.3.2 DC Operations

Related to the inbound flow, the SDCs operate quite similarly where goods are unpacked, sorted, and put on the shelf. The packaging material revived are to a varying extent sorted out to be able to use it for outbound shipments. Each DC decide how to pack their outbound goods and this generates operational differences across DCs. The two biggest differences that were identified across the DCs was whether or not the DC chose to consolidate orders and if filling material was used.

Two of the DCs, SDC UK and SDC Italy, mentioned that they try to consolidate orders whenever possible as this reduces the use of packaging material to the dealer as the parts are packed in the same box instead of that multiple parcels will be shipped to the same dealer. Some DCs considered that consolidation was not a good solution from an efficiency point of view and have therefore decided to operate a one-piece-flow.

Filling material is material added inside the box to prevent the parts from moving around. The most of the SDCs try to reuse old boxes and old filling material (up to what extent was estimated by the interviewed person and if told, is mentioned in the below sections of each DC). One DC uses a shredding machine were old boxes are made into shreds. Another DC had tried this but found that it made too much dust on the products. One DC uses new material, which means buying rolls of a special paper where the machine crease the paper to take up space inside the box and prevent the part from moving around. Another DC uses no filling material and claimed this had not made any difference to the quality of delivered products. A fifth method is to use air filled plastic which is very thin and recyclable as well as very light. The one SDC that uses this is claiming the environmental effects are the same as other materials due to the weight of the material. The CDCs sends deliveries to the SDCs, if the SDCs want to reuse material it is based on what the CDCs has sent. For full overview of how the DCs relate to each other see figure 4.1.

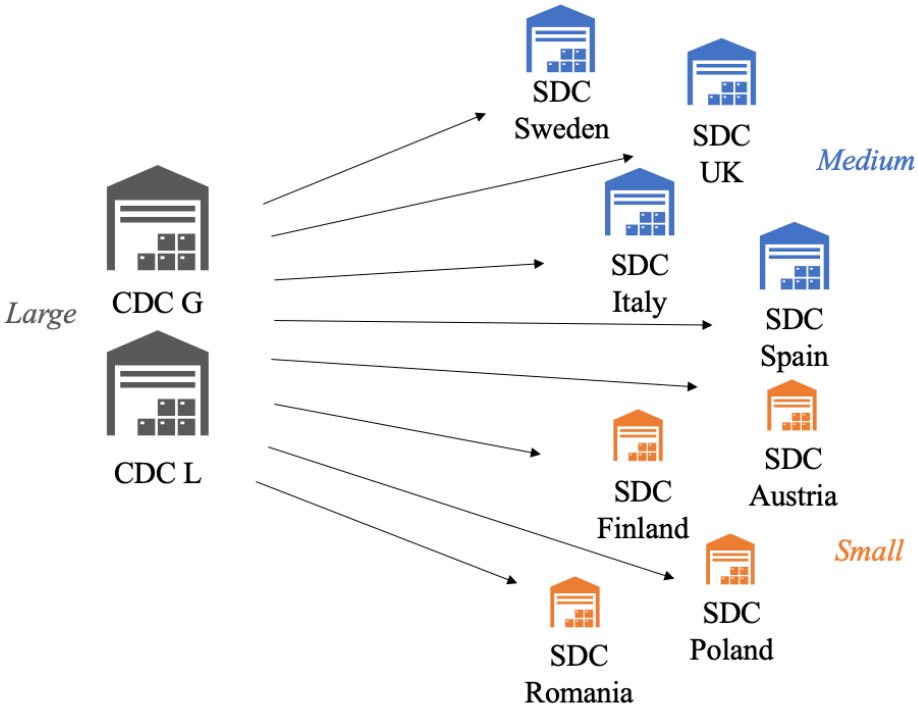

Figure 4.1: A simplified map of how the different DCs in Europe relate to each other

CDC Belgium

This CDC is the largest DC in Europe and has more shipped order lines than all DCs in Europe combined. This is because it is the largest corporate DC and ships parts to both CDCs, RDCs and SDCs globally. When shipping the goods, the aim is to analyse and optimise the transport packaging used for the shipments in order to reduce costs in both consumable packaging, such as cardboard, and the internal packaging pool. The packaging process is what decides the number of packages per order. In the DC, which is handling massive quantities, the packaging process is performed in full for each area, which means each team both pick, process and ship the order from their specified picking area. This process is called one-piece-flow. The teams are based on the district, order class and type of parts they manage. The layout of the DC is based on the size of the parts. Small parts like nuts and bolts are kept in one area whereas larger and bulkier parts are kept in another. Order class, which is the same for both CDCs, ranges from VOR which is shipped immediately, 1 which means it is a day order and shipped the same day, 2 is refill to SDCs and RDCs and 3 which is stock orders that goes straight to dealers. This means that if one order contains two parts, one lighter and one heavy, they will be shipped as two separate packages. The packaging process is the same for both shipments to dealers and other DCs, it all depends on the district or order type. In the later part of the packaging process the team checks whether the recipient is registered in the packag-

ing pool or if the order should be shipped with any other type of transport packaging.

CDC Belgium is considered to be the one that has come the furthest of AutoCo's DCs in its environmental work and is often seen as a role model for the other DCs. The reason behind their good performance is both the strict local regulations as well as the extensive internal work done. This internal work revolving around waste management includes as example efforts to increase employee awareness, training and pedagogical tools such as coloured waste bins. The CDC has a well organised waste management system as well as environmental reporting. One of the main reasons for the extensive waste reporting from this CDC is the local regulations. One regulation they need to comply with is that sending waste to landfill is not allowed in Europe and therefore waste needs to either be reused, recycled or treated by a waste contractor.

It is stated that the main driver of waste within CDC Belgium is packaging material as it is part of all activities performed at the CDC. This includes unwrapping deliveries from suppliers, packaging when sending out goods from the DC as well as in the parts' end-of-life when the part is to be scrapped and the commercial packaging has to be recycled. In order to ensure that the waste is being recycled it is important to sort the goods properly as unsorted waste risks ending up in incineration and in worst case landfill. Therefore several actions have been taken to ensure proper recycling of the waste including a program called "proud to recycle" initiated by CDC Belgium. Through this program the DC has managed to become better at recycling through visualisation by clearly marking the bins with what waste that are allowed and not allowed to go into them as well as providing the employees with awareness training. It also included training where the employees are informed what happens with the waste if they do not sort it in the correct way. Having knowledge about the full picture of sorting has been identified as a key action to improved recycling accuracy. The waste bins in the DC are collected by their local waste contractor which are also the ones registering all the information regarding waste into their waste reporting system.

CDC France

CDC France is the second CDC located in Europe. It has approximately 500 employees and delivers goods to both RDCs, SDCs and more than 500 dealers. The DC is heavily involved with all parts of the packaging process, from developing commercial packaging to pre-packing the parts from supplier. Employees at the warehouse are divided into different teams; one is responsible for the outbound packaging, one team is responsible for all projects related to metal parts, one is responsible for the commercial packaging and one team is responsible for the pre-packing of the products. Some parts arrive pre-packed from the supplier and in other cases the pre-packing is done at the CDC. It has been estimated that 60 % of the parts delivered by AutoCo's suppliers are repacked in-house at the CDC. Sometimes the CDC also buys the pre-packing service from a subcontractor but they try to do as much as they can internally within the DC.

The CDC mainly supports two of AutoCo's brands. For one of the brands they use reusable packaging from AutoCo's packaging pool and for the other brand they have specific cardboard packaging based on internal company standards. The packaging has been developed into six different sizes ranging between 5 litres to 40 litres in volume. They also have other packaging for parts that do not fit in these boxes.

Extensive work with reducing the amount of waste has been done. Primarily the focus has been on reducing the number of boxes used. When placing the order, the CDC has a platform to regroup the order so what was previously sent in different packages are now being consolidated into one parcel. This has resulted in a decrease of used boxes of approximately 20 % for the larger parts. This initiative was taken as the CDC cannot affect the number of order placed but can affect the way they are picked and packed. A lot of effort has also been put into the reuse of packaging material. Today approximately 90 % of the outbound flow of cardboard can be reused through milk rounds both within the country's borders but also the rest of Europe. The CDC has also invested in a packaging machine that packs naked parts into boxes that are custom made for those specific parts, resulting in that the minimal amount of packaging material is used. In addition, the CDC has taken a decision to not use any filling material as they believe that if the right box is chosen at the packaging stage, no filling material is needed to ensure that the part is delivered in a good condition. The latest initiative that has been taken is to investigate whether the wood pallets that are being used within the operations can be replaced with cardboard pallets. This is done both out of cost and environmental reasons as cardboard is a 100 % recyclable but also due to the fact that the transportation is paid by weight and cardboard pallets has significantly less weight than the wooden pallets.

SDC Italy

This SDC is considered to be mid-sized with over 300'000 shipped order lines annually. The warehouse receives parts from CDCs and serves approximately 500 dealers with parts from all brands. As a difference to the other DCs the dealers for this warehouse mostly consist of direct delivery points to private owned stores and workshops and quite few ones owned by AutoCo. As the country the DC is located in is quite elongated SDC Italy has delivery points covering the entire distance from north to south and the country is characterised by a long coastline where the large focus on the maritime business drives a lot of the sales of parts.

The warehouse has documented its waste streams for several years and divides them into six different waste fractions; iron, paper, general waste, glass/aluminium, wood and plastics and the warehouse sorts all categories on site into different bins. Like most of the other SDCs the main driver of waste is considered to be packaging out of which the majority of the packaging material is cardboard. The packaging is derived both from the deliveries from the CDCs but also via the reverse logistics flow, returns, from the dealers. Cardboard is included in the paper category when

reporting, together with regular paper which is the result from a rather bureaucratic way of working. It is estimated that of what is sent to recycling in the paper category 30 % is paper and 70 % is cardboard.

For this SDC the most problematic waste to manage on site is considered to be scrap from metal parts as well as glass. This has mainly to do with the fact that the DC does not have the volumes to have a dedicated contractor taking care of the waste for these categories. Due to regulatory restrictions it is complicated to find contractors for these waste categories and it is also associated with a substantial amount of money when the waste are not within the standard categories. As the warehouse does not encounter these waste streams that often the SDC rather applies ad-hoc interventions to handle it. The complexity and the cost are the main reason for not scrapping parts at the SDC. The parts are instead in most cases sent back to the CDCs.

The SDC has taken several actions aiming at reducing the waste from operations. It reuses all the cardboard boxes, both from CDCs and dealer returns when they are in good condition. It has been estimated that approximately 98 % of the cardboard packaging that are received is reused, the rest is recycled. Also filling material from the CDC is reused whenever possible. When it is not possible to reuse filling material or if it is not enough amount available, this warehouse uses recyclable plastic that are filled with air to protect the parts. This decision was taken since plastic bags are significantly lighter than adding cardboard as packaging material which means that the DC will pay less for the transportation while still using a recyclable material.

SDC Sweden

This mid-sized SDC with an area of 18'000 sqm is the largest one of the SDCs in terms of number of shipped order lines. This SDC used to be a CDC but as a lot of the business was moved to current CDC Belgium, it turned into a SDC.

The DC categorises its waste into nine different categories called paper, plastic, glass, wood, corrugated cardboard, combustible, electronic waste, dangerous waste and household waste. All waste, apart from the household waste which is taken care of by the municipality, are handled by the SDCs assigned waste contractor, Stena Recycling. When the waste have been picked up by the waste contractor, each fraction is weighed and the SDC then receives a reimbursement based on how many kilos that have been recycled of valuable scrap. The compensation depends on the type of waste, but it is described as the cost of collecting and handling waste often takes each other out. In order to motivate the employees to sort well, notes with both compensation and what each bin may contain have been set up because good sorting is a prerequisite for being able to recycle it.

Within the plastic category there is a difference between for example plastic bands, plastic bags and shrink wrap as it is necessary to distinguish types of plastic in order to be able to recycle them. Regarding plastic bands, there are a few different ones,

some have a separate binge and some end up in combustible. It is mentioned that what is driving metal is parts that are no longer to be kept in stock, so called obsolete parts, or parts that have been damaged in some way. The main reason for wood waste is either one-way pallets or pallets that have become damaged. The majority of the cardboard waste is generated during the inbound operations. Each day the SDC receives a delivery from CDC Belgium. When the goods arrive from the CDC they are either packed in AutoCo's packaging pool material which is mainly a pallet with an associated pallet collar that can be adjusted to different heights or on a pallet if the part is too large to fit in a collar. Within the collar there is a wide mix between small and large parts. The larger parts are single packed and placed on the shelf in the condition as it arrives to the SDC, with box and plastic bands. The smaller parts are packed in small boxes, often containing several parts of each article.

The reason for why the goods are packed in this way is that it should be easier for the warehouse workers to separate the items and thus get a smoother unpacking process as well as safety reasons as the boxes protect the items from each other in the pallet. However, packing the items in these small boxes drives a lot of waste. It is mentioned that the majority of the boxes are too thin to be reused out to the dealer as they are not designed to handle multiple shipments. Some of them can be used for internal use but the majority are thrown in the bin for corrugated cardboard and go directly to recycling as they are perceived quite thin and made for a one-way flow. In addition to the boxes, the pallet may also include filling material to hold the goods in place during the transportation. The filling material consist of thin paper out of corrugated cardboard which end up in the binge for packaging material for reuse in outbound shipments.

When the goods are placed in the warehouse, they are placed in different zones depending on the brand and the size of the part. It is also from these different zones that the picking takes place. There are different types of orders ranging from urgent orders that need to be shipped immediately, so called VOR (vehicle of road) orders, to less urgent orders that need to be shipped the same or the next day. On average, 1.6 - 1.8 items are picked per order and therefore the SDC have chosen to apply something that is similar to a single piece flow. Parts that are picked in the same zone, going to the same dealer, are consolidated into one shipment while if parts are picked from different zones it will result in two shipments to the same dealer. In the SDC, larger products are kept and stored in the same box that it arrives in from the CDCs i.e. the part is not unpacked completely at the SDC. This box is later packed into another box in the outbound flow as the first one is not in acceptable condition for another shipment. This has sometimes led to complaints among the dealers as they perceive that they receive too much cardboard material.

Apart from the outbound flow the SDC also handles a return flow of parts that is also driving waste. It is estimated that approximately ten % of all the shipped order lines are returned to the DC which takes both time and generates waste in terms of packaging material. AutoCo has a goal of reducing this number as this flow is unwanted, among other things, from an environmental point of view. This is not

something SDC Sweden can affect as it is based on AutoCo's very generous return agreements with dealers.

When talking to the employees at SDC Sweden it is acknowledged that it would be beneficial to gain new perspectives of the operations as one eventually becomes blind for additional improvements that can be made. The employees were questioning whether there would be better options of filling material available than the one that is currently being used and whether it would be possible to implement a more durable box so that one box can be used for the entire flow from supplier to dealer. The representatives states that a more durable box would reduce both waste and handling time as the boxes currently used are too thin so if they would be used again the company would likely face quality issues, i.e. that the part will not arrive in good condition to the dealer. Another aspect that was raised was whether it somehow would be possible to reduce the number of one-way boxes within the AutoCo packaging pool. Previously, they had used returnable plastic boxes that the interviewees considered worked better and had a convenient return flow.

SDC UK

SDC UK is the second largest SDC in Europe and servs approximately 120 dealers. Half of the dealers are owned by AutoCo and half of them are privately owned. Apart from only working as a SDC, operating the regular service market logistics operations of AutoCo, this SDC is unique in its operations as it is also providing service market logistics operations for another brand in the local market. This local brand consist of non-branded truck and trailer parts and generates a significant amount of the order lines handled at the DC.

The SDC has eight different waste categories as per 2019. Prior to that the SDC categorised its waste into five main categories. The difference is that today there is a separate category for paper which was previously sorted as cardboard and the non-hazardous waste category has been extended into an additional two categories called food and dry mixed. Each category has dedicated bins for sorting. Non-hazardous waste, paper, Food and Dry mixed recycling is collected weekly by a local waste contractor. Wood, cardboard, metal and plastic are emptied once full, i.e. there is not a set pick up time. The main driver of waste are perceived to be packaging material from inbound orders, both from two of the CDCs but also from local suppliers. The packaging material for example consist of cardboard, shrink plastic, wood crates, pallets and strap bands.

Another driver of waste is scrap products. Four times a year the SDC receives scrap orders of products that are no longer to be kept in stock. These are not sent back to the CDC but are taken care of on site. The scrap products, is seen as the most problematic waste to handle, mostly due to the fact that the part needs to be disassembled and then sorted into the proper bin in order to be able to recycle it which can be rather time consuming.

Several actions has been taken at SDC UK in order to reduce the waste. This includes consolidation of goods when picking the orders, changed purchasing strategy or certain items like distilled water used for the forklifts and elimination of filling material for outgoing goods. Filling material has not been used for several years and it is stated that is has not resulted in any complaints regarding damaged goods. The actions also includes changes in kitchen supplies in order to reduce the amount of e.g. plastic cups. Some work are being done with reuse of packaging material and it is stated that cardboard boxes are reused when possible although it is currently on a limited scale.

SDC Spain

This SDC is medium sized with 13 employees, serving multiple brands and up to 400 dealers. The large number of dealers is because they are serving the boating brands which has multiple service points in addition to regular dealers which increases the number of total dealers. Similar to other DCs they have a contractor that takes care of all their waste.

The waste fractions at this DC is wood, cardboard and iron as well as plastic from scrap parts, the rest is sorted as general waste. Plastic from other sources than scrap parts therefore goes into general waste as it is percieved difficult to recycle. Besides being the most problematic waste within the DC, it is also identified as an issue since for example many parts are sent in plastic bags to the dealers. This DC gets its new cardboard packaging from a supplier which delivers it on pallets. The pallets are not always reusable and generates a relatively large portion of wood waste.

This SDC used to buy new material in the form of paper which they made filling material out of. As part of a cost reduction program this was removed with savings of €2000 per month and instead they invested in a machine that makes filling material out of existing boxes and cartons. This was ten years ago and during the most recent years they have discovered they can in most cases skip the filling material without any quality complaints from the dealers.

Other actions taken to reduce and reuse material, beside filling paper, has been to reuse incoming plastic material and cardboard boxes. The challenge is to reuse boxes that are contaminated or have labels that are incorrect. In order to prevent scrap they send back rotors, a special spare part, to the main CDC where it is either re-manufactured or scrapped. Parts can be sold as re-manufactured or new, where re-manufactured are cheaper.

SDC Finland

This SDC is classified as small, serving 40 dealers, of which the majority is owned by AutoCo. Common to other SDCs the biggest waste driver is perceived to be packaging. Even if as much as possible is reused, what is of poor quality is either put to recycling or used as protection material in packages. A shredding machine has been

considered and tested but it generated too much dust to be found feasible to have in the operations. The most problematic waste is scrap products which needs special treatment as it consists of multiple different type of materials. There are only six main waste fractions reported called cardboard, paper, office paper, organic waste, burnable waste and waste with energy recovery. Everything possible is incinerated with energy recovery. The contractor picks up the waste at a set schedule and not when full, making the numbers to be potentially overestimation as they are reported as if the containers were filled to max.

This DC has managed to make a drastic reduction of waste during the past ten years where the key action has been to reuse material in a more extensive way than what was previously done. Today an estimated 80-90% of the inbound consumable packaging material is reused for outbound transport packaging. When asked, the representative does think that a waste target would be good and possible but that waste reduction requires joint efforts from both DCs and central functions. Plastic is barely used in the packaging process and most dealers are part of the corporate packaging pool.

SDC Austria

With less than 200'000 shipped order lines per year this SDC is categorised as one of the smaller ones in Europe. Their sorting routines are similar to other DCs with seven categories. Due to extensive scrap orders in recent years the mixed waste, wood and glass fraction increased during 2019 and 2020. Overall, the main drivers of waste is perceived to be the extensive amount of cardboard paper together with mixed waste and plastic. The majority of the waste is recycled and what cannot be recycled is incinerated with energy recovery. The waste containers out in the yard, see figure 4.2, are only emptied when full and the contractor is contacted.

Figure 4.2: Waste sorting at SDC Austria, small dust bins for plastic, mixed waste and paper as well as containers out in the yard for all six waste streams.

The biggest actions taken in order to reduce waste is to encourage reuse of packaging in the picking team and reduce consumption of new packaging such as cardboard and plastic. Uniquely for this SDC is that they use new material as filing material where a special machine takes flat paper from the roll and compress it to create a dynamic moving filling. As with all other SDCs they track how much packaging material that is bought. Consolidation of orders is seen as a potential way to reduce

waste, but right now due to quality reasons it is a one-piece flow similar to other SDCs.

SDC Poland

With a total of eight employees and less than 100,000 shipped order lines this SDC is the second smallest SDC in Europe. It serves a total of 64 dealers, primarily from two of AutoCo's brands. This DC are sorting its waste on site into seven waste categories including paper and cardboard packaging, glass, bulky waste, sorbent, plastic, wood and metals.

It is within the cardboard waste stream that most of the efforts of reducing and reusing material has been done. A couple of years ago the DC bought a shredding machine that can convert old cartons to corrugated cardboard which means that boxes sent from the CDC can now be used as filling material for the DCs outbound orders. Metal has also over the years been a rather large waste fraction for the DC. The metal waste is generated from scrap orders and are handled and recycled by a local waste contractor.

SDC Romania

This DC is the smallest in Europe with a total of three employees. The DC serves 19 dealers out of which 16 of them are owned by AutoCO and three of them are privately owned. In this particular DC, five main categories of waste are measured including cardboard, plastic, metals, glass and city waste, also referred to as general waste. The metal bin are normally emptied once a year while glass waste is very rare and emptied more seldom. This DC performs sorting on site in dedicated bins. In order to take care of the waste the DC is collaborating with a local contractor which picks up the bins when they are full which occurs two- to three times a year. The main driver of waste is cardboard and the waste that is perceived most problematic to take care of is metal waste. This waste primarily originated from scrapped parts which are either sent back to the CDC or taken care of by the contractor, i.e. some separation of the parts are performed by the DC when the parts is made only out of metal.

Out of the material that is being sorted the DC tries to recycle as much as possible on the spot. This means finding new areas of use for the waste which for example can include reuse of boxes as well as plastic bags from the CDCs out to dealers. It is estimated that 90 % of the orders are shipped with new cardboard boxes from the DC own stock and 10 % of the boxes out to dealers are reused ones from CDCs. Furthermore, the DC also tries to reuse plastic bands to the greatest extent possible. In addition to reusing materials that are in good condition, the DC also tries to utilise and make the most out of the materials that are not in good enough condition to be reused. This includes actions like shredding damaged boxes in order to create filling material.

4.4 Benchmarking

The benchmarking process resulted in a review of six companies. The targets of all companies included some kind of waste reduction, some with specific targets and other with more extensive descriptions of actions. Many companies work with specific targets on plastic, with set numbers, while other has a stricter focus on either hazardous or food waste depending on the industry they are in. The rest of this section will include detail results from both public information and the interviews held with each company.

4.4.1 IKEA

IKEA is one of the world's largest retail companies with 445 stores in 60 markets and over 27'000 employees (IKEA, 2020). The overall objective of the company is to transform into a circular business. Before 2030 IKEA has set the target to have only recyclable materials, climate positive operations and that the products are designed for reuse, re-manufacturing and recyclability from start (IKEA, 2020). Another goal that has already been achieved is to remove all single-use plastic products from its assortment and therefore IKEA no longer sells straws, plastic cups etc. The next target is to move from new polyester to recycled polyester in textile products. In order to achieve this target one of the actions is to prevent waste. A lot of focus is put on reducing wood waste as it is a common material used within the products.

Within IKEA there is a broad perspective on packaging and no distinction is made between commercial and transport packaging. The distribution flow from supplier to customer can go through many different units. Either from supplier directly to DC, warehouse or even customer as well as from DCs and warehouses directly home to customers. Overall the packaging targets are to avoid over-packing items, avoid plastic and ensure that all material are recyclable and easily separated from each other. In order to achieve this, many smaller targets are set up such as reducing a specific type of material that is non-recyclable. For the waste that ends up within the DC the majority is packaging material which is sorted in waste categories such as metal, glass, plastic and wood. Each DC and warehouse manages their own recycling with a local contractor. At some sites it was found to be suitable that the cardboard is sold back to paper mills for being used as raw material for paper production.

How an IKEA customer chooses to dispose their waste is outside of IKEA's control, but much focus is put on how IKEA can enable and promote recycling and correct disposal. One way of trying to increase the recycling rate is an internal policy, as mentioned earlier, stating that all packaging material should be easily separated. For example, no plastic is glued to cardboard or any other material. Another action is the possibility for customers to return waste in the stores. Furthermore, there is the overall decision to reduce the usage of plastic, even if in some cases the CO_2 emissions are comparable or less to what a paper substitute would generate. This decision was taken in order to have a strong policy to reduce fossil material and the fact that IKEA cannot guarantee how the customer will dispose the packaging. If

plastic would end up in the nature or be incorrectly disposed it will have a much worse effect on the environment compared to paper-based packaging material. The overall policy to reduce plastic is foremost focused on the consumable packaging as the recycling of it is out of the control for IKEA and they can ensure that the plastic used in transportation internally is disposed correctly. A material that was banned some years ago is styrofoam as it was creating a lot of waste and is made out of fossil material. Currently the most challenging task with waste and circular economy is for IKEA to create waste with an economical value where the disposal is part of a value transaction. This includes the customers and an economical incentive for correct waste disposal could encourage correct recycling.

In the warehouse the packaging process is based on the type of ordered goods, large pieces that require home delivery are sent as one package and smaller items can be delivered by post. If both a large item and a small item is ordered for home delivery the items are consolidated. An order with many smaller items are packed in one larger box with filling material made out of paper. There are two different types of paper filling used, both from a shredding machine and paper cushioning (compressed paper). When it comes to dead-stock IKEA throws away nothing. They know well in advance when something is to be phased out or seize being produced. From that they analyse the sales patterns and ensure that production is stopped in time or that the existing products are relocated to where the demand for the product is higher e.g. shipped between warehouses.

There have been multiple actions taken in order to reduce waste, many of the key aspects are considered by the packaging engineers already at the design phase. Packaging engineers are located at a decentralised level at each department, such as kitchen appliances or beds. Their task is to design both a commercial packaging, if needed, and a transport solution. Most products are sold either as a knock-down product or as a naked product. Naked products are put into multi-packs when transported out to warehouses. The knock-down packages, which are the typical IKEA products that requires final assembly at home, requires much thought in the design and it is important that no pieces can move around. All products transported between locations are put onto pallets made out of corrugated cardboard which is a substitute to wooden pallets, such as the traditional euro pallet. This was a decision taken in the 2010's and in 2016 almost all pallets were replaced. The decision was taken both out of environmental and economic reasons. The cardboard pallets are better designed to increase the level of filling in transport and are more easily disposed of as they generate less weight. The pallets are made for one-way usage which means no return flow is needed as each site has a compressor and the high-quality cardboard used for the pallets generates a good income source as they are sold to paper mills. The pallets can carry up to 620kg and can manage the most of the product assortment. In order to secure the goods and ensure that they will not move during the transportation, shrink wrap is used. Previously, plastic bands used to be the choice of securing material but it was perceived to cause breaking and cutting through the cardboard and damaging the goods and hence creating quality issues and waste.

4.4.2 HP Inc

HP is an American manufacturer of PCs, printers and related products with international production and sales and 53'000 employees working globally. The benchmarking interview was done with the former Environmental Director of HP. As of last year he has transitioned to another role but has spent 14 years within the sustainability department and a total of over 30 years with HP. Benchmarking is a well established tool within HP and they are used to share best practice with other brands, customers and manufacturers. Sustainability has always been a key quality and is incorporated in all actions and parts of the company.

To start with, the global footprint HP produces is well monitored and 90% is linked to material extraction while only 10% is part of logistics. This is due to the fact that they take into account the whole value chain, useful life and disposal. This means emissions created when extracting raw material, through the manufacturing process, to the distribution and also how much is emitted when the product is used. Another overall concept is circular economy which HP takes into account in all steps of the value chain and tries to create as many loops of material and resources as possible. This also accounts for products which if they come back to HP are re-purposed or refurbished before they are disposed. One important target is to reduce the single-use plastic from all over the company with 75%. This includes the products and the whole supply chain.

HP is operating in the electronics market which is strictly regulated when it comes to the waste management and end-of-life. This also means that HP experience the most waste in their take-back process when the products have reached their end-of-life and HP takes them back through re-sellers to recycle as much as they can. At some re-sellers, so far just in the US, any type of electronics can be handed in and HP will recycle the parts and use the plastic in their new products. They estimate that 35% of the plastic in a new product is recycled. They have managed to make this process equally as economically profitable as producing new plastic and the recycled plastic is at par with new.

When it comes to packaging material it is also covered by the 75% single plastic reduction. To reach this target they have replaced as much as possible in terms of shrink wrap to filling material. They have replaced polystyrene foam with carton and corrugated filling. To keep their sensitive products, such as PCs, protected in their box they often use moulded pulp which is the same material as egg cartons. The next step HP is looking at is to replace plastic tape with paper tape. Most products travel in their commercial packaging. Computers can be delivered out without an additional package, and the commercial packaging will also function as a transport packaging. When transported between sites, PCs are packed in their commercial packaging, staked on pallets, with some protection, while printers comes in bulk and are packed on site. The challenge is big and heavy products where plastic is still

an important packaging material. HP wants to prioritise keeping the product safe, otherwise the waste will increase if they would have to scrap it. Besides focusing on removing plastic as much as possible, recyclable material is used and packages are consolidated.

Sustainability has always been an important value for HP and today it saturates the whole company and all decisions made. For HP it is important to differentiate sustainability from cost when taking decisions and measuring its strategic impact. The culture and governance is what is considered the reason to the overall high environmental consciousness. From top down the management is prioritising sustainability and initiatives and employees are measured in how they are achieving goals in terms of sustainability.

4.4.3 Access Solutions

This world-renowned company is operating in the access engineering industry. It has presence in over 70 countries all over the world and the company employs approximately 48,000 people. The company has been built up on acquisitions and today consist of over 300 different companies. The company operates both B2B and B2C and its distribution network consist of both regional warehouses, dealers, retail chains, multi stores as well as other actors distributing the company's products.

Access Solutions has a clearly expressed focus on working on minimising the waste stemming from its manufacturing processes as well as waste related to packaging (Assa Abloy, 2020). The company had an aggressive target of reducing the non-hazardous waste between 2015-2016 by 20%, which they succeeded with. Now the new target is set for 2025 which states they want to make a further decrease of 25% before 2025. To succeed with this, the company have chosen to follow the waste hierarchy, which means that the company aims to reduce, reuse, recycle and recover as much as possible. In order to do so, several measures have been taken. Some of the activities the company has implemented to improve its waste management includes, but is not limited to, reducing the physical paper documents by implementing electronic order and integrated information flows between systems as well as reducing the amount of packaging materials. One initiative that has been implemented is that when a product is to be distributed, the first consideration to take is whether packaging material is actually needed or not. If it is needed the company have started to switch to more environmentally friendly packaging materials and the introduction of reusable and recyclable containers. So far, the possibility of taking the packaging back is rather limited and therefore the focus has been on ensuring that all the material that ends up at the customer must be of very good recyclability. However, the most important aspect so far is quality, ensuring that the product can handle the transportation between the sites or out to the customer.

Apart from the waste streams concerning packaging material or paper the company also have other sustainability efforts that they are working with. For example, the

company is working with servitization, i.e. having maintenance contracts that entails working preventive in order to ensure that the customers products are always up and running and that service occurs before it breaks down. The replaced part is then taken in for remanufacturing and can then be used as a replacement when other customers need to prevent breakdown of the same part.

Within the company, there is a distinction made between the waste categories recycled metal, non-hazardous waste and hazardous waste. The non-hazardous waste is divided into seven different waste categories. For the non-hazardous waste the category "household deposited waste" accounts for approximately 40 percent, almost twice as big as the second largest waste fraction, namely wood waste.

For the non-hazardous waste the target for 2020 was to reduce the waste intensity by 20 % compared to 2015. The waste is measured in tons. For the hazardous waste the company have hired a certified contractor to appropriately dispose any hazardous waste that cannot be reused. Currently only seven % of what is classified as hazardous can be recycled. The waste classified as hazardous waste have been increasing during the last year, partly due to stricter national regulations of what is classified as hazardous.

4.4.4 Husqvarna

Husqvarna produces and sells power tools for forest and gardening globally, but with high presence in a few concentrated areas. They employ over 13'000 employees in more than 40 countries. Currently they have production at 25 locations and twice as many global warehouses. Their distribution channels are mainly through dealers, which sells their heaviest products, as well as retailers that sells their lighter gardening products. The pick-and-pack process in the warehouse results in consolidated orders out to dealers, no matter what has been ordered.

Husqvarna has products similar in composition to the ones of AutoCo. They are mainly made of steel and plastic which are both recyclable. Husqvarna aims to increase the recycling rate and are exploring how to use more recycled plastic in their products in order to create circularity of material (Husqvarna, 2020). The target is to have 50 innovations within circular economy launched before 2025.

In order to reduce the packaging sizes and increase transport efficiency and reduce material and optimisation project has been conducted. This project is a result of many years of increased awareness of packaging design. Main factors considered for the project was how to reduce time, cost and keep quality in the packaging. An example of project was to optimise the pallets and transport packaging of lawn mowers. With a few centimetres decrease on each side of the packaging they could fit two instead of one in each container. The project much focused on the early phase of design and from production out to customer and is an example of how to prevent waste. The project tried to tie together the knowledge from the value chain through

a network. People working in the workshops had good knowledge but did not know they could do anything to optimise. A network was created and educations started which enabled to create better communication between workshop workers and the packaging design department.

Other sustainability initiatives that has been taken is to reduce plastic in commercial packaging, such as single-pack for screws. They have had an increase collaboration with both suppliers as well as within the organisation when it comes to delivering parts in a better way. Instead of having a part delivered in a poor box that needs to be repacked, they have started asking if they can get it correctly packed already at the supplier. To their surprise this has been easier than expected. They still see it as a disadvantage to not have the same opportunities as AutoCo due to their smaller size and lower quantities as this makes some suppliers less prone to adapt. When it comes to regular transportation they use pallets and wrap plastic around. Paper or fibre pallets has been investigated as a potential replacer.They try to avoid scrap and when greater volume of a part is being phased out they try to re-balance within the region and for production.

4.4.5 ICA Gruppen

ICA Gruppen is a Swedish retail company with focus on food and health. ICA Gruppen consists of multiple companies where both grocery retail, real estate management and financial services are included (ICA Gruppen, 2021). The core business is grocery retail and ICA Sweden is the biggest company with 1'300 independently owned stores operated by local retailers. ICA Gruppen, hereafter solely ICA, is also a logistics company and distributor as they operate and arrange their own transportation and delivers to all stores from their warehouses. They have five distribution centres, out of which three are larger central distribution centres, from which products are delivered out to all stores across Sweden. Besides the flow from warehouse there is a cross-docking flow where the transportation is provided by ICA but the supplier has packed the orders to the store.

When it comes to waste the biggest focus within ICA is food-waste reduction. Before 2025 they want to make it half as much as compared to 2016 (ICA Gruppen, 2020). This is therefore a big focus within the DC operations where quality of packaging and transport solutions is prioritised. An identified trade-off when it comes to packaging is that the quality of the packaging is limited by the margins of the product. Low margin products cannot have too expensive packaging solutions, while high margin products are more worth protecting and can have a better packaging. Besides making packaging that prevents products becoming damaged they work hard with routines in the handling of products (packaging and unpacking processes). Furthermore they work with their suppliers in order to reduce the breaking and damaging of products. The packaging of products in the grocery detail business is well developed as there are multiple standardised ways of working between actors. In Sweden there is an industry owned box system used for fruit, vegetables

and some other products where the plastic crates are rotated and shared between suppliers and grocery stores. This reduces the need for packaging and last year the estimated CO_2 savings were 16'000 ton for just ICA. Additionally, the products are delivered in a standardised packaging from suppliers and they use a special module measurement that makes the filling degree high when packed in larger containers. The only consumable packaging that might be necessary is a plastic cover if the trolleys needs protection. Out of the 50'000 unique products that ICA sells many of them are standardised to the module measurement. This enables higher fill rates in the transportation and enables optimisation of shelf space. Therefore, ICA tries to encourage suppliers to ship the products as per these standard measurements.

Even if many types of returnable packaging solutions are used, some consumable packaging is unavoidable. Similar to other companies interviewed, ICA has conducted projects in order to reduce packaging. One case included looking at the packaging solution of six different products that were transported as half-pallets. Instead of being both wrapped with plastic, strapped with plastic band and sometimes also with a carton layer on top, they tried to remove everything but the plastic bands. It worked and resulted in a great reduction of plastic used annually.

When it comes to measuring waste they have some standard waste fractions; corrugated cardboard, soft plastic, hard plastic, organic and burnable. The organic waste goes to bio gas and the burnable goes to incineration with energy recovery. As mentioned the main target within waste is to reduce food waste, but there are work to improve the recycling rate within the operations as well. When it comes to packaging material there is a prioritisation of finding the right packaging, rather than persisting to use any type of material. They see a trade-off between environmental savings now and looking at the greater picture. If a packaging becomes lighter and saves weight in transportation, it might result in more damaged goods and hence have the opposite environmental effect in total.

ICA aimed to be climate neutral until 2020 which they managed up to 76% with the rest being fulfilled with climate compensated projects. They keep aiming higher and before 2030 they want to have zero net emissions which means no climate compensations. Waste is included in these calculations. Finally, on the topic of plastic or no plastic in the operations ICA's stance is, as mentioned, not to ban anything but to find the best solutions for the products in order to protect them. They have taken a company wide initiative to reduce plastic in some products and to have the material of their own products being fully recyclable.

4.4.6 Nike

The only case company reviewed for benchmarking without an interview is Nike, an American retail company specialised in sports shoes and clothing. As they are recognised as one of the top performers within sustainable warehouse operations and has much available information online they are interesting to include. All information is derived from Nike's annual sustainability report (Nike, 2020).

Nike states that waste is generated throughout the company's value chain and that they are applying activities to reduce, reuse or recycle in order to manage and dispose waste responsibly. The company has a clearly formulated target regarding waste management - *to eliminate footwear manufacturing waste to landfill or incineration, while continuing to reduce overall waste from manufacturing, DCs and headquarters*. A quantitative measure has been developed in order to achieve this, they want 10% waste reduction per unit in manufacturing and distribution as well as per employee in headquarters. This shall be done through improved design and operations efficiency. Furthermore, Nike has identified key actions such as adapting a circular approach and work across the entire value chain, from initial product design to the return phase in the end-of-life stage.

About 85% of the waste in DCs is corrugated cardboard cartons. This is generated from repack of inbound cartons to customised outbound orders to customers. In order to reduce the waste in DCs they have an extensive "Re-Use-A-Box" programs which means a greater reuse if corrugated cardboard cartons. They also explore other alternative packaging solutions, such as reusable shipping boxes. In order to prevent waste at the source they have made a new footwear box design, which is a transport packaging for footwear in e-commerce with 18% less corrugate material. This reduces CO_2 emissions by 50%. They have also designed the e-commerce parcels used for clothing to be more optimised in terms of size and made it returnable. When it comes to filling material Nike has taken a stance in removing the plastic air pillows and this will result in a reduction of 90'000 kg of plastic annually. As they state, this was done in order to debunk the myth of outbound goods needing filling material at all, which proved false. They have also made extensive investments in machines that can transform old products, such as footwear, into material that can be used in new products.

4.4.7 Summary of Benchmarking Result

All interviewed and reviewed companies had both similarities and differences in terms of targets and how to action these. This is summarised in table 4.2. All companies states they want a waste reduction overall. Access Solutions and Nike are the only two companies with a stated measurable waste reduction target. IKEA, HP and ICA has formulated targets to reduce plastic. Nike does not specifically state a plastic target but has still taken action to reduce plastic as part of overall waste reduction.

Company	Targets	Actions
IKEA	Waste reduction, Plastic avoidance, Circular business model	Reduce overall packaging, avoid plastic, increase recyclability and separability. Scrap products phase out & re-use. Wooden pallets, end-to-end perspective on packaging
HP Inc	Waste reduction, 75% plastic reduction overall	Supplier encouragement, remove/replace/reuse materials that are of concern, recycle plastic in products, straw pallets, bulk packaging.
Husqvarna	Waste reduction, 50 circular initiatives	Design-out waste, increase reuse of plastic, packaging optimisation
Access Solutions*	Waste reduction 20% waste in kg/ M SEK before 2025	Measurement of waste in kg/MSEK, packaging optimisation, reusable containers
ICA Gruppen	Waste reduction (food) 50% before 2025, plastic reduction and increase recyclability	Product packaging design, routines, overpackaging case, collaboration with industry and suppliers
Nike	Waste Reduction by 10% before 2025, elimination of landfill waste to landfill or incineration	Reuse of inbound packaging, material reduction in e-commerce packaging, removal of plastic pillows as filling material as part of removing all single-use plastic from operations.

Table 4.2: Waste related targets and actions of benchmarking companies.

5

Discussion

In this chapter, the results of the study will be analysed and discussed utilising theoretical framework. The results will be discussed and analysed in a structure based on the research questions.

5.1 What waste is managed in the DCs?

Several waste categories can be identified within DC operations. During the interviews, some of the most frequently mentioned ones were cardboard, paper, metal, wood and plastic. The fact that these were brought up during the interviews is reasonable as in most cases it was also these categories that accounted for a large part of the total waste generated in DCs if looking at the data collected.

Some of the above mentioned waste streams have a clear cause while some waste categories have multiple drivers for it. The first four waste categories of cardboard, paper, metal and wood, have only one main driver for the resulting waste. For the cardboard and wood category, the main driver is the excessive use of packaging material, both cardboard boxes but also wood crates and pallets for one-way deliveries. Paper waste are mainly derived from administrative tasks. Some DCs like SDC Italy have a quite substantial amount of paper waste as a result from bureaucratic procedure requiring extensive documentation in paper format as well as physical delivery notes.

The main driver of metal for all DCs are scrapping of parts. As most of AutoCo's parts are made of different types of metal, it is also the type of waste that is generated when the parts are to be scrapped. In most cases, apart from the parts that are being re-manufactured, the parts are sent for recycling through the waste contractor. Plastic is the only prominent waste stream with two main drivers. One source is the use of packaging material in terms of plastic bags, plastic bands and shrink wrap. The second one is scrapping of products since some of the parts are either made entirely of plastic or have elements of plastic in them. A summary of the main waste categories and their corresponding driver is presented below in table 5.1.

The two main drivers of waste that has been identified are the excessive use of packaging material as well as scrapping of parts. For the CDCs, the waste is generated mainly in the inbound flow from suppliers as well as scrapping of parts, both their

Waste	Driver
Cardboard	Packaging
Paper	Admin
Metal	Scrap products
Wood	Packaging
Plastic	Packaging & Scrap Products

Table 5.1: Waste categories within DCs and their main drivers.

own but also parts they take back from SDCs and dealers. For the SDCs the majority of the waste is derived from the packaging material sent with deliveries from the CDCs and scrapping of parts. The last step in AutoCo's distribution chain, the dealers, mainly recieve waste generated from the deliveries from the SDCs in the form of excessive packaging material. This is visualised in figure 5.1. The packaging waste that the SDCs receive mainly comes from packaging material that is put into the pool packaging such as filling material or paper cartons to keep the products protected and separated. It can also be one-way packaging if no pool packaging is available or the products do not fit. The other waste stream to SDCs is returns from dealers, which produces both scrap products (if this is the return cause) and packaging that is put to waste.

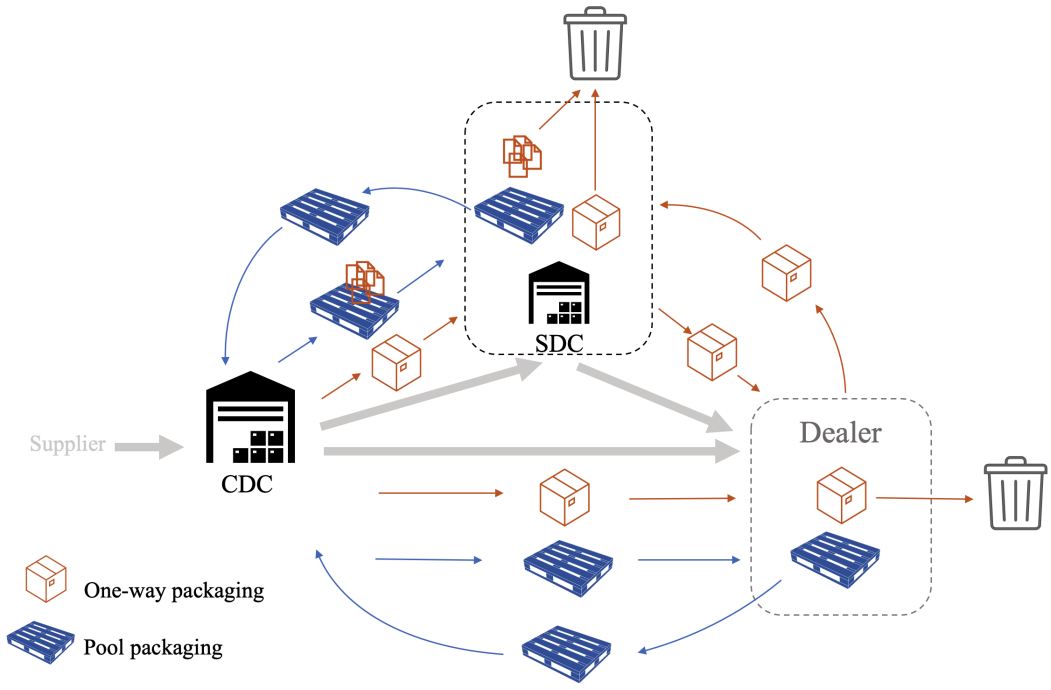

Figure 5.1: The circulation of packaging, both the packaging pool (blue) and one-way packaging (orange)

Diving further into the data, it can be acknowledged that what is considered to be the main waste categories; cardboard, paper, metal, wood and plastic account for

a large proportion of the total waste generated at the DCs. This is illustrated in table 5.2. Many of the DCs do not distinguish between cardboard and paper when reporting the waste and reports these two as one waste category. Hence, for the DCs that do report this as two different waste streams these have been merged into the category called paper-based in order to facilitate the comparison. As can be seen in figure 5.2 there are quite large variations in both waste per order line and which waste categories that are the most prominent ones in the different DCs. For some DCs, the totals of these four waste categories can account for up to 100 % of the waste of the DC, as is the case for both CDCs. However, there are exceptions to these observations. In table 5.2, it can also be acknowledged that for some DCs, the above mentioned categories accounts for very little of the total waste percentage.

DC	Size	WPO	Plastic	Metal	Paper-based	Wood	Other
CDC France	Large	0,68 kg	1 %	50 %	20 %	21 %	8 %
CDC Belgium	Large	0,91 kg	2 %	65 %	11 %	18 %	4 %
SDC Italy	Medium	0,01 kg	15 %	2 %	31 %	26 %	26 %
SDC Sweden	Medium	0,23 kg	2 %	38 %	18 %	7 %	35 %
SDC UK	Medium	0,09 kg	-	3 %	43 %	12 %	42 %
SDC Spain	Medium	0,12 kg	3 %	11 %	16 %	59 %	11 %
SDC Finland	Small	0,08 kg	-	-	27 %	-	73 %
SDC Poland	Small	0,11 kg	13 %	44 %	2 %	7 %	34 %
SDC Romania	Small	0,05 kg	27 %	34 %	20 %	-	19 %
SDC Austria	Small	0,18 kg	3 %	27 %	12 %	8 %	50 %

Table 5.2: Summary of Results from Data Collection with ratio of waste per orderline (WPO) and plastic, metal and cardboard/paper as percentage of WPO. ** Average WPO over the years 2018-2020.*

There are quite large differences both in WPO and in terms of how large percentage the four main categories account for in each DC. That CDC Belgium and CDC France are the DCs with the highest WPO is not surprising as they both receive deliveries from the suppliers in boxes that mostly needs to be repacked as well as take back scrap orders from some of the SDCs, hence generating more waste than if they would solely take care of their own operation. The fact that the distribution of waste varies between the different DCs can have several explanations. It can either be due to the high volumes of other waste categories which makes plastic, metal, paper-based and wood become only a fraction of the other categories. It can also be because the DC applies other names for waste categories so that what usually ends up in the four most common categories instead ends up in a more general category like “combustible” or “burnable”.

The DCs also have different preconditions for handling certain waste types which also has an effect on the distribution of waste. For example, SDC Italy have a hard time finding waste contractors who can handle waste from scrapped products in a suitable way and at a good price. Therefore they send back their scrap parts to CDC Belgium, hence contributes to increased volumes of metal and plastic waste at

CDC Belgium but that other waste categories also get a higher leverage at SDC Italy.

From the numbers presented in table 5.2 it can be seen that plastic is only a relatively large part of the waste for SDC Romania where it accounts for up to approximately 40 % over the years 2018-2020. For the other DCs plastic never accounts for more than 15 % of the waste. According to the waste contractor plastic is sometimes incorrectly sorted as combustible waste. This may be true also for AutoCo's different DCs around Europe so this fraction may be underestimated since it is barely or non-existent in some DCs. One of the reasons for why plastic may not be as prioritised as other waste streams are the complexity of handling it. It is both easier and cheaper for companies to sort the waste into the combustible bin if the knowledge and volumes are not there. However, it is worth acknowledging that plastic, when not specified what type of plastic it is, can be a result from both packaging material or from scrap products in AutoCo's case.

In figure 5.2 the development of generated waste as well as the number of shipped order lines for the SDCs over the years 2018-2020 is illustrated. As can be seen in the figure, there is a trend in decreasing order lines over time with SDC Poland being the exception. For waste, the result does not follow the same pattern for all DCs. Some of them have been decreasing their total waste over the years while other DCs have been constantly increasing in waste. However, there are also those that have rather volatile amount of waste, for example SDC Austria. The variations of waste over the years can have several explanations, including frequency of pick up of waste, frequency and volume of scrap orders as well as local projects affecting the total waste generated. Some of the DCs have agreed with their waste contractor that collection of waste will only take place once the bins are full. Hence, as the volumes of certain waste categories are so low for some of the waste streams, pick up will not occur each year but rather every second- or third year. This implies that when the bins are emptied, they will have a significant impact on the total amount of waste that year, which in figure 5.2 is represented by peaks in the total waste generated. As an example, for SDC Austria the year 2019 stands out due to glass being a major waste stream in that year which is one of those types of waste categories that are not collected each year for this particular DC. Scrapping of parts follows the same reasoning. It is only SDC UK that states that they receive scrap orders on a regular basis. The other SDCs claim that they scrap parts once in a while but that it is not consistent, neither in volume i.e. weight nor in number of shipped order lines. Lastly, local project may also affect the amount of total waste generated. As an example SDC Spain has over the last year conducted a remodelling project of the DCs, causing addition waste in addition to the waste that is generated through their everyday operation. That the waste can vary quite a lot from year to year indicates that calculating WPO for each year would not be appropriate since there are many aspects affecting this number. Therefore WPO was calculated as an average.

The WPO differs quite a lot between the SDCs as can be seen in figure 5.3. The figure shows that SDC Sweden has the highest waste per order line, WPO, and SDC

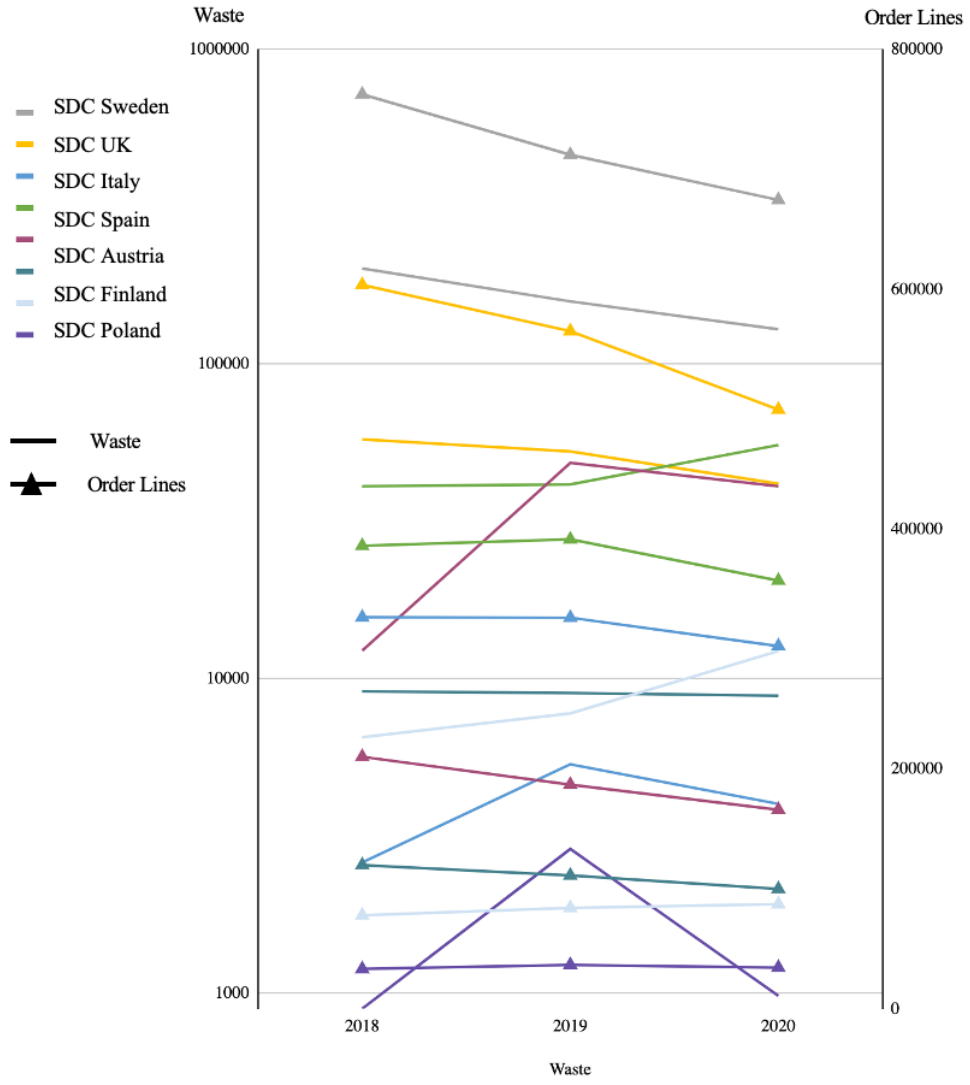

Figure 5.2: Waste (left axis) and order lines (right axis) over the three years 2018, 2019 and 2020. A downward trend is seen already before the Covid-19 outbreak in 2020 and that waste has followed at most SDCs.

Italy has the lowest one. In the figure it can be seen that there is limited correlation between size, measured as described in section 3.3.2 and WPO. SDC Sweden is the SDC with the highest number of shipped order lines but also the SDC with the highest WPO. When comparing to SDC Italy and SDC UK which are the second and third largest SDCs, SDC Sweden has more than twice the amount of WPO. What is interesting here is that they try to consolidate the orders whenever possible, which could indicate a higher environmental awareness but also the aspect of scrap orders. It has previously been stated that SDC Italy do not take care of the scrap orders themselves, hence they have hardly any plastic or metal waste which are the most prominent waste fractions at SDC Sweden and also normally account for quite a large percentage of the waste due to the weight of metal in other SDCs which is

something that needs to be considered when reflecting on the credibility of the comparison between sites. The numbers could indicate a correlation between scrapping and high WPO and something that needs to be further investigate as SDC UK is reported to take care of all the scrapping themselves but still have significantly lower WPO than SDC Sweden which indicated that other factors also need to be taken in consideration. For the remaining SDCs the WPO is more even. SDC Romania is the smallest DC and also the one having the lowest WPO apart from SDC Italy due to above mentioned reasons relating to handling of scrap parts. Inconsistent and large volume scrap orders that generate a lot of waste in relation to the total amount of shipped order lines in a DC can have a big impact on WPO. For example the extensive scrapping project in SDC Poland that generate far more waste than the normal operations, hence affecting the WPO.

To conclude, the number of shipped order lines annually does not seem to have an immediate effect on the amount of waste that is generated at the SDCs. It is still interesting to further investigate why SDC UK has relatively much lower waste volume than SDC Sweden.

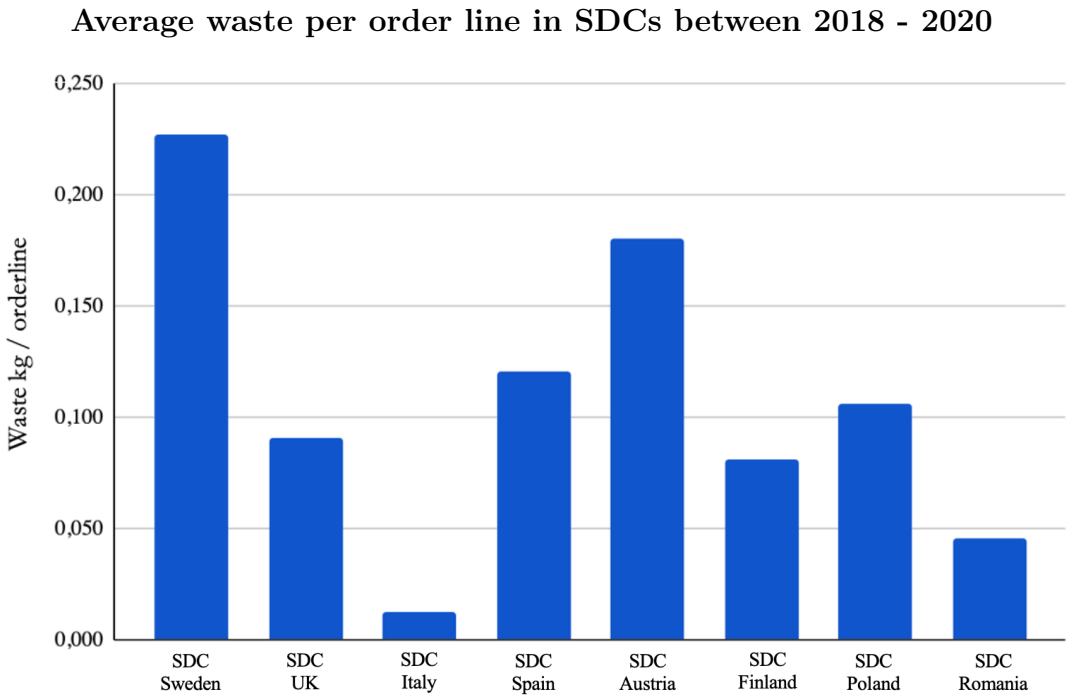

Figure 5.3: Waste per order line in all SDCs on average for 2018-2020, order lines per year in descending order from left to right.

5.1.1 Packaging

Packaging material is one of the main drivers of waste within AutoCo's DC operations. Since packaging production and packaging waste has a both direct and indirect effect of greenhouse gas emissions (Pålsson, 2018), it accounts for parts of

AutoCo's environmental footprint. Primarily the packaging waste comes from inbound goods delivered by suppliers or from the CDC depending on which DC that are looked at. Some of the packaging material is also generated in the return flow. Packaging drives waste in terms of cardboard, filling material (which differs between sites) and plastic.

As Ajwani-Ramchandani et al. (2021) and Pålsson (2018) mentions, companies often see their product as the value and the packaging as an unwanted must with short useful life. This is similar to the perception of AutoCo's approach to transport packaging as they are mainly focusing on one of the aspects brought up by White, Wang, and Li (2015), quality, i.e. that all parts that are shipped from a DC should arrive without damages. This is sometimes in contrast to other aspects of packaging, for example increased logistics efficiency and minimising packaging material mentioned by Pålsson (2018) as there has been complains about an excessive use of packaging material which results in large amount of waste as well as extra handling efforts.

However, cardboard is a large waste stream for several of the DCs. In both SDC UK and SDC Italy cardboard and paper accounts for approximately 40 % of the waste. For the remaining DCs, apart from SDC Poland, cardboard accounts for approximately 20 %.

Cardboard is something that the DCs are able to affect to some extent. AutoCo's use of the internal packaging pool reduces some of the cardboard waste that would otherwise have been generated as the packaging material from the pool can be either returned to the DC sending the goods or it can be used out to dealer. This is in line with Baudin (2004) and García-Arca, Garrido, and Prado-Prado (2017) observation that when it comes to reuse, returnable packaging is one favoured method due to its environmental and cost benefits as it ultimately results in that less material needs to be recycled, incinerated or put into landfills. However, some of the DCs have chosen to make this problem a resource and uses the cardboard as filling material. In this way they are working with reuse since the boxes can be used again but for a another purpose. However, not all DCs do this, but some buy completely new material as filling material.

5.1.2 Scrap Parts

Scrapping of parts is the main driver of the fractions metal and plastic as most of AutoCo's parts are made out of these materials. Some parts also are categorised as electronic waste. Scrap orders are being initiated either due to goods being damaged or obsolete. That scrap orders are generated may not come as a surprise since as Cohen, N. Agrawal, and V. Agrawal (2006) stated, it is difficult to forecast when having that many SKUs, hence suffering a risk of obsolescence. Depending on what the scrap product is made of, it can be more easy or difficult to handle and recycle.

Metal is easy to handle and reuse while plastic is more difficult due to sorting re-

quirements and volumes. If a part consists of several materials the DC have to disassembly the part before it can be recycled as the waste contractor need as clean waste flows as possible in order to be able to recycle it. Otherwise the parts are sent down the chain where contractors have to take care of the disassembly. This will affect the value of the scrap as the cost lies in the disassembly, hence it is more economically favourable for AutoCo to perform the disassembly if the knowledge and time is available. However, it is also important to notice that not all material are possible or suitable to recycle as stated by Geueke, Groh, and Muncke (2018). Although it is good to work for recycling as much as possible since it both limits the the use of new material (United Nations, 2013) and provides an opportunity to regain otherwise lost value (Lewis and Slack, 2017), it is also important to work with the first and second step of the waste hierarchy, to prevent and to reuse.

AutoCo has already come a long way in its recycling process and can therefore be considered mature to work with reuse and prevention. Today, only a limited range of parts are re-manufactured, i.e. a form of reuse which could be extended in the future. However, the fact that AutoCo receives payment for its waste by the waste contractor the incentives to do more than recycle may be lowered. Prevent is the ultimate step in how to reduce the need to extract and manufacture new products and materials, thereby making the best out of the world's limited resources, hence getting closer to circular economy (United Nations, 2013).

Metal is a fraction that varies a lot between the DCs. For some, metal account for up to 50 % of the waste while for others it is hardly or non-existent. Both CDC France and SDC Sweden have a lot of metal waste while SDC UK, SDC Italy and SDC Finland almost have none. One thing affecting the amount of metal are the frequency of scrap orders. For SDC Romania they have one year where metal waste account for approximately 60 % of the waste. This has to do with both the frequency of when the bins are emptied and how often the scrap orders are placed. As a contrast, in SDC UK where it was described that they receive scrap orders four times a year their metal waste is quite consistent. As there are these types of inconsistencies in scrap orders, it is questionable whether the data is representative for a normal year.

However, the amount of metal generated also partly depends on the individual DCs preconditions. For example, due to national regulations SDC Italy struggles with finding appropriate waste contractors for scrap products that are not too expensive, and therefore sends goods back to the CDC for scrapping, hence affecting the CDCs numbers instead of their own. Another example is SDC Poland who talked about a local scrapping project generating a lot of waste. The same goes for SDC Spain where they are performing a reconstruction of the distribution centre where old shelves and similar parts are generating a lot of metal waste. These local projects makes it difficult to compare the sites. For SDC Sweden there is no clear reason for whether it would have more scrap parts than the other DCs. However, they are working with a contractor that makes it easy to recycle metal so a correlation between good accessibility of waste contractors is one aspect that is worth evaluating.

5.1.3 Other

Some other major waste streams that have been identified apart from cardboard, plastic and metal are the waste categories wood and glass. There is no specific pattern in terms of the size of the DC or the number of order lines shipped. Wood is a significant contributor to the total waste generated for CDC France, CDC Belgium, SDC Italy and SDC Spain. CDC France and CDC Belgium receive a lot of deliveries from suppliers, hence generating wood waste both in terms of pallets that cannot be reused but also through wood crates as packaging material for some parts. The reason for SDC Italy's high share of wood waste has most likely to do with the fact they they barely have any metal waste, hence the other waste categories receive a larger proportion of the waste. SDC Spain is the DC that stands out in this waste category as the proportion of wood waste is so large that all other fractions are barely noticeable in the totals. As has been mentioned previously, the majority of wood waste for SDC Spain is generated when receiving deliveries of packaging material from suppliers according to the DC representative. This is interesting as other DCs also receive packaging material from suppliers but are not even close to the numbers of SDC Spain. Hence it may be interesting to investigate whether there is an opportunity for SDC Spain to lower its levels of wood waste.

5.1.4 Data quality

Overall the waste data is of rather low quality. As the DCs decide themselves together with the waste contractor which categories they are going to sort its waste into this varies between sites, i.e. there are no standardisation of the data collection. Also how thoroughly the waste are sorted differs. There are only four categories that are common for all DCs which is metal, plastic, cardboard and wood. However, even in these categories the measures differ and assumptions and estimations have to be made. Some DCs separate e.g. paper and cardboard while others do not have a paper category. SDC Italy for example said that they separate paper and cardboard but it is still reported as one common fraction, making it difficult to know whether other DCs are doing the same or whether it ends up in other categories such as city waste or combustible waste. Without more accurate and granular data it can therefore be difficult to compare the DCs and draw conclusions.

5.2 What needs to be considered when setting targets for waste prevention?

When it comes to waste, AutoCo faces many similar challenges as the companies reviewed in the benchmarking. The benchmarking companies have a variety of actions and set targets to tackle these challenges, which AutoCo to some extent can

be inspired by. This section will analyse what companies have decided in terms of waste targets and to what extent AutoCo can adapt them as well. Specific targets for packaging, plastic and scrap will be discussed separately.

To start with, all companies included in the benchmarking mentions waste reduction as a target in their annual sustainability reports. The waste targets of each company has been identified and broken down further in a comparative analysis, see table 5.3. The focus of the discussion with the first benchmarking company, IKEA, was on packaging and transport packaging solutions. In their annual report their overall targets were displayed, where reducing waste, avoiding plastic and creating a circular business model was highlighted. They have not defined a specific target expressed in numbers or as a measure but works with clear actions in how to achieve circularity. When comparing IKEA with AutoCo there are some important factors that needs to be considered. IKEA has a very different sales channel where their products do not need to compete on the shelf with other actors since they are all sold in their own stores. This impacts the way they can work with packaging as there is no need for branding or commercial packaging to the same extent.

Company	Waste Reduction	Measurable	Plastic
IKEA	Yes	-50% Food waste 2022	Yes
HP Inc.	Yes	-75% Plastic	Yes
Husqvarna	Yes	No	No
Access Solutions	Yes	-25% Overall waste by 2025	No
ICA Group	Yes	-50% Food waste 2025	Yes
Nike	Yes	-10% Overall waste by 2025	Yes
AutoCo	Yes	No	No

Table 5.3: Comparison of targets between benchmarking companies. 1. Does the annual report state a target of reducing waste, 2. Does the company have any measurable waste targets, 3. Does the company have any targets specifically for plastic.

Both IKEA and AutoCo distribute their products globally and have a wide product assortment that comes in many different shapes and sizes. The difference of the products lies in both cost and complexity, where AutoCo operates with more complex and expensive products. IKEA works hard with the product and packaging design to be fit for a circular life of reuse, re-manufacturing and recycling. AutoCo may face a limitation on how much the end-of-life can be considered in the design phase due to the complexity of their products. On the other hand, if the product contains more precious raw materials it is of higher value to recycle the product and therefor consider this in the design of the product. Nevertheless, there is a trade-off that needs to be considered when it comes to setting targets. If the ambition is to create a fully circular business model the thinking must be implemented throughout the whole organisation, from product design, to production and for many years in the service market. It can be difficult to predict if material used today will or will not be possible to be recycle in the future and if it will be of value. IKEA's products

have, even with circularity as a goal, a shorter lifespan than some of AutoCo's most standard parts.

Similar to IKEA, HP works for both reduced plastic usage and for a more circular business model. They have not defined key actions to the same extent but apply the reduce, reuse and recycle framework to both reduce hazardous waste and packaging. They do not have a specific quantifiable target for waste reduction either, but for single use plastic they want a 75% reduction in both the operations and products before 2030. HP's products are somewhat more similar to AutoCo's than IKEA's. Most interestingly, they have electronic equipment and more hazardous materials. The focus of the interview with HP was on overall sustainability work and their annual report added more details on their waste targets and operations. Their main CO_2 footprint is not derived from their operations or the usage of their products. Instead the main driver is when the raw resources are extracted. Therefore HP see a long life-cycle of their products as a key factor in order to postpone the need to extract new material. They therefore work with a product repair, reuse and recycling program with a target of recycling 1.2 million tonnes of hardware and supplies before 2025. So far they are at 500'000 tonnes. In order to make it economically efficient they take back any type of hardware, including competitors. This take back system for HP's end-of-life products is something that AutoCo could implement. This would mean they would take back the parts that are being replaced at the workshops and reuse the material. Such an implementation requires further investigation to understand what parts are the most valuable to take-back. In terms of targets AutoCo could therefore adapt the quantitative target of taking back parts.

Out of all companies in the benchmarking, Husqvarna was the most similar in targets compared to AutoCo with solely waste reduction as a target on a company level. They state to have the ambition to include more recycled plastic in their products, similar to HP. As for Access Solutions they have a measurable actual waste target of reducing 25% of overall waste before 2025. The measurement tracked is kilogram of waste per "value added". The only other company apart from Access Solutions with a measurable target is Nike. They have broken down their measurement even further and discuss it on a manufacturing, DC and headquarter level. The first two types of sites measure their waste per order line handled, while the headquarters measure their waste per employee. Besides having the most clearly defined waste measure, Nike is also the only company out of the benchmarking companies that in their annual report express a target to reduce waste to incineration. Most companies expresses the desire to reduce landfill, while not mentioning a desire to reduce incineration. As Zink and Geyer (2019) state, all material eventually has to be disposed in either incineration or landfill and as Rabl, Spadaro, and Zoughaib (2008) adds; incineration can have as much environmental impact as landfill. There is a regulation for incineration in place in the EU that regulated incineration and most importantly, EU does not recognise incineration with energy recover as renewable energy. This seems to not be the perception of either some of the interviewed companies or within AutoCo's DCs. Most benchmarking companies mention circular economy on a conceptual level and this of course is a way of reducing waste and

hence, waste to incineration as well. Still, it is only Nike that includes reduction of incineration as a target which means they take away the opportunity to reduce their waste to landfill through simply moving over to incineration.

5.2.1 Packaging

When talking to IKEA, Huqvarna and ICA the topic of the discussion mainly revolved around packaging. For ICA the most important objective with packaging is to minimise product waste and of high packaging quality. For IKEA the focus was rather on minimising packaging material, with a base requirement of keeping the product safe from damages and efficient to transport and handle. For Husqvarna, the objective of much previous work with packaging has been to create logistics efficiency in terms of optimising packaging and also get a cost saving in terms of minimising packaging material. By mapping these responses to the four primary targets for packaging by Pålsson (2018), see table 5.4, it can be seen that only three out of four is actually mentioned as important by the benchmarking companies and one is not mentioned at all.

Pålsson's packaging targets	Target most important to
Minimising product waste	ICA
Logistics efficiency	Husqvarna
Being Value Adding	-
Minimising packaging material	IKEA

Table 5.4: Mapping and comparing the primary packaging target of someof the benchmarking companies to the four packaging targets by Pålsson (2018).

It is interesting that no company mentions *being value adding* as an important target for packaging. Looking at the EU waste directive, it also discusses packaging as a something that could be value adding, but still no company seemed to have that communicated as a target. Instead the most interesting finding that can be seen is how the importance off packaging and how its purpose differs.

5.2.2 Plastic

The views on how to handle plastic waste differ greatly both within AutoCo and between the benchmarking companies. As discussed with SDC Sweden's waste contractor Stena Recycling, it is a complicated topic. Taking stance in the targets of the benchmarking companies they also reflect this very debated topic. Four out of six companies state that they want to reduce their usage of plastic, the other three mention that they want to recycle and use better plastic. As plastic is not like metal, that can be recycled multiple times, it requires much more investment in order to make recyclable. IKEA and HP are two of the strongest promoters of reducing plastic, both with the aim of preventing plastic from ending up in the environment. IKEA see's it as their responsibility to do what they can to prevent post-consumer waste from their product to end up in the nature, and if it does, it is better if it is

not plastic.

For HP, much of the focus was on getting the products back as this is where the majority of their plastic lies. As they are operating in the strictly regulated electronics market they could leverage on this and include plastic recycling in their take-back process. These two companies give examples of how to work with plastic both in terms of post-consumer waste of packaging or the product, as well as resource extraction. The difficulty when applying these potential targets to AutoCo is the difference in the product and distribution. Internally there are discussions on how to work with plastic waste from production, this work could also be applied to the DC operations as they work with different types of plastic as well. For plastic to be recycled DCs must sort the plastic, both from packaging material and from scrap products. The latter is what is problematic as products needs to be taken apart, but this is also the key enabler for making DCs a source of resources and create circularity of material.

A plastic target for AutoCo and their DC operations is definitely possible and could help increase the recycling rate of the plastic. This would mean a better income from waste contractors as sorted plastic waste is more valuable. AutoCo has to make a decision whether or not they want to standardise the view on plastic, as example some SDCs prevents plastic while others see it as a good material e.g. some use it as filling material. With the view of IKEA, AutoCo should consider who is the recipient of the plastic and what they will do with it. Nike has taken the stance in the specific decision of plastic filling material and removed the plastic pillows from outbound goods. This has been done even without a formulated plastic reduction target. Poor disposal might be a consequence that levels out the positive aspect of plastic such as lighter transportation. Targeting reduction of plastic might result in ineffective solutions, such as non-suitable packaging that makes the product go to scrap, which is the view of ICA. The view on plastic should not be yes or no to plastic, but rather a more circular view on how to reduce and reuse it. As multiple interviewees has stated, the knowledge on plastic is low within many companies and it is a topic many are debating.

Between the SDCs it can be seen in the waste data that plastic is measured and categorised differently. Some SDCs did not report any plastic while others did. This leaves room for suggesting a standardisation of what type of material should be sorted. Local adjustments needs to be made for the local contractors standards, but a SDC standard for the European region could be possible. This would help AutoCo better track their plastic and set a standard for the future when increased regulations might require separation of different types of plastic, and also help increase the profit on plastic. In order to start increasing the recycling of plastic there must be a baseline of how plastic is disposed currently, which a standardisation would enable.

5.2.3 Scrap Parts

Due to the different industries that the benchmarking companies operates in the waste targets are formulated differently in order to detect the most critical aspect within each industry. For two of the companies, ICA and IKEA, the measurable waste target is focused on scrap. For ICA this means preventing their main assortment, food, from being damaged during handling. The restaurants of IKEA is a big part of their business, but not their primary value offer. They have still included food waste reduction in their target, as the only quantifiable target. This is motivated in their annual report to be due to the immense amount of food waste in the world, where one third is estimated to go to waste. Therefore IKEA wants to highlight and help reduce the issue. Scrap targets in terms of products is not found among the other companies' annual reports. Only HP has taken the initiative to reuse old products in their production. Therefore they have a target of taking back a certain volume of products and hence, a quantifiable measure on scrap. This is something AutoCo could investigate further and try to set a target that will increase the reuse of old products such as HP has done.

5.2.4 Regulations of today

Looking at the packaging waste directive from the European Parliament (1994) it can be seen that there for a long time have been regulations for preventing and reducing packaging. This has become stricter as the packaging directive was amended 2018 (European Parliament, 2018). The consciousness among companies and AutoCo of these regulations is unclear. It was not asked about in the interviews, but neither was it brought up by the persons interviewed. The regulation is solely for packaging, and as all types of waste in have been included, it is hard to identify how much further that AutoCo needs to go in order to achieve these targets. The current average recycling level at the SDCs of Europe is 78% . This can be compared to the data from the only company that has it published for its DCs separately, Nike. Their recycling rate of all their DC waste is 87%, and this is their global numbers. In order to meet the regulations of 2025 AutoCo needs to create an understanding of how much plastic is recycled, as this can be expected to be the most challenging to achieve. Not many DCs know what actually is done with their plastic, and after discussing with the waste contractor Stena Recycling it was understood that much plastic also goes into general waste and is automatically incinerated.

Some of the employees at AutoCo mentioned the increasing amount of electronics components included in the end-product and expressed concerns of how this might change the requirements on the service market. Increased electronics components does not only make the parts more complex and increases complexity in product development and sourcing, it will increase the amount of WEEE that AutoCo's DCs generate and therefore be part of a stricter regulated waste fraction. The WEEE directive (European Parliament, 2012) requires stricter collection and treatment. HP are strongly affected by this regulation and expressed in the interview that it is something they have to work a lot with. As mentioned, HP has taken the advantage

of the return system of their products and take back more than just the electronics. Not if, but when, AutoCo reaches the stage that WEEE both from DCs and dealers become a substantial amount they can consider recycling full parts. As some parts are already being re-manufactured there is the potential to expand this scope to electronics parts which needs special end-of-life treatment.

The impact of the COVID-19 pandemic has scarcely been mentioned in this study. One effect of the pandemic is the impact it has had on the economy in Europe. The EU has decided to give financial support to many affected industries, and in order to finance this the plastic taxes has risen. Now the cost per kilo is €0.8/kilogram. This is not something new, plastic taxes has been in place already since January 2018. This puts even more focus on the previous suggestion of AutoCo to start mapping and working with the plastic material flowing in the distribution chain.

5.2.5 Setting new targets

This study is focused on the distribution chain from CDC out to dealer, but it is evident that for bigger changes more parts of the organisation needs to be evolved. Since the benchmarking companies' targets were extracted from their annual report they were general for the whole organisation and is compared in the format of table 5.5. The targets that will affect the amount of waste in the DC operations is included, as can be seen this starts already in the product design phase. The targets extracted from the benchmarking companies are in some cases hard to distinguish from actions taken but the content of the table should be read as targets for each stage in order to reduce waste. The targets are a mix of reducing waste from scrap and from products.

Value chain stage	Target	Measure	Inspired by
Product Design	Easily separated products		HP
Packaging Design	Minimising material Design for reusability		IKEA Husqvarna Nike
DC Operations	Overall waste reduction Plastic standardisation	Waste (kg) per order line	NIKE IKEA Access Solutions
End-of-life	Take-back products No incineration	Take back volumes (kg)	HP

Table 5.5: Targets that AutoCo can be inspired by and investigate further in order to reduce the amount of waste in the value chain, primarily focused on what ends up at DCs and dealers.

When AutoCo is setting targets for actual waste reduction they need to consider what of the suggested targets, see table 5.5 will have the most impact for the DCs and what is the most feasible. The benchmarking has shown that some companies are ahead in multiple aspects and that stricter recycling regulations will require more ambitious targets. Most importantly, a strong thinking around circularity is what the best performers have communicated, rather than having a fixed measurement. Incineration should be avoided and plastic needs to be investigated further, it is not a yes or no decision, but a how to make it better in terms of circularity.

5.3 What are the key actions to prevent waste or reuse waste from DCs?

Identifying key actions to prevent waste is of importance as it can help AutoCo get one step closer to its goal of becoming climate neutral by 2025. When evaluating key actions, the company can look at both what is done internally at the different sites but also on other companies to identify possibilities of what to improve. As this study mainly focuses on how to prevent waste from DC operations that will be the main focus of this discussion section. Some reuse and recycle ideas were found in the result which will also be discussed.

5.3.1 Environmental Awareness

Historically, cost has been prioritised over environmental aspects in many central functions at AutoCo. However, this has started to change slightly as more environmental aspects have been raised in order to comply with regulations as well as economic incentives relating to increased environmental awareness and social pressure from society.

Within AutoCo there is generally a mature view on recycling and efforts to remove waste. Many sites recycle most of the waste that is generated and several sites have applied for the certification as landfill free which indicates that the departments within AutoCo are ready to advance toward higher levels in the waste hierarchy.

However, between DCs and across central functions the view on plastic and importance of plastic reduction is differing greatly. Some has the same perspective as IKEA, to reduce as much as possible even though there are no specific targets for it while others take the view of that plastic can in some cases be unavoidable or better than paper, similar to the view of ICA.

Relating to the differing perspectives on plastic, the DCs also have differing views on filling material. Some choose filling material based on what they consider to be most environmentally friendly, some based on weight as they want to pay less for transportation, hence still mostly considering the cost perspective while others like SDC UK have chosen to remove filling material. Therefore it would be interesting

to dive further into the no filling material approach to see whether if it has an effect on quality or not. If not, it can be seen as a potential and something worth investigating across other sites as well.

Within AutoCo, most of SDCs do what they can on an operational level to handle the waste through recycling and reuse to the extent possible. However, it is on central level that the larger changes related to prevent waste can be achieved but also where the environmental awareness is lacking.

5.3.2 Packaging

Packaging has been found to be one of the largest waste streams. This was both the perception communicated by DC employees and reflected in the waste data.

Prevent

In order to prevent waste from packaging two main actions has been identified, top-down change of packaging perspective and bottom-up operational improvements. These actions will result in operational effects that will prevent waste since less material will be used, less packaging will be damaged, less material will end up at dealers and less handling of packaging will be needed by DC operators. These actions and their effects is displayed in figure 5.4.

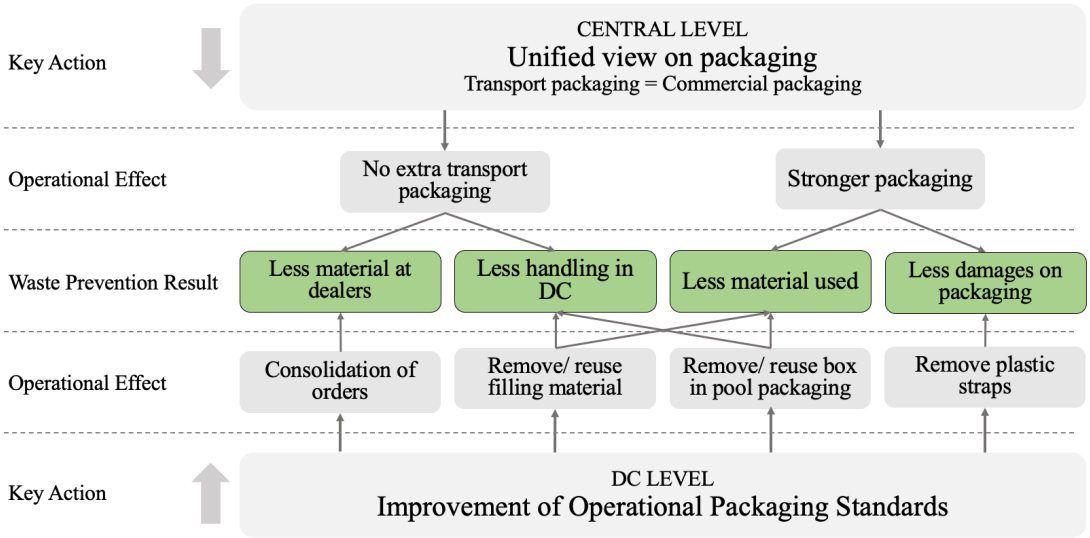

Figure 5.4: In order to prevent waste from packaging the actions must come both from central top down initiatives and from bottom up operational process improvements

The top-down actions mainly concern the current separation between commercial

and transport packaging. Commercial packaging is managed by its own department while transport packaging is managed at a DC level. In bright contrast, at least two of the interviewed benchmarking companies have a different approach when it comes to packaging. There is no differentiation between commercial or transport packaging, all is managed as one solution being used all the way from manufacturing, through distribution and out to dealer or customer. This is both IKEA's and HP's practice. The packaging is still branded but in most cases packed as it is on pallets and used as primary packaging all the way through the distribution chain. Adapting this way of looking at packaging would be beneficial in multiple ways for AutoCo.

First of all, the removal of extra transport packaging will result in less material ending up at dealers and therefore less waste for them to manage. Excessive amount of packaging has been a complaint reported both to the central organisation as well as to DCs. Less packaging material will result in less handling for the DC operators as well and they will save time packing the orders. A packaging solution that can be sent as-is will result in one step less in the pick-and-pack process. The trade-off when moving towards a packaging solution that does not need transport packaging is how specific for each product the packaging should be. An assortment of ten different sizes will create excessive space in the packaging, while many different, or even product specific packaging sizes, will make the packaging more expensive.

Secondly, a stronger packaging will result in less damaged commercial packaging in handling. Currently the thin commercial packaging breaks when handled at DCs as plastic bands are used to strap them onto pallets. This can also be solved by removing the plastic straps, which will be discussed later. Overall the main advantage of using both less transport packaging and using stronger packaging instead is that it will generate less material usage.

If AutoCo would like to move into the suggested direction and integrate the commercial packaging and transport packaging it does not and shouldn't be done to all products and not simultaneously. Figure 5.5 shows a suggested prioritisation tree for which type of products that should have a sturdier commercial packaging to begin with. The segment of products that can be sent with one type of packaging all the way should include those sharing the same characteristics as HP's parts which they send with one packaging solution through the distribution chain all the way to the customer. To start with it is the most interesting to investigate if some parts are sent as day orders. The parts that are most commonly sent as order type 0 or 1, meaning either VOR or day orders should be prioritised as they are usually sent alone and not consolidated with any other parts. Stock orders uses pool packaging and it needs further research to determine how a new packaging solution would affect the use of pool packaging. It is more interesting to look at the parts that have some kind of commercial packaging. Commercial packaging is most commonly used to keep the part together with its sub-components, if it has any, and brand the product from a marketing perspective. If the part is not sold over the counter it means it is installed directly into the vehicle in the workshop. Those parts that goes straight into the vehicle will not be seen by the end- customer and the branding perspective

will be less important. Therefore, these parts are most interesting to start to look at.

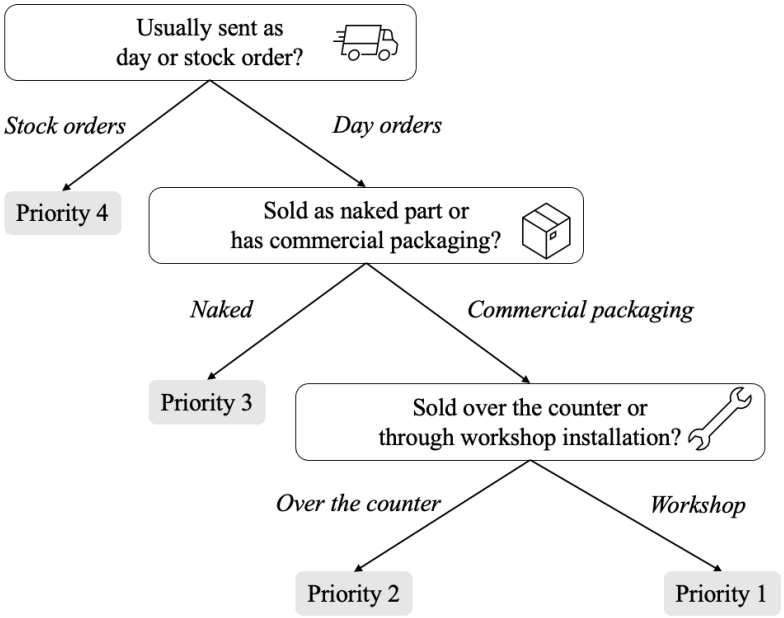

Figure 5.5: This is suggested hierarchy of priority for where to start with merging commercial packaging and transport packaging into one solution.

Moving on to the bottom-up actions that can be taken as per figure 5.4. These suggestions will mainly affect how the DCs operate and will have to be implemented in collaboration with the central functions of SML. The different DCs operates in different ways. The first difference is the way orders are shipped, whether they are consolidated or not. For the bigger DCs the one-piece-flow currently in use was implemented a couple of years ago and before that all parts going to the same dealer were sent together. In order to reduce the box-in-box issue, meaning that dealers receives parts in multiple layers of packaging material, the consolidation point has to come earlier in the picking process. The decision by AutoCo to not consolidate the pick-and-pack process was partly based on quality concerns and the need to reduce picking errors. This is a valid reason, but partly increased consolidation could be implemented at DCs with smaller assortment. None of the benchmarking companies expressed that they had a single-piece flow to the same extent as AutoCo.

Secondly, the DCs used different types of filling material. Some DCs used plastic pillows, some used reused material from inbound goods, others use new material solely bought for the purpose of being filling material, and most interesting, two SDCs do not use any filling material. In order to prevent waste, less material must be used, therefore it is suggested that the alternative of reducing the usage of filling material should be further investigated. It was claimed by the SDC not using filling material that no changes in volume of damaged goods had been noticed. This goes well in hand with the the benchmarking findings where several companies explained

that they work with reducing the amount of packaging and that over-packaging was common. Less filling material would also reduce the handling for the DC operators and decrease the handling time for orders.

Third, the DCs can increase the efficient usage of the small paper boxes used in the pool packaging. The small, very thin, paper boxes are added by the CDC for refill orders to SDCs. At the SDCs these are thrown away as they are too fragile to reuse. These boxes could be redesigned in order to serve a second purpose once it reaches the SDC. For example they could be designed to serve as outbound packaging or as filling material. The best option would be if the paper box can be removed and replaced by something more long-lasting that can be returned in the pool packaging. Similar to the removal of filling material this would result in less handling of material and less material used which will reduce the amount of waste generated.

Fourth and final are the operational changes regarding the plastic straps. It was observed that commercial packaging in some cases got damaged by the plastic bands used for strapping boxes onto the pallet. Therefore, it could be beneficial to review alternative options for plastic bands to see if there are alternatives that does not damage the boxes during the transportation or handling. The result is the same as having stronger packaging as it would result in prevention of damages on packaging.

Reuse

In the previous section actions for preventing waste from packaging was discussed. If AutoCo is not able to prevent waste then reuse becomes essential. The SDCs brought up reuse as an action taken to reduce waste and this was without being asked whether or not they did reuse the packaging. SDC Finland claimed their success in reducing waste was due to the increased reuse of packaging material. SDC Sweden, which can be seen as having a relatively high waste volume was one of the few that said they only reused packaging material to a limited extent within the DC.

A good inspiration is Nike's reuse-a-box program that they have rolled out within their DCs. This means using a reused box for outbound shipments. A way to move in this direction is to better design the outbound packaging from CDCs so they can be reused as outbound in SDCs. This packaging is usually pool packaging, but the paper boxes inside the pool packaging, as mentioned in section 5.3.2, can be better designed for reuse.

As also mentioned in the Prevent section, the filling material can potentially be removed. If filling material must be used it should be primarily sourced from old inbound packaging material instead of new material. In order to achieve this change there must be a collaboration between CDC and SDC, as the former feeds the second with packaging material that is the source for reuse.

Recycle

AutoCo is already doing well within recycling and as the focus of this study is to achieve the highest step of the waste hierarchy, prevent waste, this has not been in focus. However, some good practices have been discovered both in the interviews and in the benchmarking that should be mentioned. As the regulations are strict within the country that CDC Belgium operates, they have to sort their waste into many categories. This gives a very detailed overview of what are the main drivers and how many different types of plastic they receive. Some SDCs do not sort their waste solely in regards to what material it is but instead sorted some materials into categories named after its disposal or recycling method. This created categories such as "burnable" and "energy" which is problematic as it does not say at what quantities of each material it includes. The same goes for categories called "mixed waste" which for some DCs accounts for more than 50% of their total waste. This type of reporting on waste makes it problematic to increase the recyclability. This also implies that the data is poor and subject to variation across the DCs. DCs already report on how much they recycle, incinerate and put to landfill, but not what it consists of. For example, in order to know how much plastic is recycled, the plastic has to be both sorted and measured, and the contractor has to report what they do with it. The lack of standardisation of data also makes DC operators unaware of what is happening to their waste. As previously mentioned, plastic is in many cases not recycled even if it is sorted and therefore perceived that it will automatically be recycled.

In order to increase the recycling of packaging material the main action for AutoCo to take is to reduce the different types of materials and ensure that they are easily separated. This is done well in many aspects but can also be improved when it comes to plastic labels on cardboard as it makes the box less reusable and creates a mix of plastic and cardboard when it goes to recycling. Most important is to standardise what types of plastic is sent from the CDCs out to the SDCs and to ensure the use of a type of plastic that the SDCs' local contractors can recycle.

5.3.3 Scrap Parts

The second of the two largest waste streams is scrap products, resulting in primarily metal but also some plastic waste and electronic waste.

Prevent

In order to prevent waste generated from scrap products, several actions have been identified. Some of these changes lies within the scope of SML while other changes are mainly within the responsibility of other departments of AutoCo. Therefore, in order to be able to implement certain changes, cross-functional collaboration with other departments are needed. The proposed changes includes design for durable parts, improved forecasting process and damage control which are suggested in table 5.6. Depending on which change is considered, the change will need to take place in

different parts of the distribution chain. Some changes are required already in the design phase while others can be implemented later in operations.

Phase - Action	Prevent	Reuse	Recycle
Design	Durable parts that lasts longer	Design for reuse	Design for recycling. Easily separated, recycled material.
Production/ Remanufacturing	Continuous improvements of forecasting process	Remanufacturing Reuse raw material from scrap parts	Use material from scrap parts and recycled material
CDC	Prevent damages	Send to remanufacturing	Separate material –> increase scrap value
SDC	Prevent damages	Send to remanufacturing	Separate material –> increase scrap value
Dealer	Prevent damages	Send to remanufacturing	Send back to AutoCo

Table 5.6: How to prevent scrap as well as increase the circularity of material in each step of the value chain.

The idea behind the design for durable parts is to design and manufacture parts that last longer than the already existing ones. This will allow the part to be used for a longer period of time. Thus, the part will either be able to be replaced later than when it would otherwise have been or perhaps not at all, which means that fewer products will be needed and thereby counteract the generation of waste. A possible trade-off would be if more material would be needed or if other types of material that are more difficult to take care of in the next steps of the waste hierarchy - reuse, recycle and ultimately disposal would be affected negatively.

With continuous improvements of the forecasting process, this change is two-folded as it includes both forecasting regarding the total amount of parts to be produced of each type and forecasting regarding where the parts should be in the distribution chain in order to make the best use of it. Improving the forecasting process is something that AutoCo is already is working on. Improving the forecasting process is out of SMLs scope but is something that other departments, for example DIM, is already working on. DIM has launched the end-to-end project which aims to enhance the forecasting and movement of spare parts to optimise the dealer inventory processes which will ultimately get AutoCo one step closer of reaching the desired goal of no

scrap parts. The current improvements revolve around enabling execution of the forecasts in all nodes simultaneously. If improvements in the forecasting process is achieved, AutoCo believes that they can achieve a higher accuracy in where the parts will be needed, i.e. prevent stock-out, and that the parts are phased out at the right time which in turn would reduce the amount of scrap. Improving the forecasting accuracy is important for companies when they have to ensure availability of the products for a long time while not having too large stock left that needs to be scrapped due to obsolescence, a risk related to specific product characteristics and a high number of SKUs as mentioned by Cohen, N. Agrawal, and V. Agrawal (2006) and Dekker et al. (2013). AutoCo's preconditions differs to companies such as ICA and IKEA as their product assortment differs both in terms of how long they need to stock a product but also regards to how they can sell goods in another way to handle the phase-out of a product, either due to shifts in trends or expiration dates. AutoCo is instead more similar to Husqvarna in this sense, phasing out products due to changes or improvements of the parts' already existing features or due to new models of the product entering the market which changes what spare parts that are requested. Improving the forecasting accuracy might become increasingly important when the system needs to comply with both traditional automotive parts and new parts as a result of increased electrification.

In terms of damage control the parts suffer a risk of becoming damaged both when transported between sites, during handling inside the DC and during transportation to the dealer. Some of the waste have been confirmed by DCs to occur during these steps and therefore it is of weight to identify where in the distribution chain the damages occur in order to be able to prevent them. Once it has been identified where possible damages might occur AutoCo can start reviewing the processes and routines connected to that step in the distribution chain in order to see what can be improved and take appropriate action based on the root cause of the problem. For example, if a dealer would more or less often receive damaged parts from an SDC, it needs to be investigated if it is AutoCo's packaging that does not meet the standards, if the transport partners do not do their job at the level of quality promised or whether something else is the problem. This is considered to be the change that SML really has the opportunity to influence as they are responsible for the entire transport flow and handling between CDC and dealer.

Reuse

Since the circular economy concepts prioritises prevention of waste this has been the focus of the study. However, if AutoCo is not able to prevent waste, they should look at the next step of the waste hierarchy, to reuse waste. The different functions and actors within AutoCo can take different measures of action when it comes to reuse but also in this step the majority of the improvements lies outside the scope of SML.

On a higher level, in order for AutoCo to enable reuse and remanufacture, these aspects have to be considered already in the design phase. Having a design for reuse mindset and by considering the design already in the product design phase,

AutoCo can ensure that the parts are easy to separate, recycle and remanufacture once they have served their purpose and getting closer to their end-of-life phase, hence enabling the material to be reused again in new parts. Through this, AutoCo can minimise the amount of new material that needs to be extracted and processed which is a process that has a significant impact on the environment. Prepare for reuse can be considered to lie in between the prevent and reuse stage in the waste hierarchy but as the action in this context mainly focuses on not extracting more material than necessary, hence prevent, while still facilitating recycling and reuse, prepare for reuse is considered to be an action mainly belonging in the prevent category.

Also in the production step, there are opportunities for a reuse mindset. In this step the parts and the material can be reused in the production of new parts. Therefore the key action here is for AutoCo to start looking more into reuse of the scrap products that are generated, similar to HP who reuses e.g. recycled plastic for new parts so that their new product can consist of at least 35 % recycled plastic in the new product. This is connected to the reasoning regarding prepare for reuse. AutoCo has started re-manufacturing of parts on a small scale operational basis as they have identified benefits with not producing the parts from scratch. As discussed by Diener and Tillman (2015), re-manufacturing can contribute to increased material efficiency and reduction of impact on global warming. However, re-manufacturing comes with a trade-off. Many products can be re-manufactured, but it must also be economically profitable to both transport them back and re-manufacture them compared to disposal of the current product and extracting a new product from the start. For the most basic parts that neither does not consume that much material it may be less environmentally friendly for AutoCo to take the product back for re-manufacturing than simply scrapping it while for more complicated parts there may be both an economical and environmental incentive for re-manufacturing. Hence there is sometimes a trade-off and sometimes an alignment between environmental aspects and the cost aspects in this decision. However, these aspects limits the range of AutoCo's parts that will be possible to re-manufacture. The parts that are of most interest for AutoCo to investigate for developing the remanufacturing program are the ones that are more expensive and complicated to produce or the ones consisting of the most material as the margins for taking the product back for re-manufacturing will be higher, more material will be salvaged from extraction in the production phase and time savings from already performed work. Therefore, apart from the parts that AutoCo are already remanufacturing, it may be beneficial to look at parts that meet these design requirements and start looking at implementing a tack-back program for them. Through the take-back initiative, more parts and materials can be collected and reintroduced in production of new parts which would make remanfacturing more widespread in the organisation. The take-back procedure, i.e. how the parts should be brought back from the DCs and dealers to production, either through milk rounds or less frequent pick ups for example will require more research. In addition, the economic and environmental gains need further analysis.

What lies within the scope of SML in order to enable reuse of parts to a greater extent is to make sure that the parts are taken back and reaches the production/remanufacturing step. Hence, SML has the role of an enabler for the changes suggested as SML will work as an important cog in the readmission process. SML, including CDCs and SDCs, can contribute to reuse actions by sending parts that can be remanufactured back to production. They can also try to encourage dealers, both owned by AutoCo and private ones, to do the same. This can be compared to HP's take-back system. Hence, when the parts have reached their end-of-life AutoCo can use their nodes to gather parts and by doing this the parts, and more specifically the material that they are made of, can be used again and any parts of the part that cannot be used again can be recycled in a good manner.

Recycle

AutoCo is currently recycling most of its waste that is generated in the DCs. However, in order to facilitate the disassembly, sorting and recycling, hence work for improving recycling rates even further, AutoCo can make changes already in the design phase. By choosing material that can be recycled and easily separated, both today but also in the future, as the regulations keep getting stricter for how to handle and report waste, AutoCo can ensure that the material can be handled and taken care of in an appropriate way. To succeed, it can be of interest to collaborate with the waste contractor to a higher degree to see how to design parts as they have a lot of insight of what would be needed in order to improve the recycling rates further.

AutoCo are facing a reality with an increased number of electronic components in their spare parts assortment as the development in the industry is moving towards electrification and more advanced technology with for example sensors in the final product. This may complicate the recycling process as it may become more difficult to disassemble the product into the correct waste streams in order to take care of them properly. However, it is important to prepare for being able to recycle these types of material as the regulations for how to take care of electronic waste are very strict and companies needs to comply with regulations such as the Waste from Electrical and Electronic Equipment Directive (WEEE), something that is appropriate to prepare for already in the design phase.

In the production/remanufacturing step, AutoCo can start looking into whether they can use material from scrap parts and recycled material to a greater extent than today. This is, just like in the reuse phase, connected to the idea of having a higher degree of recycled material in the new products, similar to what HP is currently doing. By using recycled material into the products AutoCo can ensure that less new material needs to be extracted, something that would benefit the environment and reduce the generation of waste.

What lies within the scope of SML is to ensure that the waste are sorted into its components as it will both facilitate the recycling of the material but it can also be of economic interest for AutoCo. As the company receives compensation for its

waste, the purer the waste flows are, the higher the compensation. How thoroughly the waste is sorted is differing across sites, from CDC Belgium that have a wide range of bins and are tracking its waste and environmental impact with very high accuracy in comparison to other DCs which only categorise their waste into four different categories. Sorting the waste as mentioned by the waste contractor of SDC Sweden, is important in order for it to be recyclable. It can be considered that there are opportunities for improvement, as it is stated by the waste contractor that it is easier to handle the waste the more granular separated it is. Sorting the waste more accurately could be challenging for some of the DCs if the proper infrastructure in terms of appropriate waste contractors is not available. Some of the DCs, like SDC UK disassembles all its parts to its components while other DCs let the waste contractor take care of it, postponing the sorting of the waste further down the chain. If the waste would be sorted, and have the prerequisites of being sorted on site it would increase the value of the waste. However, the waste contractor of SDC Sweden also brings up other challenges connected to sorting on a more granular level as the sorting takes both time and space from AutoCo's core business, distributing spare parts, hence there is a trade-off between the extent of sorting, efficiency and economical incentives that needs to be taken into account. In the recycle step it is also of weight to involve the dealers and collaborate with them so they can send those parts that AutoCo can recycle and then use in production again back to AutoCo, similar to the recycling initiative of IKEA where the customers can return the waste to the warehouse for recycling.

5.3.4 Other waste streams

One of the top performers within sustainable warehouse operations, IKEA, has replaced all wood pallets with pallets made out of corrugated cardboard. This is a big task and when asked, most other benchmarking companies has reviewed this option but found the investment too big. The trade-off identified here is cost versus quality and environment. As paper pallets are only used one-way and reduces the amount of scrap wood it is a good initative on routes where there is no or limited return flows or in those flows where the DCs cannot use the pallets again. Some of the SDCs have large volumes of wood that they have to dispose each year which could be prevented. SDC Spain, for example, has a very high amount of wood waste in comparison to the other DCs which they claim mainly is derived from pallets received from suppliers of for example packaging material. Since they are scrapped they are not considered to be possible to reuse as of today, hence it is both beneficial to look into the opportunity of whether the pallets can be sold to other actors or reused in their own flow but also to investigate the possibility of implementing cardboard boxes on these deliveries as they would generate less waste.

6

Conclusions & Recommendations

Circular economy can prevent waste within many context, the distribution centre operations within a service market is one of them. The result of this study shows that there are both examples of good internal practices that can be standardised and used across all DCs, as well as new projects on a central level that can be initiated in order to decrease the waste generated at AutoCo.

The conclusions will address the three research questions and thereafter the recommendations to AutoCo will be presented.

6.1 Conclusions

Overall, the total waste generated in the DCs are increasing and the major waste categories that are managed by the DCs are plastic, cardboard and metal. The CDCs generate significantly more waste than SDC on average, three to four times more waste per shipped order line (WPO) than the SDC with the highest WPO. There is currently no evidence that the number of shipped order lines annually correlates with a higher WPO. The results are rather implying that it is the actions performed and overall environmental awareness within the DC that affects the WPO.

For the DCs, the waste categories cardboard and plastic are primarily driven by the use of excessive material whereas metal is primarily driven by scrapping of parts. The most problematic waste category to manage is considered to be scrap parts as it is both time-consuming to handle, disassemble and dispose.

There are multiple factors that needs to be considered when setting targets for waste prevention. The study showed that there can be a gap of information and implementation between the company-wide targets and the targets set at the department level. The benchmarking companies with the best practices had managed to create company wide implementations of the targets. Having some type of waste reduction target is seen as best practice but it differs in the way it is formulated. The best-performers have both measurable and non-measurable targets.

There is definitely room for AutoCo as a company to articulate more aggressive waste targets. It can be stated that the targets of the benchmarking companies are applicable to a certain extent but much is dependent on the collaboration between SML and other departments. One example is minimisation of material. This needs

to be considered not only in the operations but already in the design phase and throughout the value chain. As it was found that scrap and packaging material are the biggest drivers of waste these sources should be specifically targeted. Waste per order line could be applicable but the number of scrap orders and infrequent emptying of some of the waste categories skews the waste volumes and this will need to be taken into consideration in the measurement.

Among the companies in the benchmarking it was common to have a particular target for plastic. However, formulation and level of ambition differed greatly across the companies. Some of the companies state that total elimination of plastic is desired whereas some wanted to limit the use. AutoCo should take a stance in how targets shall be formulated within the company as it was observed that there are different opinions across the DCs. An overall ban or general reduction is not the only option. Instead a standardisation target of using as few different types of plastic could be suitable, where increased recycling of plastic is the ultimate objective. Plastic is the most problematic material to sort and future regulations and taxes on plastic further motivates better tracking and targeting of plastic.

In order to prevent waste, AutoCo can take several measures on a central and DC level. Overall the most important ones are to increase the environmental awareness on a central level and include key measurements when deciding to scrap parts as well as when designing packaging. On a DC level there are multiple actions that can be taken immediately that will improve the waste management.

First of all, preventing packaging material needs to be done through collaboration both between central functions and DCs as well as between CDCs and SDCs. Unifying the view on packaging mean that the commercial packaging department takes a more holistic view. This would enable actions where the commercial packaging is in some cases developed to act as transport packaging as well. More durable packaging solutions will decrease the amount of damages in DC handling. A commercial packaging that does not need transport packaging would also result in less handling for both dealers and within DCs as there is one less packaging to manage. Most importantly, a removed transport packaging would result in less material used and less material put to waste. This will be further leveraged if DC operational improvements are made, such as increased reuse of material, consolidation of orders and removal of all excessive packaging material. Excessive material identified is foremost filling material that should be further investigated to see if it can be decreased or fully removed.

Secondly, scrapping of parts is a big driver of waste which should be prevented to the greatest extent possible, even though it is impossible to eliminate. There are ongoing efforts to reduce the amount of scrap as it is strongly correlated to cost. Still, there are identified actions that can be taken. The parts should overall be designed to enable more convenient handling once they turn to scrap. This means more easily separated parts and materials that can be recycled. There should also be environmental factors considered when deciding to scrap a part. This is outside the

work of SML and needs long-term collaboration with the DIM department among others. Immediate actions that SML can take is to ensure that as much as possible of the scrapped parts are disposed correctly. For parts that become scrap at dealers there should be further research done to investigate if the parts can be taken back for recycling at DCs in order to prevent the dealer from disposing them incorrectly. An even better solution would be to benefit from the scrap products as a source of material in production. Another way of increasing the reuse before disposing is to increase the assortment of parts that are re-manufactured.

6.2 Recommendations

For the practical relevance of this study a summary of the conclusions and what these implies for AutoCo will be presented.

6.2.1 Major Improvements

Actions that can be implemented in a longer time perspective.

- Investigate the possibility to extend re-manufacturing to include more parts that otherwise would go to scrap. If re-manufacturing is not possible, reuse and recycling of material within AutoCo's production should be investigated.

- Implement a holistic perspective on packaging in order to reduce the amount of packaging material needed and increase the re-usability in the distribution chain. This needs to be reflected in the organisational structure, both regarding the responsibilities for transport packaging as well as the networks connecting different aspects of the product development all the way to the DC operations.

- Create collaboration between SML and product design to increase recyclability and separability of parts to enable easier handling and disposal.

- Prepare for a compliant recycling infrastructure of electronics components. The increased amount of electronics in the products will require higher control of how the parts are disposed which needs to be taken into consideration in future operations. This includes both the DC level as well as the dealers.

6.2.2 Moderate Improvements

Actions that could be implemented within a medium-length time span.

- Investigate what assortment of parts can have a commercial packaging that is robust enough to not need a transport packaging, i.e. the transport and

commercial packaging is combined into one solution.

- Start reporting at SDC level how much waste is sorted into which category in order to improve the data. The waste categories need to be standardised and specified in terms of what waste should be included in which category. This is important in order to set targets and to track the progress. The waste data will need to be tracked in the larger data system of AutoCo.

- Increase the environmental awareness in central functions. This can be done by implementing sustainability parameters in decisions concerning scrapping of parts and in the packaging development.

- Integrate disassembly to a greater extent in operations to enhance the value of the waste and increase the financial compensation of waste sorting.

6.2.3 Minor Improvements

Actions that can be implemented within a short time-span.

- Investigate whether the filling material in parcels sent from CDCs and SDCs can be fully removed. If not, investigate how the reuse can be increased.

- Start searching for new materials that can replace the plastic straps that cuts through and damages commercial packaging.

- Find a new solution to replace single-use boxes in pool packaging. Either with return packaging or a better way to pack the parts where the single-use boxes are not needed.

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A

Interview Templates

A.1 Template for SDC interviews

Starting by introducing ourselves and our topic for the thesis as well as asking if the interviewee is fine with the interview being recorded.

Waste Streams

- What do you perceive as the main driver of waste in the DC? E.g. packaging, plastic, dead stock etc.
- What type of waste is most problematic to manage at the site?
- Is this the same as the most problematic to recycle?
- Is this the same as the most problematic to sort?
- Do you perceive that you have the same preconditions as other SDCs to manage waste? (E.g. regulations, access to contractors etc.)

Waste data

Questions based on the specific SDC's waste data.

- Is this data collected by you or by a waste contractor?
- How much of the waste is sorted at the DC?
- Is each waste stream possible to break down further?
- What are the drivers to waste within each waste stream/fraction? (within plastic this would for example be plastic bags, PET bottles, plastic bands, plastic bags etc.)

Deadstock/ returns

- How is dead stock sorted and disposed?
- How are returned parts managed or disposed?

Benchmarking

- Do you know any other company that does particularly well in distribution centre operations and climate neutrality?
- Do you think a waste reduction target would be possible to have?
- Do you think it is necessary?

Key Actions

- What have you done in order to reduce waste?
- What do you see as next steps for reducing waste?

- Do you have any specific ideas or opinions on how to reduce scrap from both dead stock and packaging or actions required? (from both central departments such as packaging as well as within the CDCs operations)

Dealers

- How many dealers do you have?
- Do you measure your waste to market? If so, how?
- At what level of detail do you measure it?
- Do you have any dialogue with the dealers on packaging?
- Do you collaborate with the dealers in some way?
- Do you re-use packaging material out to dealers?
- Have you received any complaints from dealers?
- How many of the dealers are part of the packaging pool?
- What do you use as filling material?
- Do you think the responsibility or possibility to reduce waste from DC operations are located at a DC level or at Volvo Group centrally?

Final questions

- Do you think there is anyone else we should talk within AutoCo to that might have further insights of this?
- Further question of data, can you send us, or know who can?
- How much packaging do you purchase monthly or annually in volume?

A.2 Template for Benchmarking

Starting by introducing ourselves and our topic for the thesis as well as asking if the interviewee is fine with the interview being recorded.

- What type of waste do you have within your supply chain and your distribution centers? (e.g. plastic and cardboard)
- Can you describe the packaging process in the warehouses, do you consolidate or do you have one piece flow? (does it differ between stores and private customers?)
- How to do measure waste from your distribution centers? What is included and to what detail?
- What actions have you taken to prevent waste? Ongoing and previous projects?
- How do you handle outgoing/discontinued products?