



© Plastindustrien

Recycling plastic packaging waste from households

– A study of recycling challenges and market opportunities for the recycled waste fraction

Camilla Fløe Cruse Henriksen

Master's Thesis – MSc. Management of Innovation and Business Development

Supervisor: Carsten Greve, Department of Organization

61 pages and 149,342 STU (equivalent to 66 pages)

Copenhagen Business School

March 15, 2017

Abstract



In a world where the resources we use are finite and the pressure on them is constantly growing, the traditional linear economy in which resources are taken to make products, that are then used before being disposed as waste (also known as the take-make-use-dispose economic model), is no longer feasible. Circular economy is often seen as a solution to the problem, given that it seeks to prolong product lives and to close value chains in order to make economic growth independent of the world's scarce resources. Part of the transition from a linear to a circular economy evolves around the recycling of products, and this thesis seeks to understand the challenges that lie within this subject.

Given Europe's increased consumption of plastics, and the large amounts of it being discarded as waste, especially in the form of packaging, the thesis aims at gaining more knowledge of the issues associated with recycling of waste. More specifically, the waste fraction collected from households in Denmark is the topic of the thesis. In addition to trying to understand the main challenges that lie with the increased recycling of household plastic packaging waste, the study attempts to identify actions required to close the value chain. The study first seeks an understanding of the challenges with recycling and a circular economy from available theory and literature. Next, six Danish companies and institutions are investigated because of their involvement in the plastic value chain, aiming to understand each company's point of view and experience with regard to the aim of increasing recycling rates of the waste fraction. The information gained from reports and the empirical data is used to identify the biggest challenges with recycling plastic packaging collected from households.

Evaluating these challenges with the theories and reports presented, the study identifies eight activities required by the Danish government, European Union, other public institutions, and/or private companies in the immediate future. These activities involve raising public awareness of the subject of recycling, increasing the recyclability of packaging products, implementing homogeneous waste collection systems, and lastly ensuring that secondary raw materials can be used in the production of new goods, and to incentivize this use. These activities represent the most important changes to be made nationally, if a transition from a linear to a circular economy is to take place.

Plastic packaging overview

The most common types of plastic packaging are seen in the table below¹.

Logo	Name of fraction	Commonly used in
 PET	Polyethylene Terephthalate	Fizzy drink and water bottles. Salad trays.
 HDPE	High Density Polyethylene	Milk bottles, bleach, cleaners and most shampoo bottles.
 PVC	Polyvinyl Chloride	Rigid PVC: Pipes, fittings, window and door frames. PVC Foam: Thermal insulation and automotive parts.
 LDPE	Low Density Polyethylene	Carrier bags, bin liners and packaging films.
 PP	Polypropylene	Margarine tubs, microwaveable meal trays (also produced as fibers and filaments for carpets, wall coverings and vehicle upholstery).
 PS	Polystyrene	Yoghurt pots, foam hamburger boxes and egg cartons, plastic cutlery, protective packaging for electronic goods and toys. Insulating material in the building and construction industry.
 OTHER	Other (often PC or ABS)	Beverage bottles, baby milk bottles, compact discs, sunglasses and automotive headlamps.

¹ Information taken from www.wrap.org.uk (website of the sustainable British organization, WRAP).

Table of Contents

ABSTRACT	1
PLASTIC PACKAGING OVERVIEW	2
TABLE OF CONTENTS	3
INTRODUCTION	4
LITERATURE REVIEW	5
SETTING THE SCENE	6
PRESENTATION OF THEORY	8
<i>Circular Economy</i>	8
<i>Recycling of plastic</i>	10
<i>Reasons for becoming sustainable</i>	11
<i>Sustainability and collaboration</i>	12
REPORTS ON PLASTIC PACKAGING WASTE AND THE RECYCLING HEREOF	13
<i>The Nordic Council of Ministers' Reports</i>	14
Moving towards a circular economy	14
Collection & recycling of plastic waste	15
Future solutions for Nordic plastic recycling	18
<i>Recyclability by Design</i>	19
<i>Recycled plastic: From household waste to household waste sorting system</i>	21
<i>Stimulation of market-driven demand for recycled plastic in the value chain</i>	22
<i>Limitations</i>	26
ANALYTICAL FRAMEWORK	26
METHODOLOGY	28
INTENDED APPROACH	30
ACTUAL APPROACH	31
ANALYSIS	34
CHALLENGES FOR A TRANSITION FROM A LINEAR TO A CIRCULAR ECONOMY	34
1. <i>Quantity and quality</i>	34
1.1 Low quantity and poor quality of collected plastic packaging waste	34
1.2 Little recyclable nature of new plastic packaging products	38
1.3 (Too) high quality of new products stemming from product requirements	39
1.4 (Too) high quality of new products – demanded by consumers	39
2. <i>Little public awareness</i>	41
3. <i>Little market for recycled plastic packaging</i>	42
4. <i>Limited recycling capacity</i>	43
REQUIRED ACTIVITIES	43
DISCUSSION	50
CONCLUSION	60
REFERENCES	62
APPENDICES	66

Introduction

In a world where resources and materials are finite (Ellen MacArthur Foundation, 2015) and the consumption of plastics is increasing, the subject of circular economy is high on the agenda in today's society (Snällfot, Leisner, Skovgaard, & Warberg Larsen, 2013). There is a need to rethink how the available resources and materials are used, and how product lives may be extended to relieve the pressure on the scarce resources.

Denmark is one of the countries in Europe, which produces the most waste per inhabitant (about 447kg per annum in 2011), and the country has a tradition of incinerating its waste to a much greater degree than other countries (about 80% of household waste is being incinerated) (Danish Government, 2013). With the European Union having set a target whereby member countries have to recycle at least 50% of household waste by 2020 (European Commission, 2014b), major changes need to be implemented in the current Danish waste system. Especially the plastic packaging waste fraction require changes, given that almost 70% of the plastic waste collected from households originates from packaging (Danish Government, 2013). In response to the European Union's recycling target, the Danish government launched a resource strategy in 2013 to get the country to start thinking about increased recycling rates and greater use of secondary raw materials (Danish Government, 2013). In this strategy are national recycling goals, governmental initiatives to promote the transition from the country's current linear economy to a circular economy and recommendations to municipalities, companies and citizens for how they may help this economic change.

Based on these facts, this thesis studies the plastic packaging waste fraction and the market for the recycled material. More specifically, it studies the challenges related to higher recycling rates of this specific fraction and the opportunities that exist with such increased rates. In order to guide the research, the following research question is formulated:

How can the market for recycled plastic packaging from households be increased?
What are the actions required in the immediate future to increase the use of recycled plastic packaging, and from whom are they required?

In order to answer this research question, the paper first presents and defines the notions of circular economy and recycling in order to show how these two are understood throughout the rest of this paper. Then, the literature chapter sets the scene in order to understand the issue at hand, after which relevant theory is presented. Both circular economy, recycling, sustainability and collaboration theories are included in order to establish a theoretical base for the paper's analysis. Adding to this base, publically available reports on the topic of recycling produced by companies, organizations and institutions are introduced. Based on these, an analytical framework is then created with the aim of guiding the analysis and to allow for a structure throughout the paper. After this literature review and presentation of the analytical framework, a methodological section follows. The philosophical assumptions made by the researcher and the methods applied to conduct the research are described. Ultimately, a short presentation of the companies studied follows.

Subsequently, the analytical chapter follows the framework created in order to discover the biggest challenges with increased recycling of household plastic packaging waste. Once these are found and examined, a number of required activities are presented as suggestions for initiatives, which both public institutions and private companies in Denmark may take in the near future as steps towards a transition to circular economy. These activities are identified as the most important actions required to relieve the market for the existing biggest challenges. After the analysis, the discussion evaluates the research in its entirety, the theories and methods used in the study and lastly the validity of the findings. Finally, the thesis has a concluding chapter in which the research question is answered and the entire study is summed up. The concluding chapter finishes off the thesis with brief reflections for future research.

Literature Review

This section will present existing theories on topics related to the study's focus. However, given that the topic of recycling and circular economy remains rather new and "hot" topics, and that recycling of plastic packaging is such a specific area of study within this topic, the theories relevant for this thesis' research will have to remain quite general. For this reason,

these are supplemented with publically available reports and case study papers on the topics of circular economy, recycling of plastic and household waste. The theories reviewed below, have been chosen with the conviction that they may help get an understanding of the general topic (circular economy, recycling), whereafter they may facilitate the understanding of this paper's specific subject: recycling of household plastic packaging.

First, the study has a section defining and explaining the concept of circular economy. Following this, the chapter presents theories suggesting why companies should engage in sustainable activities (and thereby join the transition towards a circular economy). Subsequently, the study will review theories suggesting a link between sustainability initiatives and companies' innovativeness as well as on how collaboration may or may not help circular economy transition.

Setting the scene

Living in a world where resources have become more and more scarce, the need to reinvent the way these are used and viewed has become a serious matter (European Commission, 2014a). Not only attempting to reduce the vicious effect our handling of resources have on the globe, but also trying to make the available resources last longer, sustainability has become a much discussed topic in today's world. With sustainable development being defined as the ability of our generation to meet current needs without compromising the future generations' ability of meeting their needs (World Commission on Environment and Development, 1987), researchers and scientists have increasingly looked into how to redefine the value chain that we know today.

Among the popular topics that have risen as a consequence of this, the circular economy of consumption goods is especially popular. The Ellen MacArthur Foundation provides a widely accepted definition of the term circular economy, namely it being "... one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles." (2015, p. 2). The value chain is thus no longer to be considered as a take-make-use-dispose activity, but rather a re-use and recycle one (Ellen MacArthur Foundation, 2016).

Before delving into existing theories of the circularity of our economy, it is important to note, as mentioned earlier, that the topic remains relatively new, and the theories related to it therefore often are unfinished or unproven. Evidence of this is seen in the titles of the published papers, which include wording like “introductory note on”, “moving towards”, and “interrogating” (Andersen, 2007; Gregson, Crang, Fuller, & Holmes, 2015; Kiørboe, Sramkova, & Krarup, 2015). This is also the case for papers on recycling and the future of plastics: “new”, “future solutions”, “guidelines” etc. (Ellen MacArthur Foundation, 2016; Fråne, Stenmarck, Gíslason, Løkke et al., 2014; 2015a). A clear pattern stands out in all of these titles, namely a precaution in suggesting best practices or developing models to act upon. While recent and maybe still unproven theories may not be the ideal material to back up any arguments made on the topic, this is a natural consequence of writing a thesis about such a contemporary subject. Thus, well aware of the possible weakness of any argument or conclusion based on these theories made in the thesis, a review of existing research and reports made by official institutions, governmental organizations and the like will follow the theoretical review of literature. These will serve the purpose of supporting the theories reviewed in an attempt to strengthen the arguments made in this thesis.

Digging into the theories existing on circular economy, many researchers have indeed looked into the closing of value chains (as suggested by the Ellen MacArthur Foundation above), which entail making the best use of what has already been discarded (for instance, by creating new products from waste). In another line of thought, some researchers believe that circular economy entails minimizing waste production and recover entire products to be kept in the economy for as long as possible (Hazell, Hill, & Benton, 2014). While the latter may be the most desirable outcome (see the EU waste management hierarchy in Figure 1 below), it is far more time-consuming than an attempt to recycle and re-use the waste produced today, and it requires vast amounts of changes in production, design, packaging etc. With the belief of the former perspective (re-use and recycling of existing products) being the most plausible solution for the near future, the theoretical focus of this thesis will be within this perspective only, and will disregard the subject of waste prevention entirely.

While the European Commission defines waste as “any substance or object, which the holder discards or intends or is required to discard” (European Commission, 2008, p. 9), redefining

waste is necessary in order to enable a transition towards a circular economy. Waste needs to be perceived as something that may be a resource to someone else. It needs to be something that can either be *re-used* or *recycled*. Re-use is the act of using a certain product again for the same purpose for which it was conceived, and recycling may be defined as any kind of recovery of waste materials being turned into resources and used again (European Commission, 2008). These resources may be similar to the materials' original purpose, but may also be for new purposes.

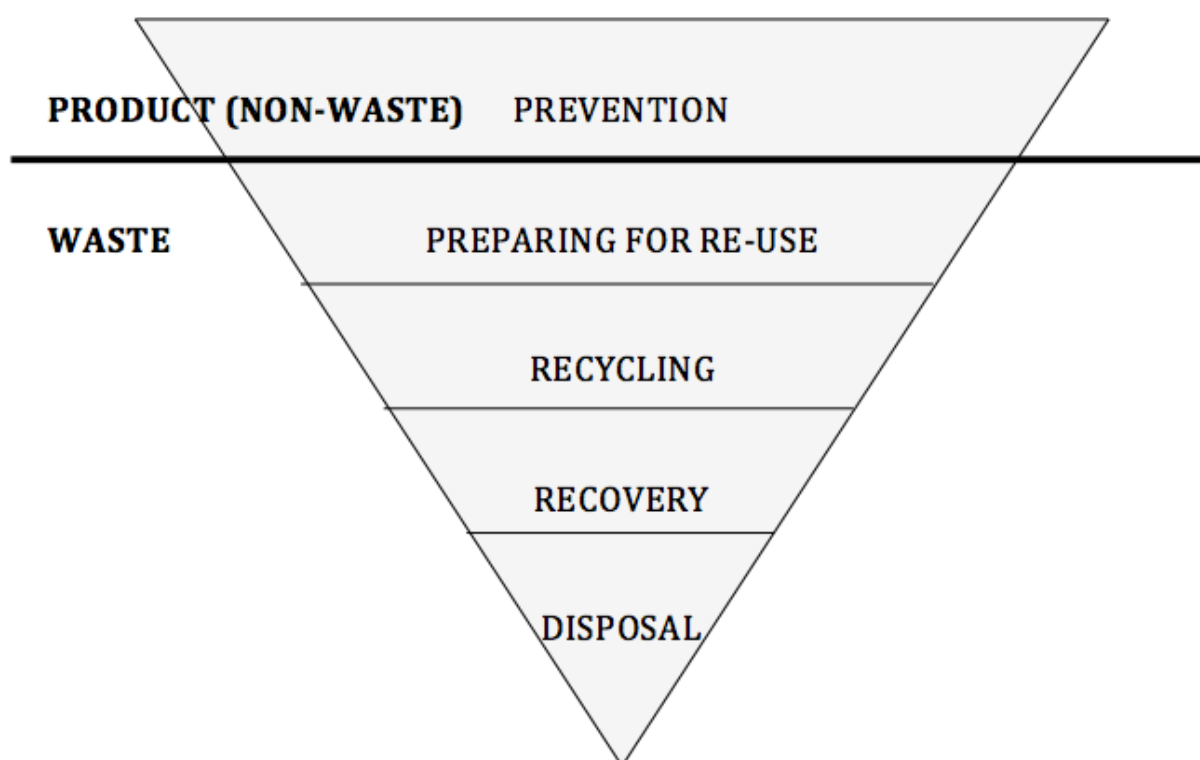


Figure 1 The EU Waste Management Hierarchy (Directive 2008/98/EC on waste (waste framework directive)).

Presentation of theory

Circular Economy

In a paper about the challenges with a circular economy, Gregson, Crang, Fuller and Holmes (2015) explain their understanding of circular economy as being either about creating an industrial symbiosis – i.e. exchanging by-products and waste with other companies aiming at giving a second life to materials – or to extend the products' lives. The latter means that companies should attempt to “... stretch the economic life of goods and materials by retrieving

them from post-production consumer phases” (p. 223) collectively. Furthermore, the paper highlights three main challenges of making circular economies from waste within Europe; to process waste in a way that makes it a tradable good on the European markets, to do this locally while the demand for recycled products is international, and to do it under the strong European conditions of environmental regulation and clean production. The paper thus considers that a circular economy will be achieved through either or both of the above two mentioned initiatives – both being producer-led. In the authors’ opinion, it is therefore up to the companies to push the linear economies towards circular economies. While these two initiatives are thought to be the way forward, companies must find a way to overcome the highlighted challenges simultaneously. The position of these authors’ paper in the debate of circular economy, and its validity, will be considered later in the thesis by looking at the theory from the perspective of the empirical data collected.

Further adding to the circular economy literature, Lieder and Rashid (2016) focus their attention on the simultaneous environmental and economic aspects of the circular economy. They argue that while the environmental benefits of circular economies are rather easy to grasp, there seems to be a general trend of failure to understand the economic benefits of it. In an answer to this problem, they present a framework that would help countries to implement circular economy without failures. The framework (seen in Figure 2 below) suggests a simultaneous top-down and bottom-up approach to the implementation. Public institutions should make an effort to implement a circular economy – the top-down approach. This may be done by governments funding projects that have a positive environmental impact or by introducing tax systems in which non-renewable resources are taxed more heavily than renewable resources. The lower half of the figure represents the bottom-up approach; industry approaches. This involves demonstrating the economic benefits of a circular economy. The ways to do so are manifold and include creating collaborative business models, where several companies rethink their individual business models into a common one, sharing resources and using each other’s waste (otherwise referred to as an industrial symbiosis (Gregson et al., 2015)).

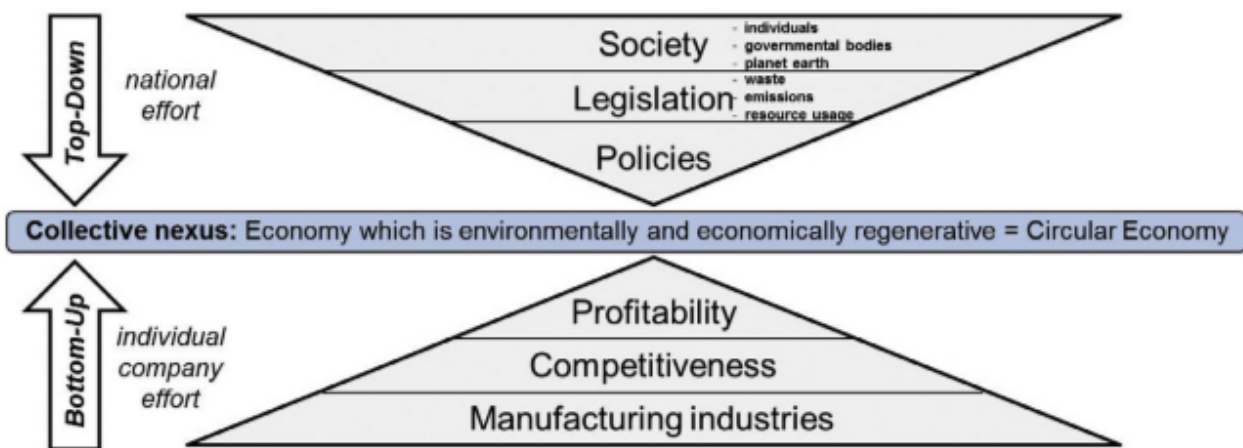


Figure 2 Proposed CE implementation strategy applying top-down and bottom-up approach (Lieder & Rashid, 2016).

Lieder and Rashid (2016) believe that such a framework is necessary when ensuring a proper move from a linear to a circular economy, since stakeholders have different concerns, and thus different measures that need to be taken in order to accommodate and appeal to each of these. Following their suggestion, a nation would avoid the prioritization of environmental benefits at the expense of economic growth or the opposite – the simultaneous approach will incorporate both benefits at the same time and lead to a Collective Nexus. Such state is one in which the local economy is both environmentally and economically regenerative (Lieder & Rashid, 2016).

Recycling of plastic

Delving into circular economy research specifically dealing with plastic, the following paper has looked into the challenges and opportunities companies are facing with the recycling of plastics. Focusing their research on the largest single source of plastics waste (production and disposal of plastic packaging), Hopewell, Dvorak and Kosior (2009) discuss the challenges and opportunities for improving plastic recycling in the near future. After an initial presentation and description of different ways of dealing with plastic packaging waste, they look into which practices are executed today, which are not, and why this is the case. For instance, the reason for poor recycling rates of plastic packaging today is because of the little feasibility of mixing virgin polymers with recovered plastic when making new products. This would create products, which are even more difficult to sort and recycle, once these become waste. Also, companies still largely prefer virgin polymer over recycled plastics in product production

mainly because of the strict property requirements set in place for plastic production. This thesis will, however, reveal that many of these requirements are often set by the companies themselves, and not by official regulations.

Following a detailed explanation of waste recycling (collecting, sorting and separating fractions), the authors reach the conclusion that there is a need for innovation within the area of recycling methods. Finding applications for recycled plastic, which is of a higher value than presently, and developing more reliable detectors than the existing Near InfraRed (NIR) sorting technology to allow for better sorting, are among the most pressing ones (Hopewell et al., 2009). While the latter relies on the development of new machines, the former appeals to creative minds to discover new, useful ways to use recycled plastic.

Without addressing any of the suggestions in greater detail, Hopewell and his colleagues highlight the importance of publically raising awareness and increasing the support for projects attempting to reduce the amounts of incinerated plastics and increase recycling (2009). In addition to this, the authors argue that the market value of the recycled plastic should be increased. This thesis will look at their suggestions in relation to the empirical data gathered.

Reasons for becoming sustainable

The following section presents theories on companies' reasons for engaging in sustainable practices. In their paper, Bansal and Roth (2000) investigates these reasons by engaging in a qualitative study of the motivations for companies' ecological initiatives². They suggest that such actions are induced by wishes to comply with legislation, respond to stakeholder pressures, reap economic opportunities, or based on ethical motives. The authors found that corporate motivations to act responsibly towards the environment could be explained by three main motivations; competitiveness, legitimation, and ecological or social responsibility. Companies engaging in ecologically responsive initiatives for competitive reasons do this primarily to achieve higher profits or market shares, to lower their costs or to differentiate their business from that of competitors (Bansal & Roth, 2000). Such initiatives may involve

² Hereon forth, "ecological" and "sustainable" initiatives will be used interchangeably to define companies' response to social responsibility.

engaging in energy and waste management, source reductions leading to the same output levels with fewer input levels, investing in green marketing and developing eco-products. Activities like these are thus not induced by the company's willingness to become sustainable, but because being sustainable will allow them to reap certain benefits (Bansal & Roth, 2000). Other companies may engage in sustainable activities to achieve legitimacy from desired stakeholders. Such initiatives can thus be considered as a reactive rather than proactive response to external demands. By complying with legislation, employing environmental managers to oversee the environmental impact of processes, developing networks with local communities, conducting environmental audits and aligning the corporate image with the requirements of environmental advocates, companies may thus achieve legitimacy in the form of avoiding fines and penalties, satisfying their employees, and lowering business risks (Bansal & Roth, 2000). The third motivation for engaging in ecological initiatives suggested in their paper, ecological responsibility, may induce a redevelopment of local community areas to greenfield sites, donations to environmental interest groups and local communities, the use of recycled materials in the production, and/or the replacement of retail items with more sustainable ones. Actions like these will likely lead to feel-good factors within the company, increased employee morale and individual satisfaction (Bansal & Roth, 2000).

Having discussed the reasons for engaging in sustainable behavior, the following section describes how certain theorists argue that sustainability and innovation are more likely to take place in collaborations among companies, rather than within each company.

Sustainability and collaboration

While companies may possess skills and resources giving them a competitive advantage in the market in which they are present, a desire to maintain this competitive advantage requires collaboration with other firms possessing different skills and resources (Nidumolu, Prahalad, & Rangaswami, 2009). These may be skills and resources, which concerned companies cannot acquire in their respective industry. Thus, companies can benefit from collaborations by accessing different skills, which they do not possess themselves. This would give all participants access to a greater pool of knowledge. According to the Relational View, these can be seen as interfirm competencies gained through collaboration and networks (Dyer & Singh, 1998). In their report, the authors present four main reasons why companies engage in such

partnerships. While the first is to reach a position of competitive advantage through investments in relation-specific assets, the second is to access and participate in a thorough exchange of knowledge and skills with other companies. In the first behavior, firms are only able to gain competitive advantage if they engage in unique or specialized activities, such as invest in transaction-specific capital assets. Dyer and Singh's third suggestion of why partnerships take place is that participating companies can gain competitive advantage by developing unique products through a combination of resources and capabilities. Last but not least, the fourth source of competitive advantage through partnerships is that of decreasing transaction costs to a point where they become lower than competing alliances. These four sources of competitive advantage through partnerships make up relational rents. These rents are profits above normality, which can be created only through relationships between companies, and not by one company on its own. Once these relational rents have been obtained, they are preserved in the partnership in which they were created thanks to a number of factors. For instance, the development of trust or partner-specific absorptive capacity in the network takes time to develop and cannot be sold on the market, or the high interconnection of interfirm assets, binds the participants together (Dyer & Singh, 1998).

Reports on plastic packaging waste and the recycling hereof

The following section will give an overview of the contemporary issue of sustainability and waste management and review the main reports existing on this topic. Specifically, it will look into the field of plastic packaging waste from households in Denmark. Packaging may be defined as "all products... to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer" (European Commission, 1994, p. 12). Assessing the field of existing research by reviewing these reports will permit a better understanding of the issue at hand, and lay the foundation for this thesis.

The reports included in this section have been chosen to back up the limited theory found on the topic for recycling and household plastic packaging. As is the case for most of the below reviewed reports, the nature of, and findings from, their case studies have been of great help to get a better understanding of the topic, the issues with increased recycling as well as the proven best practices for collection schemes in the Nordic countries. The reports came up

during searches on key words and concepts, such as recycling of plastic packaging waste, household plastic packaging waste and circular economy. In particular, the Nordic Council of Ministers proved to be a very useful source given their initiatives on the topic and therefore many studies undertaken and reports published.

The Nordic Council of Ministers' Reports

Moving towards a circular economy

This catalogue, created to inspire businesses to make changes in the direction of circular economy, and to encourage innovative and creative steps underway, presents 18 Nordic case-studies as examples of companies which have already made the shift to a circular economy, and provides certain recommendations on how to arrive at a circular economy in the Nordic countries (Kiørboe et al., 2015). Initiated by the Nordic Waste Prevention Group under the Nordic Council of Ministers, the objective was to make the circular economy thinking more mainstream in the Nordic countries and hereby accelerate the development of circular economies in these.

Prior to the creation of this catalogue, a workshop was held in the spring of 2015 for many stakeholders relevant to the circular economy transition, which led to the development of the paper's policy recommendations. Among these policy recommendations, the workshop found that the Nordic governments should impose simple and long-term regulations with regard to re-use targets, product requirements and traceability, support greater quality recycling, and help create a market for recycled material through public procurement. In addition to these policy recommendations, the workshop suggests that producers should think recycling into the design of products, the creation of a recycled certification scheme would boost the market for recycled material, and that there should be greater communication of and transparency on best practices. Finally, the catalogue recommends the Nordic Council of Ministers specifically to clearly demonstrate incentives that can pull towards a circular economy, to identify the most relevant areas for a circular economy transition and to spread the word of the Nordic examples to the European Union in the hope that this will foster greater improvements in the European development towards a circular economy (Kiørboe et al., 2015). The intention of including this report in the thesis is not to use any of the 18 examples of good practice within different sectors and industries, but simply to use the above-presented recommendations and

suggestions for a proper transition to a circular economy. Therefore the cases will not be presented, and only be drawn into the paper later, if deemed necessary to prove a point.

Collection & recycling of plastic waste

Under collaboration between the Nordic Prime Ministers, a growth initiative (*The Nordic Region – leading in green growth*) was launched in 2011 with the intent of finding future solutions for a greener tomorrow (Nordic Council of Ministers, 2011). It was believed that market cooperation among the Nordic countries and sharing knowledge would influence product designs, recyclability and waste management systems to a greater extent than single-country initiatives. As a response to this initiative, the Nordic Waste Group (NAG³) was requested by the Nordic Council of Ministers to develop a Nordic project activity on “innovative technologies and methods for waste treatment, aiming at resource efficiency in the waste sector” (Fråne, Stenmarck, Gíslason, Lyng et al., 2014, p. 7). The result was the creation of one overall project, *Resource efficient recycling of plastic and textile waste* with a total of six associated projects (three on plastics and three on textile waste). *Improvements in existing collection and recycling systems of plastic waste from households and other MSW sources* is the first of the three plastic projects and is explained in two reports; *Collection & recycling of plastic waste* and *Future solutions for Nordic plastic recycling* (Fråne et al., 2014; Fråne et al., 2014). In addition to the two deliverables, the first plastic project lead to the creation of the *Guidelines to increased collection of plastic packaging waste from households* (Fråne et al., 2015a).

The research in the project was conducted with the aim of paving the way and providing “conditions for more efficient collection and recycling of plastic waste from households and other municipal sources in the Nordic countries, striving towards higher recycling rates” (Fråne et al., 2014, p. 8) . Based on interviews with municipalities and private companies, and on case studies about how waste management differs within the Nordic countries, the first report, *Collection & recycling of plastic waste*, identified the main challenges and provided suggestions to focus areas in achieving a higher recycling rate of plastic packaging waste. The

³ *Nordisk Affaldsgruppe* is a working group within the Nordic Council of Ministers that is striving towards contributing to a circular economy transition and green environment.

identified success criteria for increased recycling of plastic packaging waste in the participating countries are further elaborated in the project's second report *Future solutions for Nordic plastic recycling* (Fråne et al., 2014). With the findings from the first report, *Guidelines to increased collection of plastic packaging waste from households* outline suggestions to municipalities to increase the recycling rate of plastic waste generated by households (Fråne et al., 2015a).

By comparing the collection and recycling systems of the Nordic countries, the report presents the main challenges in dealing with the recycling of plastic packaging waste. From the comparison of collection systems, the authors found that curbside collection of plastic packaging waste results not only in higher quantities of collected material than bring systems, but also in a better quality of the collected material (Fråne et al., 2014). According to the Nordic Council of Ministers, a curbside collection scheme "... is a collection system where households are able to discard their plastic packaging waste within the boundaries of the estate" whereas bring systems are "... public drop-off points [, which] include other packaging waste fractions, where people bring their source-sorted plastic packaging waste" (Fråne et al., 2015a, p. 6, p. 15). Source-sorted curbside systems differ from mixed-fraction systems in that the waste is separated into materials at the household (Fråne et al., 2015a). An increased focus on implementing the curbside collection scheme may thus help with the problem of the poor quality of currently collected plastic packaging waste and thereby reduce the amount incinerated.

The first of the identified challenge for increased recycling concerns the basic practicalities behind plastic packaging. Its high volume and low density results in high transportation costs and possibly lower incentives to sort in the households. A second observed challenge concerns the tendency of misbelief in recycling among citizens, hindering increased collection and recycling of plastic packaging waste. The near-full recycling capacity in the Nordic countries (with only one facility located in the region; Swerec in Sweden) further raise a problem with the wish to increase the amount of collected waste. A fourth challenge to increased recycling rates of plastic packaging waste involves the costs this entails. Firstly, with the high costs of recycling plastic (in comparison to other materials), the possibility for economies of scale and rentable profits are limited. A greater focus on recycling should thus

improve the efficiency of the current collecting methods and recycling facilities with it, in order to create clear benefits to the companies incurring the costs. Additionally, the report has identified a misalignment between the increased costs (from investments in new collection systems, more sorting and cleaning of the collected material among other) that will result from higher recycling rates, and producers' wish to keep product costs to the minimum. Given that the price of virgin material is currently lower than that of the secondary raw material, and that households bear the costs of recycling, clear benefits must be demonstrated and incentives created for producers to use recycled plastic to a greater extent. This is in line with the fifth identified challenge in the report. The quality of virgin plastic is in line with its higher prices compared to the secondary raw material, which explains why producers currently have no proper incentives to use the recycled plastic instead of virgin polymer.

Entailing further challenges for the increased recycling rates is the diverse range of fractions present in plastic packaging. Packaging with fewer types of plastic mixed together would facilitate its recycling, and possibly increase collection rates from households thanks to a better understanding of what type of plastic to sort. The two last challenges identified in the report concern the market for recycled plastic packaging and the incentives to recycle. Without a high demand for the collected plastic packaging, the incentives to increase the collection disappear. Thus, greater incentives for producers to use recycled plastic over virgin plastic will automatically result in a higher demand for the recycled plastic, eventually increasing the collection rates too.

Summing up the above-described challenges, the first report from the Nordic Council of Ministers' project *Improvements in existing collection and recycling systems of plastic waste from households and other MSW sources* identified success criteria for increased recycling rates in the Nordic countries. These range from taking the entire value chain of plastic packaging waste into account and creating a market for recycled plastic, to communicating the benefits of recycling to consumers and producers in order to increase the Nordic sorting capacity and motivate the public to sort more (and better) (Fråne et al., 2014).

Future solutions for Nordic plastic recycling

Identified in the first report, summarized above, the Nordic Council of Ministers' three identified main solutions to higher recycling rates, namely to collect more plastic packaging waste to be recycled, to better sort the collected waste, and to create a market for the secondary raw materials, were discussed in greater detail in the project's second report, *Future solutions for Nordic plastic recycling* (Fråne et al., 2014). However, the report finds that all three solutions are best achieved through an increased cooperation and collaboration between the Nordic countries. Such cooperation is regarded as a solution given the limited national markets for plastic packaging waste and recycled material in each of the Nordic countries resulting in large amounts of imports from other countries (Fråne et al., 2014). Although similar market characteristics exist across the Nordic countries, waste management varies significantly between them. An increased Nordic cooperation would improve the influence authorities have on producers with regard to the recyclability and design of products, creating less variety in the waste management. Regarding greater collection of waste to be recycled, cooperation could facilitate the communication of a few, specific collection schemes, and the development and potential of these would be greater than if each country focuses on many different schemes. The same principles go for the suggestion of sorting better. Nordic cooperation would enable economies of scale on the chosen sorting systems, and common systems for all countries would most likely mean collected waste of the same quality, and in greater amounts (Fråne et al., 2014).

This report distinguishes between two types of cooperation. One is a practical cooperation where the Nordic countries make use of the same recycling facilities (and thus collect plastic packaging waste with the same systems), and exchange knowledge and benchmarking of collection and recycling systems. The other is a practical cooperation where materials can be exchanged between the Nordic countries, allowing one market to be established for the region and lead to economies of scale – a system that has already been established elsewhere in Europe. These solutions are not further elaborated in the report, which allows the readers of it to propose more specific suggestions within the frame of the report's findings. This is what is intended in this thesis.

Recyclability by Design

In 2015, the British independent organization RECOUP (RECYcling Of Used Products Ltd.) published a report with guiding principles to the design of plastic packaging in a way that facilitates the recycling of the products (East, 2015). Although developed for the British market, the report is eligible for all European countries given that it takes the European standards and regulations into account. It is thus reviewed in this paper with the assumption that it contains certain suggested solutions to the challenges identified and analyzed later.

The purpose of the report is to give recommendations to and help designers understand the implications of their design decisions, and to incentivize them to address the issues related to the design in a way that will encourage them to follow good practices. The organization follows the principle that “packaging should be designed to satisfy technical, consumer and customer needs in a way that minimises environmental impact” (East, 2015, p. 4), and they believe that any packaging design should always be fit for purpose. This is important to keep in mind when reading through the provided guidelines, since they may not always be the desired solution (improving recyclability of plastic packaging should not involve making compromises of the product’s safety, for instance). Also, noting that the packaging market, along with many other markets, is characterized by innovation, the author thus acknowledges that the guidelines provided may not remain the best solutions for recyclability in the future.

The first guidelines suggested in the report are of a general nature to all types of containers and components. These include recommending designers to use unpigmented polymer over pigmented, since it has a higher recycling value and the widest variety of end uses, and to generally opt for the use of mono-material or mixed materials of the same type in the design of products, given that it generally facilitates the sorting and recycling of the concerned products (East, 2015). Turning to the guidelines regarding specific issues but still concerning all types of plastic containers, the reports first suggests designers to create products in a design that helps get remove all the residue possible. This may for instance be designing a bottle with a wide neck, a pack that is able to stand inverted or to make use of non-stick additives in the products.

Furthermore, when property requirements demand the use of composite material that cannot be separated mechanically and the materials do not belong in the same recycling stream, the designers should consider employing very thin layers so that it may be removed by vapor during the recycling process. In line with this guideline, any seals or closures on containers should not only be recyclable but also be recyclable in the same recycling stream as the container itself. A PET bottle should therefore ideally either have a PET or PP seal, since these two types (fractions) of polymer belong in the same recycling stream (i.e. they are not sorted apart in automated optic sorting equipment). Seals or closures of another type of plastic used should therefore not leave any residuals behind when removed from the main container. Likewise, it is desirable to avoid the use of foil safety seals that leave remnants behind when torn off the container and the mix of different materials in one product (e.g. plastic containers with metal lids) since these products are not easily recycled (East, 2015). Another guideline included in the report is to avoid coloring the plastic in too strong colors because these materials give the product a lower value than unpigmented plastic on the secondary market, and also because it may interfere with the NIR machines used to identify the nature of the plastic. Finally, the report provides recommendations on the ideal use of labels on plastic containers. Firstly, minimizing the amount of adhesives used to stick the labels on the container, and the size (surface coverage) of them will help increase the recyclability of the container. Secondly, ideal labels are either soluble in water (between 60 and 80°C) or glued to the container with hot melt alkali soluble adhesives. Following these guidelines would evidently result in labels that are more easily removed in the washing process of the collected plastic packaging. The report ultimately provides individual recommendations and guidelines for the most common types of material used for containers. However, these will not be presented in this paper, since they are of minor importance to the study.

The reason for the presentation of the report in this thesis is that it gives an idea of which stakeholders can play a role in the transition towards a circular economy, and helps designers think more sustainably when designing future plastic packaging. It will be used in the paper's analysis to suggest methods for immediate improvements in the current value chain of plastic packaging.

In the following section, a brief presentation of some projects launched as a response to the issues identified in the above-described reports, will be provided. The purpose of this is give an overview of current projects taking place in Denmark, and possibly to pave the way for future researchers looking into these projects in greater detail.

Recycled plastic: From household waste to household waste sorting system

Based on the introduction of a third compartment for waste sorting in the municipality of Holbæk, citizens expressed their wish for a new sorting system taking up less space in their homes. At the same time, the municipality experienced a confused population with regard to the statement of plastic being a resource. These two reasons led to the idea of producing a sorting system for households made of the households' own plastic waste (Fors A/S). Based on customer surveys in the area, *Recycled plastic: From household waste to household waste sorting system*⁴ looks into developing user-friendly sorting systems, which would enhance the sorting in households.

In order to identify where the biggest issues lie with the current sorting systems, and to develop a system with the proper design, the company collecting waste in the municipality, Fors A/S sent out a survey to 2000 single-family houses and advertised for the survey in the local newspaper and on social media, encouraging people living in apartments to participate as well. Responses reveal that not even half of the people living in single-family houses sort their plastic, and people living in apartments believe they would sort better and more if proper sorting systems fitting into the kitchen were available (Salkvist & Aerenlund, 2015). Of the respondents living in single-family houses, only one fifth sort plastic at their household whereas the remaining sort plastic at recycling stations. These results clearly illustrate the need for improved collection systems at households. In response to the results from the survey, Fors A/S developed an eight-compartment sorting system currently being tested in several households. This system attempts to capture a greater amount of plastic packaging waste correctly sorted in households. Given the limited amount of information publicly available on this project, an interview with Fors A/S was sought in order to learn more about it. Launched less than a year ago, and still in process, it would be worthwhile for future

⁴ Genbrugsplast: Fra husholdningsaffald til husholdnings-affaldssorteringssystem.

researchers to follow the development of this project in order to identify the sorting behavior of individuals living in both single-family houses (where space for sorting systems is rarely an issue) and apartments. Unfortunately, the time frame of that project does not allow for such follow-up to be done within the scope of this thesis.

With the above information gathered from a concept paper reporting the intentions behind a specific recycling system aimed at increasing the recycling rates of plastic packaging waste, future researchers may wish to look further into how the project turns out. That is, following the project and assessing the outcome of it, future researchers may help the municipality implement an innovative recycling system leading to increased sorting in households. For other researchers, the concept paper may in itself provide an example of systems currently being tested and looked into with regard to increased sorting in households – an example which may foster ideas for alternative innovative sorting and recycling systems.

Stimulation of market-driven demand for recycled plastic in the value chain

In collaboration with the Danish Plastics Federation⁵ and the Danish Environmental Protection Agency, CLEAN – an organization promoting green growth in Denmark – initiated a project in 2013 with the aim of creating a market for recycled plastic packaging waste (CLEAN, 2014). This project, *Stimulation of market-driven demand for recycled plastic in the value chain*⁶, was created with the specific aims of establishing a forum where companies from the entire plastic packaging value chain could meet to discuss and collaborate on voluntary quality requirements with regard to recycled plastic, and to facilitate concrete collaborations between companies promoting an increased use of recycled plastic packaging waste. A report issued at the end of the project summarizes the activities that took place and were initiated during the time span of the project.

Based on the knowledge gained during this project, the report suggests how to improve the quality of recycled plastic packaging. Firstly, the report emphasizes that in order for Denmark to reach the EU 2020 target of 50% recycling of household waste, new waste management

⁵ A trade association for plastics converting companies in Denmark and their suppliers (Plastindustrien).

⁶ Stimulering af markedsdrevet efterspørgsel efter returplast i udvalgte værdikæder (CLEAN, 2014).

systems need to be implemented both in households and at recycling facilities. In a report explaining the 2013 Danish government's resource strategy (addressing the issue of too high waste incineration rates in Denmark), it is suggested that this is to be done by establishing a central recycling facility in order to keep the collected waste within the Danish borders throughout the entire value chain. However, this report emphasizes the fact that while such a recycling facility may increase the quantity of recycled plastics in Denmark, the quality of collected plastic would still remain too poor to be attractive for purchasers. Being the main motivation behind CLEAN's project, promoting cooperation across the value chain may lead to ideas and solutions as to how to increase the quality of the recycled plastic. A cooperation between a manufacturer of recycled plastic and Arla⁷ looked into how recycled plastic may become a main resource used in certain Arla products, and collaboration between the biggest plastic recycling company in Denmark (Aage Vestergaard Larsen) and recycling facilities that have created a plant to clean the collected plastic, are among the several collaborations created thanks to CLEAN's project.

Among others, these have helped identify the main areas of issue in the current recycling of plastic packaging waste system. These are outlined in the project report. Initially created to push companies to join forces in setting quality standards with regard to the use of plastic packaging, the project reveals that no real incentives for this currently exist in the Danish market. That is, because of the limited amount of plastic actually collected from households, recycled household plastic packaging waste collected in Denmark alone is insufficient to feed the local market for recycled plastic. Looking into this matter more thoroughly, the municipality of Copenhagen and the Danish waste management company Vestforbrænding is currently researching the quality of the plastic packaging waste recycled in German recycling facilities (CLEAN, 2014). This will help Denmark understand what kind of quality is required to create a market for recycled plastic. Since this is an on-going investigation, the results from this study, is not available for further use in this thesis. However, the results identified during the CLEAN project will briefly be presented and explained in the following section.

⁷ Danish producer of dairy products.

An interesting finding during the project is that of a market indeed already existing for the recycled plastic in Denmark – one, which was previously thought of as in need of being created. A main issue is thus no longer to create such a market, but to feed it and allow it to grow. Establishing a central recycling facility suggested by the Danish government, according to the project, may do this. This would minimize the amount of exported plastic packaging waste to other countries' recycling facilities, and thus give Denmark bigger amounts of recycled plastic to feed into the market for secondary raw materials. Lastly, the report helped give the plastic value chain more knowledge about opportunities and limitations in the use of recycled plastic in the production of new products, and helped build on existing guidelines for companies to combine different types of plastic in a way that will promote the recycling of the products.

Based on these results, the report presents ten suggestions on how to improve the quality of recycled plastic as a means to generate a market for the secondary raw material. The first is to continue the ongoing communication in the value chain of plastic packaging. Such communication will help ensure that the necessary restrictions on recycled plastic are overcome both by the recycling facilities and the purchasers of the recycled plastic. As a second suggestion, introducing greater recycling capacity in Denmark (as proposed by the Danish government in their resource plan) will ensure the presence of actors in each link in the value chain. As discussed above, this will decrease the amount of plastic exported to recycling facilities abroad, and may thus feed the market in Denmark. A third suggestion presented in the report, is that the collection systems in households should be in line with the technology at the recycling facilities. Having collection systems in households that sort plastic packaging waste into more fractions than what the recycling plants are equipped to do simply wastes sorting time at the households. Ensuring that all municipalities sort with the same systems or with the same amount of fractions will maximize the efficiency of the recycling facilities. This appears to be a recurring issue, and will thus be discussed in greater detail later.

In line with this, the fourth suggestion is that municipalities collaborate and use the same recycling centers for their collected waste. This will lead to greater amounts of waste collected for recycling which will eventually lead to more recycled plastic to be sold as

secondary goods. The fifth suggestion evolves around guidelines for sorting. Creating national guidelines for household sorting plastic will help steer the focus on the recycling of the right types of plastic (fractions). Establishing quality controls at current and future recycling facilities is the report's sixth recommendation. This will ensure a greater quality of the secondary material. The seventh suggestion, to create common guidelines for the design of new plastic packaging, will help producers make products with certain types of plastic favored over others, and facilitate waste sorting in households. This suggestion is based a success story of the sorting in the United Kingdom. It is important that representatives from the entire value chain (collecting, sorting, recycling, designing and producing companies) join forces to create these guidelines, if the alignment of them with all parties' interests is to be ensured. The eighth suggestion presented in the report concerns the workforce at the recycling centers. Equipment better at sorting automatically will entail less work for the facility's staff and result in more uniform secondary raw material. Making sure that the employees have varied tasks will ensure the compliance with the Danish health and safety considerations. The two last suggestions are those of establishing a fund to support the creation of local central recycling facilities, and to look into business model innovation regarding the secondary raw material available after the recycling process. Exploring innovative ways to make use of these leftovers could help finance the recycling of all plastic fractions and would reduce the amount of plastic incinerated.

Having reviewed the main issues that came to light from the collaborations during this project, the next natural step would be to execute some of the suggestions. Presenting companies in the value chain with these suggestions may help them to set the quality standards, which are currently non-existent in the market. Future research would thus ideally look into each of the ten suggestions of the report, and look into how more extensive collaboration between companies may help address the issues in question. This report may further be of interest for future researchers for numerous reasons. Firstly, the forum created during this project may contain relevant and interesting information from companies representing the entire value chain of plastic packaging waste. That is, future researchers may wish to leverage the information shared among companies, in an attempt to gain knowledge on the most urgent issues with recycling plastic packaging. This knowledge may, once again, foster new ideas to be further researched. Ideas, which may eventually be presented in the

forum and allow companies in the value chain to test the implementation of these. Alternatively, future researchers may wish to look into the specific collaborations formed during this project in an attempt to gain knowledge on the specific issues in question, and possibly to come up with solutions benefitting all collaborating parties.

Limitations

Common for the above reports are their roots in political institutions and organizations. Initiated by the Danish and Nordic governments or responding to strategies initiated by these, the reports not only present findings of conducted research, but also steers their findings to coincide with the authors' political positions. This is important to keep in mind when further using the reports. While not doubting the validity of the results and studies presented in the reports, there may well be a "flip side" of the research that is not being presented or discussed in them. Additionally, these reports have all conducted some sort of initial research on the topic and come up with suggestions to areas of improvement with regard to greater collection and recycling of plastic packaging waste. What seems to be missing in the field of research, are follow-up reports on the initiatives taken in response to the issues identified, and more projects responding to the findings of the reports.

Analytical framework

For the sake of the paper's study and in order to facilitate the understanding of the researcher's thought on the analytical process, an analytical framework has been created. Such a framework will help steer the analysis in a direction that should allow the researcher to uncover the most pressing issues concerning recycling of plastic packaging waste and eventually answer the paper's research question and conclude on it. The framework comprises three main steps, each of which is explained below.

Firstly, based on the theories and public reports reviewed above as well as the empirical data found during the data collection period of the research, a presentation of what appears to be the most pressing challenges in today's handling of plastic packaging waste will be made. These will be carefully reviewed and explained before moving on to the second step in the framework; the assessment of these challenges. This step involves evaluating the challenges

based on whose responsibility it may be to seek to overcome them. In order to assess each major challenge to either the private (i.e. companies) or public (government, public institutions etc.) sector, inspiration from Lieder and Rashid's (2016) paper and framework is drawn. This will allow a greater overview of the challenges and what solving them may incur. Lastly, the third step in the framework involves carefully discussing the responsibility and suggesting the specific, required activities of both public bodies and companies. This step-by-step analysis should result in an outcome in the form of a discussion and assessment of specific activities required when aiming to create a circular economy and close the value chain of plastic packaging waste. An illustration of the framework is seen in Figure 3 below.

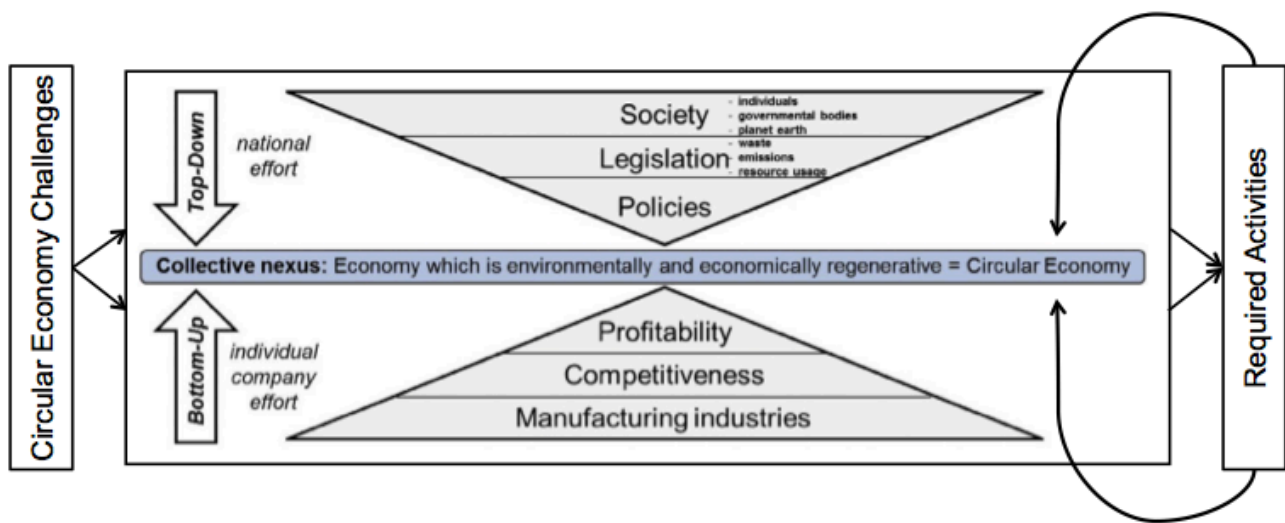


Figure 3 Analytical framework, inspired by Lieder and Rashid's model (2016).

The main challenges of recycling plastic packaging, which became apparent in both the theories and public reports reviewed above are the poor quality and low quantities of the collected plastic packaging waste, the (lack of) awareness of the citizens expected for sort properly, the little market for recycled plastic material, and lastly, the limited recycling capacity in Denmark. These challenges will be analyzed and evaluated with empirical insight obtained. The literature reviewed above will be drawn in where seen fit, and help evaluate the suggested challenges.

Since not all of the literature presented in the above chapter is of equal importance to the analysis in this paper, an overview of which theories and reports will be used for which parts of the analysis, explaining their use and importance, follows. Concerning the identification of the challenges of arriving at a circular economy, the main data will stem from the empirical

data collected and the public report *Collection & recycling of plastic waste* (Fråne et al., 2014). However, the paper by Hopewell, Dvorak and Kosior (2009) will also be used thanks to the identification of certain challenges of plastic recycling in it. When it comes to arguing that private companies are responsible for certain actions, which will allow for a smoother and faster transition to a circular economy, Gregson, Crang, Fuller and Holmes' (2015) paper on industrial symbioses and the extension of product lives will be the main source. Supporting this, the paper by Dyer and Singh (1998) on partnerships and why to engage in them will be employed. Regarding the upper part of the framework, public responsibility, most of the reports by the Nordic Council of Ministers, public institutions and Danish government, have proven useful. That is, *Moving towards a circular economy*, *Collection & recycling of plastic waste* and *Future solutions for Nordic plastic recycling* (Fråne et al., 2014; Fråne et al., 2014; Kiørboe et al., 2015) by the Nordic Council of Ministers, *Recyclability by Design* (East, 2015) by the British organization RECOUP, *Stimulation of market-driven demand for recycled plastic in the value chain* (CLEAN, 2014) by the Danish organization CLEAN, and *Recycled plastic: From household waste to household waste system* (Fors A/S) by Fors A/S and the share the view, that some of the responsibility in the concerned matter lies in the hands of public institutions and the government.

Finally, as a last step in the analysis, an identification of the activities, which are the most required within the coming years in order to advance the transition towards a circular economy, several articles will support the analysis' findings: the literature from Gregson, Crang, Fuller and Holmes' (2015) reviewing industrial symbioses and the extension of product lives, Hopewell, Dvorak and Kosior's (2009) identification of challenges of recycling plastic, and the reports *Moving towards a circular economy* (Kiørboe et al., 2015), *Collection & recycling of plastic waste* and *Future solutions for Nordic plastic recycling* (Fråne et al., 2014; 2014).

Methodology

The following section will look into the philosophical assumptions made and methods applied in the paper both in gathering empirical data (data collection) and analyzing the information obtained in the collection phase. First, a review of the philosophical assumptions made will be

presented. Subsequently, an explanation of the intended methods (*Intended approach*) used in order to answer the following research question will be provided: ***How can the market for recycled plastic packaging from households be increased? What are the actions required in the immediate future to increase the use of recycled plastic packaging, and from whom are they required?*** Following this section a review of the methods actually applied (*Actual approach*) is provided due to a change in the methodology. The two sections are both included in order to show the reader what the original idea of the study was, and later to suggest that the approach used (*Actual approach*) may still be a solid basis for the study.

The philosophical assumption made in the paper is described, since this determines the interpretation of the information received throughout the process of writing this thesis. In this project a critical realist philosophical stance will be taken. According to this philosophy, observations are reflections of the truth, the actual world (Bhaskar, 1989). However, for a critical realist these observations are interpreted by the individual observing the phenomena, and may thus reflect a different image than what is actually real. This likelihood of misinterpretation stems from individuals' social conditioning – each individual's background, ideals and beliefs will influence the way phenomena are interpreted. This notion is especially important in the type of study conducted in this thesis, since the topic is rather new and the literature therefore not very conclusive. In other words, according to Bhaskar's critical realist perspective the researcher will have to rely on the literature found, existing reports and data gathered first hand as being true (1989). Although both reports and the empirical data gathered may be biased towards certain ideas and political stands, the validity of the information will not be questioned any further during this thesis.

The design of the study can be described as exploratory since it tries to understand the subject in question and to identify the main challenges and opportunities involved through the information obtained. The research approach applied in the study follows a combination of inductive and deductive designs. Given that the research began with an investigation of literature on the topic, the overall research design is deductive (Saunders, Lewis, & Thornhill, 2009). Following this logic, the researcher strove to gain an understanding of the subject before collecting empirical data and creating the guides for the interviews. That is, existing theory and reports have shaped the data collection (Saunders et al., 2009). However, when it

comes to conducting the interviews and analyzing the empirical findings, the research follows an inductive logic. This means less structure in the interviews and the order in which the questions were asked in interviews, and a greater reliance on personal interpretation of the information acquired (Saunders et al., 2009).

Intended approach

The intention for the study's research was to use a rather small sample size of expectedly six companies in a multiple case study. This approach would allow the researcher to go into great depth in order to make sense of the current state of circular economy activities (looking for similarities or differences in approaches and opinions between the case companies), and seek new insights in order to come up with recommendations on how to improve this in the future. Also, rather than studying changes occurring over time within recycling of plastic packaging, a cross-sectional study would have been used to examine the situation at a certain point in time, namely today. This knowledge and insight would have been gained through semi-structured interviews with employees responsible for (or experts in) the production system and the involvement of recycled plastics in the respective companies. Allowing the respondents to elaborate on and explain themselves in greater detail, many questions may need to be open-ended. Furthermore, rather than a static set of questions remaining the same for every interview, the interviews consist of a list of themes and questions to be covered – some of which may ultimately not be asked during the interview, and where additional questions may prove necessary to include. By applying a case study method and not questioning information gathered during the thesis process, it is important for the researcher to triangulate data collection techniques employed (Saunders et al., 2009). Relying on both academic papers and theories on the subject of recycling and related topics (such as circular economy, innovation and the like), official reports from public institutions and governments addressing the subject and by collecting data firsthand from experts in the private industry, ensures the validity of the data obtained.

The sample of companies studied in the paper should have consisted of certain producers of plastic products (for instance plastic containers) using secondary materials rather than virgin polymer in their production (to a smaller or larger extent), while another group of companies should have been manufacturing companies simply using secondary plastic materials in the

production of parts of the final product (for instance car manufacturers). Such a selection of companies would expectedly have given a certain similarity in the reasoning for using (and not using) recycled plastic in the production, and a discussion of this would have been provided. Such insight would have allowed for an assessment of the reports presented in the literature review and their suggestions as to how to increase the recycling rate of plastic packaging.

Regarding the selection of companies to study, the intention was to use a structured approach rather than a random selection of available companies. That is, upon a meeting with the biggest Danish waste management company, Vestforbrænding, the researcher became aware of sorted and recycled plastic packaging from Danish households (among other) being taken to a recycling plant in Sweden; Swerec. At Swerec, the plastic is further recycled and sold to companies wishing to use the secondary raw material in their production (Swerec, 2011). Thus, contacting Swerec to get ahold of information about the companies (what industries, what nationalities etc.) that act as customers to them, was the structured path to decide on what type of companies to contact. Once a list of companies obtained, a simple selection of different types of companies would have been made in order to arrive at a select sample of diverse companies making use of the secondary materials. In addition to these, an attempt to find similar companies not using recycled plastic in their production processes would have been included.

Actual approach

The actual approach applied in the thesis however differs from the intended approach explained above on certain actions for a number of reasons. Firstly, but most importantly, it was not possible to obtain the desired information from Swerec due to their tight sharing policy. Being unable to proceed as intended, the search for relevant companies to study in this paper had to be less structured. During this less structured search, the researcher was cautious not to randomly select the companies that were to be in focus, but to study their intentions and methods carefully before selecting them.

The actual approach applied to find case companies was therefore to conduct an extensive search on newspaper articles and reports on the topic of circular economy, recycling and

plastic packaging as well as following the recommendations from contacts in the Environmental Protection Agency under the Danish Ministry of Environment and Food⁸ as well as The Danish Plastics Federation. In the reports and articles studied, the companies that stood the most out – i.e. the companies most present in these and with a clear ambition to change the handling of household plastic packaging – were looked at in greater detail. The study thus became more in-depth than multiple-case as was originally intended. That is, rather than studying several specific cases and comparing these to one another as initially intended, the study instead attempted to get an understanding of each organization's obstacles and opinions on the most pressing challenges for greater recycling of household plastic packaging. Such a method was chosen due to the position of the studied organizations in different stages of the value chain – positions which would allow for an understanding of the entire value chain's positions, opinions and issues with greater recycling. In spite of the change in the data collection approach, the intended interview structure did not change, and triangulation of the data used was still ensured by using theories, public reports and the empirical data to make suggestions.

The companies studied and interviewed in the paper ended up being the following: Aage Vestergaard Larsen (AVL), DanBørs A/S, Danrec, Dansk Affald, Fors A/S and Teknologisk Institut. These were chosen due to their different positions in the value chain of plastic packaging and common ambitions to increase recycling rates in Denmark. AVL is a private company specialized in the regeneration of plastic; it produces raw materials based on recycled plastic collected from the surrounding municipalities in Northern Jutland. Although it does not currently use plastic packaging from households – due to its great degree of contamination – it has participated in a number of initiatives and projects to test the possibility of this in the future. Most recently (and currently) it participated in a project with one of the other companies studied in this paper; Fors A/S. Fors A/S is a private company too, collecting household waste from the municipality of Holbæk. The project concerns testing the feasibility of using products made of recycled household plastic in the production of new goods. The aim of the project is to prove that recycled material may create products that fulfill existing product and quality requirements and thus that may replace products made of virgin

⁸ Miljøstyrelsen – Miljø- og fødevareministeriet.

polymer (Jensen, 2016). The outcome was that it is indeed possible to create a product entirely from recycled household plastic packaging – a product that lives up to its product requirements. The product that resulted from this project was a black breadbox (Jensen, 2016) that serves to prove that new products may actually be entirely made of recycled plastic packaging collected at households. The aim of the project is for Fors A/S to show citizens that the sorting of their waste allows for the production of new products in the form of sorting systems (i.e. waste bins) for the households (Fors A/S).

A third company interviewed is one similar to Fors A/S, notably Dansk Affald. This public company is also, amongst other, responsible for the collection of household waste in the municipalities in Southern Jutland. Dansk Affald possesses optic sorting facilities (in the form of a NIR machine) to separate the materials from one another in the metal, glass and plastic collected waste fraction. Once this is done, the waste is sold to Germany or Sweden (Swerec) for further sorting and recycling (Stender, 2016). This company was chosen due to its participation in several research projects (initiated by FORCE Technology and CLEAN) on the topic of improving recycling rates of plastic packaging in Denmark. Dansk Affald played the role of promoting the mechanical sorting of plastic packaging as a solution to the Danish sorting challenges. Yet another company studied in this thesis is Danrec, a private Danish company producing plastic boards for a variety of applications (e.g. stable floors, root protection, driving boards etc.). These boards, called DAN-boards, are made entirely of household recycled plastic. The raw material is bought from Germany in the form of granulate.

Finally both DanBørs A/S and Teknologisk Institut were also chosen to be included in the thesis. DanBørs A/S is a private Danish company working as a facilitator for public institutions (municipalities, waste-collecting companies and the like) and the recycling centers and sorting facilities. It thus possesses extensive knowledge on the market of household waste and the fractions this may contain, and offers counseling to municipalities on how they may improve the quality and selling price of their collected waste. DanBørs A/S was thus included in the study thanks to its extensive knowledge on the current quality and quantity of household plastic packaging as well as for its knowledge about municipalities' challenges with regards to greater recycling rates. Lastly, Teknologisk Institut was chosen to

take part in the research thanks to its many publications and studies undertaken on the topic of recycling and circular economy in addition to partaking in numerous projects on the topic. Through the institute's reports and publications, it appears to possess extensive knowledge on the existing product requirements, the quality of current collected plastic packaging waste as well as the possibilities for recycling, which is why it was included in the paper's research.

Analysis

Challenges for a transition from a linear to a circular economy

As explained earlier, the analysis will first outline the main challenges for arriving at a state of circular economy in Denmark. An aggregation of all the data gathered during the research process (i.e. both from reports and first-hand collected data) will serve the purpose of finding the challenges most recurring in today's Danish society. These are challenges evolving around four topics, namely the quantity and quality of plastic packaging waste, general public awareness about circular economy and recycling, the little market size for recycled plastic packaging and lastly, the recycling capacity in Denmark. After the identification and explanation of each main challenge follows a short assessment of whose responsibility it may be to act upon and change the current status. Further discussion of this will follow as a second step in the analysis.

1. Quantity and quality

The first of the main challenges, quantity and quality of plastic packaging, can be split into four issues allowing to look at the challenge from different perspectives; the quantity and quality of the collected material at households, the nature of material used in new plastic products, existing property requirements determining the quality of new products, and lastly, consumers' demands to new products.

1.1 Low quantity and poor quality of collected plastic packaging waste

The first of these issues, the quantity and quality of the collected material at households and recycling centers being too low, seems to have fostered a debate focusing on which collection system gives the cleanest fractions and highest quantities. In this debate, opinions are numerous and of different natures. There are, however, three main schools of thought; plastic

packaging waste is best collected through source-sorted curbside collection schemes, mixed-fraction curbside collection schemes, and through bring systems. The reason for a difference in opinion simply seems to result from different experiences; the use of different collection schemes due to more or less populated areas, a domination in single-family homes over apartment buildings or vice versa. Valid for all three, however, is the effectiveness of the collection scheme depending on citizens' willingness to sort the waste, and their understanding of the sorting system (Ærenlund, 2016).

As seen earlier, based on reports studying the different collection schemes present in the Nordic countries, the Nordic Council of Ministers suggest source-sorted curbside collection leads to the largest quantities and best qualities of plastic packaging waste (Fråne et al., 2015a). The empirical data collected for this paper reveal that the private companies Danrec and Fors A/S also view this collection scheme as the most effective. Danrec finds that this system may be the overall cheapest way of gathering materials (taking into account the subsequent recycling processes), and that it will provide the greatest similarity in the quality of the collected material on a national level (Dahse, 2016). In agreement with this, Fors A/S finds this system to lead to the greatest qualities of collected material, as experienced in the project on recycling household plastic packaging waste into sorting systems for the households (Ærenlund, 2016). This thought is rooted in the idea of clear and simple communication to the citizens sorting their waste. Fors A/S finds that it confuses citizens if different materials may be mixed in the sorting system, while only the plastic packaging waste is used to produce their future bins.

In spite of this system leading to the greatest quality of the collected plastic packaging waste according to the above actors, a source-sorted collection scheme demands manual pre-sorting at the recycling facilities, since the automatic sorting of plastic fractions is currently not feasible with existing sorting technology in Denmark, and it therefore demands manual pre-sorting to ensure an even quality of the material sent for the subsequent steps of recycling (Fråne et al., 2014). Therefore, while the source-sorted collection system may increase the quality of the collected plastic waste (given that no other materials are mixed with it), it demands further sorting of the different plastic fractions.

In contradiction to these findings, the company Dansk Affald collecting all waste from households in the municipalities of Southern Jutland finds a different approach to be most effective. In these municipalities, citizens sort their plastic packaging waste in a mixed container with glass and metal, which is collected by Dansk Affald at the households (by mixed-fraction curbside collection) and brought to the company's plant for manual pre- and optic sorting with its automatic NIR equipment (Stender, 2016). The quantity and quality of the collected material from households remain rather constant and thus allows them to make use of the plant's automatic sorting machine.

The downside of collecting waste in mixed fractions and using optic sorting at the plant is the unfeasible solution of the machine to sort plastic fractions from one another – when too many materials or fractions make up each product, for instance. The NIR sorting mechanism is only able to sort materials or plastic fractions from each other, but not to do both at the same time. Sending the sorted plastic through the machine after it has been sorted from glass and metal in order to be sorted into fractions is currently too costly a process for Dansk Affald. It would require a higher demand and greater price of the sorted plastic packaging material from companies recycling it to undertake this process. Dansk Affald's handling of the waste ends at this point (when plastic packaging is sorted from glass and metal) and it sells it to Germany where newer, more advanced technologies pursue the recycling which Danish technology cannot afford to do. Therefore, in the opinion of Dansk Affald, the future of the mixed-fraction curbside collection scheme is to establish more optic machines in Denmark allowing the sorting of polymers (Stender, 2016). This would allow the country to sort waste to a greater extent and eventually make a more pure waste fraction. Overall, in spite of their difference in point of view with regard to fraction separation, Danrec, Fors A/S, Dansk Affald, and the Nordic Council of Ministers (whose opinion come to light in the reviewed reports above) all share the point of view that the closer to the household the sorting takes place, the greater will be the quality of the collected material (Ærenlund, 2016; Dahse, 2016; Fråne et al., 2014; Fråne et al., 2015b; Stender, 2016).

In opposition to these views, the plastics regenerating company AVL finds the future of waste collection to be at recycling centers where they believe the highest qualities may stem from (Larsen, 2016). This view is rooted in the idea that recycling centers are of approximately the

same size across the country, and therefore have similar potentials for greater collection of plastic packaging waste. Unlike different types of households (single-family, apartment buildings) demanding different systems, the recycling centers all have the ability of implementing the same collection system. Further arguments for the bring collection system being the most effective solution for greater collection rates come in the form of larger amounts of plastic collected at one spot, making it easier to deal with locally and more efficient to transport (shorter transportation time and therefore fewer emissions when collecting the sorted plastic packaging waste in one location rather than from the entire municipality's households). AVL therefore suggests that recycling centers with four containers sorting the fractions of PP, PE, PVC and small combustibles⁹ from each other, will lead to cleaner collections (and thereby avoid the subsequent sorting step of the optic sorting of polymers). AVL could then directly take the fractions into its facilities for processing. As seen in the presentation of companies above, AVL currently only deals with plastic waste stemming from the plastic, construction and utilities industries due to the ensured purity and similar nature hereof (Aage Vestergaard Larsen, 2015). However, it currently does have great interest in also being able to receive plastic packaging waste from households as long as this does not require great amounts of washing and cleaning before being able to be recycled (Larsen, 2016).

The above discussion about what collection system leads to the greatest quantities of good quality collected material exist due to the Danish municipalities' freedom in choosing the collection system that is best suited for the local population. With 98 municipalities in Denmark (Fråne et al., 2014), each with different opinions on how to best increase collection rates, the result, as is seen above, is currently diverse and contrasting collection schemes throughout the country. An idea for the future collection of waste may thus be to impose certain rules or standards on all municipalities in the country. One or a few accepted collection systems (according to population density) would ensure equal qualities and quantities of the collected waste and thus facilitate the subsequent recycling procedures. The challenge of managing the diverse quantities and qualities thus falls under the responsibility of public institutions and authorities.

⁹ Småt brændbart.

1.2 Little recyclable nature of new plastic packaging products

The second issue under the first challenge of the quantity and quality of collected plastic packaging waste is the nature of new plastic products. Today, most new packaging products are made of several different materials or polymers or even types of plastic (primary and secondary) (East, 2015). For instance, certain plastic containers are sealed with a metal cap, which is then further wrapped with a lid of a different polymer type than the container itself. Such products are produced in order to satisfy current consumer demands and preferences, but the mixed fractions and materials make the products unfeasible for recycling. Many plastic bottles (primarily consisting of PE polymer) have labels of paper glued onto them (Larsen, 2016). The process of recycling such a bottle is much longer and more expensive than if the labels were made of PE too.

These issues emerge from the design of products, which currently has its entire focus on consumers' and customers' demands as well as the practicality of the packaging (East, 2015). If products were also made with recycling in mind, the design of them would naturally change, facilitating the sorting for users and the subsequent recycling processes (washing, sorting, fraction-separating etc.) (East, 2015). That is, if the mindset of design were to change into one that favors recycling, then plastic packaging could be created in a way where different materials are easily removed from each other and where the polymer type is easily recognizable.

In order to increase the recycling rates in Denmark, the design of products thus need to be rethought to facilitate the recycling of the products. In other words, the design market needs motivation to innovate and ideas on to how to produce plastic products with as few different fractions and materials as possible. This responsibility seems to be in the hands of private companies; to invent new procedures and break current standards with these. However, companies might only take such responsibility if certain incentives from leading public institutions or the local government are in place. Therefore, although really the responsibility of companies (private sector) to innovate on packaging design, this many only be ensured to coincide with recycling systems if incentivized appropriately by the government. Thus, the issue of incentivizing design companies to innovate in the right direction is assigned as a

responsibility of the public sector, while the responsibility of designing (more) recyclable products lies within the companies themselves.

1.3 (Too) high quality of new products stemming from product requirements

The third issue under the first topic concerns existing product requirements leading to certain standards, qualities and processes in the production of plastic products. In their paper, Hopewell, Dvorak and Kosior (2009) state that existing strict quality requirements lead to companies favoring virgin plastic over secondary, and mixed fractions over separated fractions. The interviewed companies share the opinion that current product regulations are too strict to allow for the use of recycled material (Ærenlund, 2016; Dahse, 2016; Damgaard, 2016; Larsen, 2016; Stender, 2016). Since it is the public that sets some of the requirements, it is also them that hinder the use of recycled plastic in certain industries. An example includes how recycled plastic material is prevented from being used in the construction sector due to imposed regulation from the European Union with regards to the CE marking (Dahse, 2016). This marking demands the quality of products to be of a certain standard and to be made with the use of specific processes, some which do not allow for recycled plastic to be used in, for instance, road pillars. These white reflector pillars on the side of the roads need to be 100% white, and cannot contain any pigments in them, thus hindering the use of recycled material (Dahse, 2016). In spite of the high importance of these pillars to be visible from a long distance, Danrec's experience with the use of recycled household plastic packaging waste in new products lead the company to conclude that recycled plastic could easily be used for such purposes without minimizing the visibility of the pillars. Requirements like these need to be altered if the use of recycled plastic is to be favored and allowed in those industries, where the products' functionality will not be minimized, and the power to do this lies within public institutions (the European Union and national governments amongst others).

1.4 (Too) high quality of new products – demanded by consumers

In addition to the public regulations hindering the use of recycled plastic in certain products, or obstructing the use of some processes, there is a general belief that consumers create certain standards themselves and eventually impose them on companies or the other way around (companies create the minimum standards, which they believe their customers and consumers will accept) (Ærenlund, 2016; Dahse, 2016; Damgaard, 2016; Larsen, 2016;

Stender, 2016). Consumer preference is known to have a powerful effect on product standards, explaining why companies more often than not choose to follow these. Certain companies thus set standards on their own production processes in order to allow for greater consumer satisfaction.

Although initially imposed voluntarily by companies themselves, many companies seem to be blaming their lack of sustainable practices (in this case not using recycled plastic in stead of virgin polymer) on the regulations they have to follow during the production process. However, this reaction seems to be excuses for avoiding to start the rather extensive and heavy investments a change to sustainable processes would demand. Additionally, companies may lack the right incentives to turn their processes into more sustainable ones. A reason for the consumer preferences generally working against recyclability and sustainability may, according to the reports studied for this thesis, be due to the limited awareness among the public on the topic (Fråne et al., 2014). Although having increased in recent years (Hopewell et al., 2009), consumers may not be enlightened enough to demand products with different standards, than the usual. That is, consumers will prefer their products the way they are used to see them until there is a general understanding of the unsustainable practices behind these products.

Contrastingly, the opinion of the interviewees in this thesis is that consumers tend to be rather prone towards sorting their waste and leaning towards more sustainable products (in spite of the possible difference in color or texture from the virgin products). For instance, in the municipalities of Southern Jutland where Dansk Affald collects and sorts the waste, citizens are more than willing, sometimes even eager, to follow the sorting instructions and make an effort to sort in the right way (Stender, 2016). While these trends might be seen in certain parts of the country, the general trend observed in Denmark remains one where citizens generally lack some knowledge on the topics of recycling, sustainability, and the benefits of this for society. Greater knowledge on the benefits may indeed affect their purchasing and sorting behavior (Nielsen, 2014).

It is thus evident that consumer preferences and habits generally need to shift towards favoring sustainability and recycling – even though this is already the case in certain parts of

the country – if companies are to be incentivized to improve their sustainable practices. In agreement with this, Hopewell, Dvorak and Kosior (2009) find that public awareness needs to be raised further on the topic of recycling, and public bodies seem to agree (the Nordic Council of Ministers and the Danish Government finds that greater communication of the benefits of recycling to the public will establish a sensation of trust, and thereby change consumer preferences in favor of recycled products (Danish Government, 2013; Fråne et al., 2014; Fråne et al., 2014)). Therefore it is suggested that an effort from public bodies and institutions is required to change consumer preferences and thereby change the so-called voluntarily adopted regulations.

2. Little public awareness

The second main challenge, which appears to be among the main topics discussed when talking about a transition towards a circular economy, is that of the general awareness of the public. That is, many are of the belief that current collection and recycling standards are the way they are because of the public's lack of knowledge on the benefits and few changes required for a better market economy (Dahse, 2016; Fråne et al., 2014). In other words, the public plays an important role in the amount of plastic collected for recycling, and it is thus of great significance that they sort their waste in accordance with the subsequent recycling processes. If citizens do not understand the purpose for sorting waste, they will not put much effort into understanding the applied sorting system nor into sorting their waste appropriately. Fors A/S' experience in the municipality of Holbæk is, for instance, that the public has had a hard time understanding that plastic waste can actually be a resource, and therefore do not put much effort into understanding the sorting system (Ærenlund, 2016).

Although it may be argued that the term circular economy and the need of a greener world has been on the public agenda for quite a few years and thus that the population already is informed¹⁰, the improvement in sorting behavior of the Danish population to the current standards is not enough to live up to the country's goal of 50% recycling of all household waste by 2022 (Danish Government, 2013). However, as observed by certain municipalities,

¹⁰ This is seen in consumer behavior shifting towards favoring sustainable and ecological products, such as Fair Trade, although the prices of such products are higher than other products (Nielsen, 2014).

citizens are actually willing to sort their waste once they understand the reasons for which they are sorting, and the benefits of it (Ærenlund, 2016; Stender, 2016). Current communication through publicities, campaigns, and public initiatives on the topic seem to be of a rather general nature. What is needed is a greater focus on advertising for the specific benefits and potentials of recycled plastic packaging waste, to make the public understand why sorting and recycling is imperative, and to motivate them to start sorting appropriately (Fråne et al., 2014). How this may motivate citizens to sort their waste more will be reviewed later under the discussion of the required activities. It seems that this responsibility of increasing the public's awareness lays both in the hands of the public institutions (the government, municipalities and public organizations, for instance, initiating campaigns and advertising for the benefits of sorting waste) as well as in private companies (demonstrating best-practice systems).

3. Little market for recycled plastic packaging

Turning to the third main observed challenge with plastic packaging, namely the little market for the recycled material, it is often argued that the reason for the failures in selling and introducing secondary raw material instead of virgin polymer in products is due to its (too) poor quality and therefore lack of demand for it (Dahse, 2016; Fråne et al., 2014). The producing companies need incentives to demand the secondary raw material over virgin polymer (Clemen, 2015). However, many believe that companies dismiss the secondary raw material with the argument that the quality is too poor to live up to current standards (Larsen, 2016). As seen above, this is not the case. Recent studies reveal that recycled plastic packaging waste from households may indeed be used to create products that fulfill the product requirements with regards to durability, capacity, color and the like (the mentioned plastic project in Holbæk) (Rasmussen, 2016). Furthermore, research reveals that there actually is a market for the recycled material, but that the offered resource needs to be able to live up to the industry's standards (Dahse, 2016; Fråne et al., 2014). Without dwelling further on that discussion here, it will suffice to say that if a market for secondary raw materials needs to be increased, the public institutions must take the responsibility to incentivize the private companies to demand the secondary material.

4. Limited recycling capacity

A last general challenge recurring in the debates about the increased recycling in Denmark is the issue of the national recycling capacity. Many suggest that Denmark does not have the capacity to sort and recycle the plastic packaging waste from households collected from the entire country. Indeed, the country currently does not have a single recycling plant, which handles household plastic packaging waste (Waste Office, 2015). However, as seen from the reports studied for this thesis, certain facilities in Denmark actually have the ability to do so, but they do not either because of the low amounts of plastic packaging waste collected at households, the low demand for further sorting the waste, or the lack of the required equipment to proceed with the subsequent steps in the recycling cycle (Larsen, 2016). The Nordic Council of Ministers is of the view that too great a focus on increased collection of household waste will lead to too much waste to be sorted with too few plants able to do so nationally or in the Nordic region (Fråne et al., 2014).

The challenge of the limited recycling capacity in Denmark is a debate, which seems to foster several different opinions regarding the best solution. While some believe that the solution is simply a question of the Danish government's willingness to invest in a plant (Fråne et al., 2014), with its location being debated, others are of the view that one plant will not suffice to solve the challenge, and that Denmark alone needs several recycling plants across the country, or even that this is not a valid solution (Dahse, 2016; Malmgren-Hansen & Nilsson, 2016). This is without a doubt a responsibility of the public sector, given the great changes required if the national recycling capacity is to be increased. However, it may be argued that part of the responsibility also lies with the private sector, given that their willingness to support a national solution and to ensure that they will make use of the facilities (both in sending their waste to them and to buy the secondary material produced) are a prerequisite of building recycling plants in Denmark. Therefore, for now, the required activity to solve this last challenge will be assigned as being both the private and public sectors' responsibility.

Required activities

As a second step in the analysis, based on the above assessment of both the private and public sector's required efforts, the analysis will now discuss the specific activities required by these

two sectors in the near future if a transition to a circular economy is to succeed. That is, while the above section presents the challenges and assesses whose responsibility it should be to solve them, the following section will present and suggest concrete activities that would be the most beneficial for a transition. These activities will be suggested based on the knowledge gained from the interviews conducted earlier in the process as well as the reports summarizing Nordic case studies on the topic. It is important to keep in mind, that the researcher does not presume to be able to boil the great debate of how to achieve a circular economy down to a few activities in the following section. This thesis merely attempts to build on the knowledge gained in the study to suggest a selection of activities which seem to be the most desired and pressing in order to help the future transition – suggestions which evidently are biased from the data and reports studied in this thesis, and without taking the entire debate into account.

Before presenting and discussing the required activities, it should be noted that the Danish government in 2013 developed a resource strategy, which addresses the issue of too much waste incineration in the country (Danish Government, 2013). The aim of the strategy was to promote the use of waste as a resource and to increase and speed of the transition to a circular economy in Denmark. With current a current recycling rate (of all household waste) of 22%, the strategy set the national goal of 50% recycling of the same fraction by the year 2022. In a report summarizing the strategy, the government declares its intention to support municipalities in their implementation of proper sorting systems for all types of housing (single-family, apartment buildings etc.) by providing information and guidance on how to successfully implement both sorting and collection systems across the country. In addition to this, the government declared its intention to financially support the development and testing of sorting systems and recycling facilities and technologies for household plastic waste, and to help initiate partnerships between companies and institutions with the aim of developing these systems and facilities. While the report suggests that a follow up of the strategy will be provided in 2016, such an assessment does not seem to have been made (publically available) yet. Thus, without possibility to document any of the described intentions and ideas, it is difficult to review the effect and success of these, and therefore to build on these initiatives for further analysis. However, the strategy is mentioned here in order for the reader to be aware of the current situation and intentions of the government in Denmark.

From the above presentation of different thoughts on the best collection scheme for plastic packaging leading to the greatest amounts and qualities of the collected waste, it was identified that curbside collection schemes seem to be favored over the other existing types of schemes. Whether source-sorted or in mixed fractions gives the best quality and highest quantity of plastic packaging waste, however, depends on the subsequent required sorting process (i.e. whether manual pre-sorting is necessary to the optic sorting, or an alternative solution which can sort the undesired waste apart, is desired). The required activity by the public sector, in this case specifically the government, to increase the quantity and quality of collected plastic waste may thus be to decide whether plastic packaging waste should be sorted alone in a separate container or together with other material fractions, depending on the desired subsequent process. Once a decision reached, a national regulation (or law) should be made in order to ensure all municipalities' alignment. Having to abide to such a regulation, the municipalities would turn to sort household plastic packaging waste in the same way, but would be free to choose whether curbside collection or bring systems is the most appropriate collection scheme for the local community. Before being able to make such decision, the government will have to settle on the desired subsequent sorting process: whether Denmark should be able to handle the entire recycling process within its borders or accepts to rely on the neighboring countries, as is currently the case. To this day, 22% of the Danish municipalities collect household plastic packaging waste separately from other waste (i.e. source-sorted) before it is then exported to recycling facilities in neighboring countries (Sweden and Germany) due to the inability of the Danish facilities to further recycle the waste fraction (Fråne et al., 2014). If the government were to follow these municipalities' practices, thoughts and possibly changes to the current recycling system would be required. With source sorted plastic waste from households, Denmark would either have to build plants in several parts of the country (in order to be able to handle the entire country's household plastic packaging waste) or remain dependent on exporting the waste for further recycling abroad, before buying the finished secondary raw material for the national market from these plants. This leads to the discussion of the market for the recycled material, which will be elaborated under the subsequent challenges.

Furthermore, as seen above, the current practice of plastic packaging design is not aligned with the desired increase in recycling rates. The concerned design companies thus need to be motivated to figure out how to design the best and most desired products (i.e. to innovate on the designs). However, as noted in the report by the British organization RECOUP, the design market (especially the packaging market) is already characterized by a lot of innovation (East, 2015). Therefore, it is important to ensure that incentives exist to innovate in the right direction (towards recycling of the designed products). According to Bansal and Roth (2000) such ecological activities happen for one of four reasons: necessity to comply with legislation, to respond to stakeholder pressures, because economic opportunities are in place, or for ethical reasons. The Nordic Council of Ministers suggest legislation will push design companies to create more recyclable products, if, for instance, policy makers were to introduce regulations on the allowed combination of fractions and materials in one product (Kjørboe et al., 2015). However, with regards to the second motivation for ecological activities, it was earlier discussed that consumers of plastic packaging do not have enough knowledge regarding the potentials of product recycling, and they are therefore unlikely to demand specific designs from plastic packaging producers. The second motivation is thus deemed unfit to currently motivate design companies to produce more recyclable products. If the design companies do not by themselves create packaging that is easier to recycle (i.e. thanks to the ethical motives), Bansal and Roth (2000) suggest it will only happen if economic opportunities are set in place. In line with this motivation, the Nordic Council of Ministers also suggest that public institutions should introduce certification of recycled materials which would give recycled products more credibility in the eyes of the consumer, and thereby represent an opportunity for economic savings (Kjørboe et al., 2015). Allowing the companies that design easily recyclable products (by following the RECOUP guidelines, for instance) to benefit from tax reliefs, may be another example of further economic savings. Thus, although the required activity to ensure recyclable designs of packaging products must be made by the design companies, it is deemed necessary for the government to take certain steps to ensure that these activities will happen. Bansal and Roth (2000) suggest that companies would follow these regulations or take advantage of economic opportunities for one of three reasons. Either the sustainable activity will lead to increased profits, lower costs or differentiating businesses (i.e. increase companies' competitiveness on the market), help companies avoid fines or penalties or lowering business risks (thus help companies obtain legitimation from

stakeholders), or create a sentiment of feel-good within the companies and increase employee morale (that is, create social responsible companies).

In line with the first two issues under the first challenge (the quantity and quality of collected plastic packaging waste, and the current little recyclable nature of new products), the last two are equally deemed to be a responsibility of the public sector. The required activity by the Danish government, European Union or other public institution with the power over the industries making use of plastic products, concerns ensuring that industry standards allow for the use of recycled plastic material whenever possible. The required activity is thus to review industry requirements and introduce new ones, most probably of lower standards, specifically removing any restrictions with regards to the use of pigmented or slightly discolored plastic. Additionally, public bodies need to help increase consumer preferences to favor recycled products by raising their awareness (i.e. showing the positive effects and the potentials of certain waste fractions). The required activity to solve this issue may for instance be to advertise more for the benefits and communicate best practice examples.

The latter suggestion of communication also counts towards activities required by public institutions to raise the general public awareness on the topic – the identified second challenge. As discussed earlier, this does not only involve more of the current type of advertising on circular economies and the world's need for these, but also demand publicities specifically targeted at raising awareness on the potentials of some waste to become a resource again, and for private companies to advertise for their initiatives and best practices.

Turning to the third challenge presented above, notably the limited market for recycled materials, the required activity also seem to fall under the responsibility of public institutions. As described earlier, research suggests a national market for secondary raw materials already exists, and certain companies are actually currently not only willing to use such material in their production (if enough good quality were available), but are actively looking and asking for it (Fråne et al., 2014). For instance, the interviewed producer of plastic boards Danrec only uses recycled plastic packaging from households in their production (Dahse, 2016). However, due to the presently poor quality of the collected material in Denmark, Danrec buys its material from recycling plants in Germany where the quality is guaranteed, but ensures its

intention in buying the materials locally, if this was a possibility. Therefore, it is not a question of creating a market but of increasing the existing one. This may be done by raising the value of the secondary material, and subsequently promoting and incentivizing the use of it in production of new products (East, 2015).

Although it has been proven that the quality of recycled plastic packaging from households may be as good as virgin polymer (Hopewell et al., 2009; Rasmussen, 2016), this is not yet the case with the amounts and qualities of the collected material from households. Before being able to increase the market for the secondary material, the quality therefore first needs to be improved (see the above discussion of the required activities to do so). Once these measures have been taken, however, producing companies are still not likely on their own to shift from virgin polymer to secondary plastic, which is why incentives thus need to be created (Fråne et al., 2014). If relying on Bansal and Roth's (2000) suggestions here again, these incentives will essentially stem from one of the above described four reasons; compliance with legislation, as a response to consumer pressures, to reap economic opportunities or for ethical motives. However, it seems unlikely that legislation will help the companies shift from virgin to secondary raw material given the improbability of companies being forced by law to use secondary material over virgin in new products. If the change is to happen thanks to consumer pressure on the producing companies, consumers need to possess enough knowledge for them to specifically demand recycled products over new ones (see the above discussion of increasing public awareness). Thus, if the producing companies do not choose to favor secondary material over virgin polymer due to their own ethical motives, economic opportunities need to be set in place. As seen above, these are likely to stem from the government or market institutions creating opportunities and policy instruments to allow for financial savings (Fråne et al., 2014). The Nordic Council of Ministers additionally suggests an increase in the transparency of the plastic waste's fate (i.e. where it is exported, how it is treated and for what purpose it is used) as well as a promotion of the good examples. This is believed to boost the existing local markets of recycled material.

Moreover, the market for the secondary raw material may be promoted and thereby increased if the frontrunners of circular economy and recycling cooperate and promote their sustainable activities and its advantages. A good example is the promotion of the

collaboration across the value chain between Fors A/S, AVL and the plastics producer Schoeller Plast Entreprise A/S in the project of proving that recycled plastic waste from households can indeed be used to create new products that live up to the different standards (Rasmussen, 2016). Such an example proves to other companies and the public that it is indeed possible to produce new products out of recycled material, and that collaboration may foster greater findings than can be developed by single companies working alone on projects, as is suggested by Dyer and Singh (1998).

The required activity for the last identified challenge above demands both the public and private sector to take action. The challenge is the limited recycling capacity in Denmark and the country's inability to handle the amounts of plastic packaging waste to be collected across the country. This challenge may be split into two issues: the lack of recycling plants, which are able to process the entire country's waste, and plants, which are able to handle the entire recycling process of the plastic waste collected. Both issues require the leading public institutions and the government to make decisions and to implement these. As mentioned earlier in the paper, certain existing companies already possess the required technology to sort and recycle plastic packaging waste from households (e.g. AVL and Dansk Affald). Their reasons for not doing this are the high costs associated with such thorough processes and the lack of demand of the created recycled material – without which the former reason is amplified. The required activity is thus for the government and collaborating institutions to decide on whether to build recycling plants in Denmark or to rely on the current method of exporting the collected, un-treated plastic packaging waste only to buy the produced secondary material from abroad again. If opting for the first solution, many questions will need to be answered (questions from worried companies and stakeholders): where should the plant(s) be located in order to benefit the entire country, how many plants should be built, what technology will they possess, and therefore, what fractions will be sorted at them, and finally, will the quality of the recycled material be high enough for companies to wish to use it, and can the municipalities ensure a steady flow of the collected waste from households? (Malmgren-Hansen & Nilsson, 2016). The Nordic Council of Ministers suggest a third solution to the problem, namely that of increasing the cooperation between the Nordic countries, and thus to build plants across the cooperating countries (Fråne et al., 2014). Furthermore, the issues also require the support and willingness from companies to make use of the facilities, if

these were to be built. In addition to the municipalities' use of them, this is a prerequisite for such plants to be a sound investment worth pursuing.

Looking back at the original framework adapted for the analysis, the suggested activities from both the public and private sector are much in line with the analysis' findings of the above-suggested required activities. In their paper, Lieder and Rashid (2016) suggest public institutions bear the role of implementing legislation and policies, and supporting the infrastructure for a circular economy, as well as being responsible for raising social awareness on the topic. These activities will facilitate the transition from a linear to a circular economy. Likewise, the industry (private sector) may influence the transition by allowing for collaborative business models, innovate and rethink product design and the supply chains as well as communicate and inform about their sustainable activities. The authors suggest this may lead to a state of Collective Nexus: "convergence of all relevant stakeholders" (Lieder & Rashid, 2016, p. 47), meaning the alignment of all activities and initiatives for a circular economy transition. However, the ideal economic state is not defined in any greater detail by the authors, given that it is still somewhat unknown what one such would encompass. Also, as seen throughout this thesis, there are many views regarding how to arrive at a circular economy in the most effective way, and there does not yet seem to be any consensus on one specific way being more efficient than others. In this thesis, the term Collective Nexus thus merely represents the future state of closed loop value chains with systems and policies working towards one, same goal – with its specifications still to be determined.

Discussion

This section discusses the choice of methods and theories used for the purpose of answering the paper's research question. Subsequently, the paper's findings presented in the analysis are summarized, and the feasibility of these required activities to occur will be evaluated. Lastly, after briefly looking into which activities are currently taking place in Denmark on the recycling agenda, an assessment of the paper in its entirety is made.

The philosophical assumption made in the paper may have affected the interpretation of the information gained throughout the study. Given the critical realist position and therefore

acknowledging that the information observed is interpreted by the observing individual, there is a possibility of the knowledge gained from theories, reports and empirical data having been misinterpreted. It may be that the interpretation made in this paper does not coincide with the truth, the reality, or is interpreted in the intended way. This is especially the case for the empirical data collected. Conclusions may have been made on information gained during the interviews – information, which may have had a different message. For instance, had another person conducted the interviews a different message may also have been interpreted given the individuality in the interpretations made.

Although, as mentioned in the methodology section of the paper, the interviewer attempted to remain neutral in the asking of questions when undertaking the interviews, this may not actually have been the case. The interviewer's personal point of view might have come to light through the way in which the questions were asked, and this may have affected the answers received from the interviewees. Furthermore, the overall research in the thesis had a deductive design given that the first step in the process was to collect and study existing literature to gain an idea of the issues with the topic of a circular economy transition. Only hereafter – after having made sense of the topic – did the researcher seek to collect empirical data. Had an inductive approach been used instead, and the empirical data gathered before extensive knowledge on the topic was gained, the questions asked in the interviews and the information obtained may have given a different view on the topic. This could eventually have led to a study of the topic from a different angle, or to a study of another subject under the same topic. Such difference may also have meant the use of other literature than what has been used in this thesis.

A possible weakness in the choice of methods applied in the paper may be the difficulty in pursuing the intended structured approach for empirical data collection. This approach would potentially have given a solid overview of the companies buying secondary raw material from the recycling facility in Sweden. With this information, it is believed that the researcher would have been able to contact companies, institutions and municipalities from several parts of the value chain: the collectors of the packaging waste (Danish municipalities), one of the recycling centers sorting and recycling the waste (Swerec), the companies buying and using the recycled plastic as well as the end-users in the form of citizens buying plastic packaging. The

structure of the intended approach would possibly have allowed the researcher to gain information from companies working directly with each other, and thereby getting a clear picture of the entire value chain. This intended approach was however, not feasible due to Swerec's tight policy on sharing documentation and information about its customers. This being said, the actual approach applied in the data collection phase of the thesis is still deemed a valid representation of the plastics value chain. Through other means, the researcher managed to interview companies from different positions in the value chain, which allowed to gain knowledge of the involved stakeholders' opinion. In spite of these companies not entirely representing a Danish value chain (given the import of foreign recycled material, for instance), they do represent the group of local companies willing to engage in the transition to a circular economy, and interested in accelerating this transition. For this reason, the companies are deemed to provide a valid representation of the value chain of plastic packaging in Denmark.

When it comes to evaluating the literature used in the paper to back up and shed a perspective on the empirical data, both the choice of theories and of reports should be discussed. As already mentioned in the beginning of the paper, the theoretical scene does not include much detailed literature on the specifics of the studied topic. While there have been a great number of contributions to the field of circular economy (Lieder & Rashid, 2016) – among other attempting to describe what is meant by the term and which actions and changes are necessary to arrive at such an economic state – the recycling sub-field remains one where specific literature is yet difficult to find. That is, while several theoretical papers study the notion of recycling (e.g. how to change human behavior to recycle, the design mindset of new products), literature suggesting how to handle the transition from a linear to a circular economy has been difficult to find. Existing literature suggest many different ways to arrive at a state of circular economy in today's developed societies without being able to point towards a specific set of practices, which have been proven to be successful. This may be the reason for the great amount of suggestive literature (as discussed in the literature review) and general lack of specific results based on proven concepts. Due to this inconclusiveness in relevant theories, the paper has had to turn to official reports studying existing cases on recycling, and has chosen to rely on those as proven concepts as well as on the limited theoretical literature available. As seen throughout the paper, specifically the Nordic Council of Ministers and their

reports have been used to evaluate any knowledge gained from the empirical data. Although acknowledged earlier in the paper, it is important to outline that the researcher has been well aware of the possibility of the Nordic Council of Ministers' findings being biased towards the Nordic governments' opinion and views on how the transition from a linear to a circular economy is to happen. For instance, several of the public reports produced by the Nordic Council of Ministers suggest that increased collaboration between the Nordic countries would facilitate and improve the already ongoing transition towards a circular economy (Fråne et al., 2014; Fråne et al., 2014). Although this may actually be a good way for the Nordic countries to move forward, it may also have been suggested because of the governments' agreement on increased collaboration. This being said, the researcher has had no possibility for validating this data, other than viewing the information gathered from the reports with both the theories on the topic and the findings from the empirical data collected in mind. Thus, although triangulation of the information applied in the paper is argued for under the methodology section, the researcher acknowledges that complete triangulation may not have taken place, as it would have, were theories suggesting specifics similar to the reports available.

Summing up this evaluation of use of theories and reports, the study of this thesis did not lead to any findings, which suggest that the existing theories on the topic should be modified. What the findings did reveal however, is that existing theory remains suggestive and rarely provides specific statements on what activities are the most likely to move the society towards a circular economy. The literature on the notion of circular economy, and specifically on recycling of materials thus appear to be missing specific theory on the required future behavior of citizens, companies and public institutions.

The following section will first briefly summarize the required activities. Hereafter, an evaluation of whether these findings are realistic activities to expect in the near future follows. The term "near future" is not supposed to mean a specific set of years during which the required activities are expected to occur but rather to underline the importance of them to happen, since they are found to be a prerequisite for the increased recycling rates and transition towards a circular economy.

From the above analysis, it was found that, among the required activities, the Danish government is responsible for several. More specifically, the government firstly should decide on whether plastic packaging waste stemming from households should be collected in mixed fractions along with metal and glass, for instance, or separately in a plastics-only container. Imposing regulation on such a decision would entail greater coherence in the currently diverse collection schemes employed throughout the country's 98 municipalities and thus facilitate the further required circular economy activities. Likewise, the government should decide whether to build recycling plants with the capacity to receive the entire country's collected plastic packaging waste and to handle the entire recycling process of the collected fraction, or to continue to rely on neighboring countries to buy the collected waste to recycle at those countries' own facilities. This decision is necessary since Denmark is to this day not able to recycle on the collected waste fraction, and greater amounts of collected material will require greater recycling capacity.

Along with the European Union and other public institutions (stakeholders), the Danish government is equally responsible for ensuring that existing industry requirements do not impede the use of secondary raw material where possible, and raise the public awareness of the benefits to recycling waste. This being said, private companies in the plastics value chain currently involved in projects on increasing the recycling rates and circular economy of the material should also be required to advertise for their actions. Simultaneous advertisement from both the public institutions and private companies would raise public awareness in general, and may inspire citizens to join the sustainable movement by recycling their waste more carefully.

Furthermore, these public institutions are required to promote the use of secondary raw materials in the production of new products. This promotion should be targeted at private companies in order to raise their awareness of the opportunities that lie within the use of recycled materials. Alongside this suggestion, the private companies currently engaged in the transition towards a circular economy (by using recycled material in their production, for instance) should advertise for their activities in order to inspire the entire value chain to act responsibly. A good example of this is the mutual project of Fors A/S, AVL and Schoeller Plast Entreprise A/S on producing sorting systems for the households made entirely of the

household collected and recycled plastic packaging waste. This project should be advertised for on the companies' websites, in local newspapers and in the plastics organizations. Lastly, the paper's findings suggest design companies should innovate with a recycling and circular economy mindset, but that this may only happen if the proper incentives are set in place for the companies. The analysis finds that these incentives should stem from the government and other public institutions and take the shape of economic opportunities or regulations in order to push companies towards producing recyclable products.

While some of these findings may be rather easy to execute and realistic to occur in the near future, others are embedded in larger issues and will take longer to execute. Common for the suggested advertising behaviors, both from the public institutions and the industry, is the rather easy and short-term implementation of the required activity. It is a question of finding the stories to sell, deciding on how best to sell it to the target group (citizens or the industry) and lastly, to launch the publicity. When it comes to ensuring that the relevant industry standards do not hinder the use of recycled materials in certain products, an investigation and evaluation of the concerned regulations is required. This may take a certain amount of time, but is also deemed a realistic activity for the coming years. The same applies for the necessity of public institutions to regulate and/or create economic opportunities for companies designing and producing the plastic packaging. While it may not be done right away, the activity is deemed realistic for the near future.

The situation is different with regards to choosing whether Denmark should be able to process its own waste entirely, or whether the country should rely on its neighbors. This issue demands thorough knowledge and research on the size of the concerned waste stream as well as careful reviews of the country's financial situation, if it is decided that recycling plants should be built in the country. In spite of this, sorting plants have recently been built to increase the Danish sorting capacity. This will be discussed later in the paper when looking into what activities are currently taking place within this thesis' topic. As explained earlier, the paper's findings in terms of required activities are based on an analysis where information from the interviews, existing theories and publically available reports on the topic have been compared, evaluated and concluded upon. The required activities suggested

in this paper are thus based on a static study of the information gathered throughout the data collection and writing process.

The following section will briefly look into what activities are already taking place, which may be aligned with this paper's findings. Firstly, as has been demonstrated throughout the paper, certain private companies (among other, the empirical examples of this thesis) are already engaging in sustainable activities in the form of working towards closing the loop of the plastic packaging value chain. For instance, initiated by the companies themselves, Fors A/S, AVL and Schoeller Plast Entreprise A/S are investigating the possibility producing new products of the collected household plastic packaging waste, and are thereby also looking into what sorting method and collection scheme will allow for this (Ærenlund, 2016; Larsen, 2016). This is an example of companies driven by ethical motives. Furthermore, the local newspaper in the region where AVL's plant is located, has advertised for the preliminary findings of the above project, which demonstrates a way for companies and public institutions to advertise for the ongoing sustainable activities (Rasmussen, 2016).

Along the same thought, research has revealed that educational institutions, in this case Teknologisk Institut, are undertaking research projects on the topic of circular economy, and more specifically on recycling (Malmgren-Hansen & Nilsson, 2016). They usually join forces with companies, universities and public institutions interested in undertaking a project within a specific field. Recently, the institute has, among other projects, researched the potentials for and solutions to greater recycling rates in Denmark as well as for building a national recycling plant. While not specifically aligned with one of the required activities found in the paper, this demonstrates that there is a current movement and interest in finding solutions for the future. These may have been fostered thanks to the mentioned resource strategy initiated in 2013, in which the government declares its intention to financially support any projects working on finding solutions for increased recycling rates and the remaining challenges associated with a more sustainable society (Danish Government, 2013).

As a last observation of current activities taking place in Denmark, certain plants are currently being and have recently been built with the purpose of sorting the household collected waste in more efficient ways than existing systems. For instance, the Amager Resource Center (ARC)

– currently a plant where waste is turned into energy – has the ambition to build a sorting plant at its facilities in order to sort plastic packaging waste, among others, collected from households in the capital area (www.a-r-c.dk). Likewise, the waste and energy company I/S Reno-Nord, which treats waste from several municipalities in Northern Jutland, built and opened the to-date most modern waste sorting plant in Denmark this past fall (I/S Reno-Nord, 2016). This plant is now able to receive the plastic packaging waste collected with metal waste from the 137,000 households making up the surrounding three municipalities (Jammerbugt, Mariagerfjord and Aalborg). Not only is a plant (with manual pre-sorting), which is able to automatically sort these two materials from one another, but thanks to its two NIR machines, the plant also separates the plastic packaging waste into several fractions. An illustration of the plant is provided in Appendix One. Only about half of the plant's input capacity is currently used, meaning that the plant has the capacity to receive collected plastic and metal fractions from all the households in Northern Jutland (I/S Reno-Nord, 2016). Upon the launching of this plant, the company declared to be working on developing collaborations with local companies to possibly buy the fraction-sorted waste being the plant's output.

While the creation of these plants may seem like an answer to the required activity for the government to decide whether to build plants or rely on the neighboring countries' existing plants, it will be argued that this is not the case. First of all, it seems like I/S Reno-Nord's plant was an initiative of, and financed by the local municipalities in its entirety (I/S Reno-Nord, 2016), proving that the municipalities and citizens are slowly moving towards greater recycling by themselves, without the government dictating exactly what actions are required by whom. Second of all, these plants are not able to recycle the sorted materials, but simply to sort the collected waste into several desired fractions. Therefore, the government's required activity to decide whether to build recycling plants locally or to continue to rely on Germany and Sweden's facilities is still valid.

This being said, the creation of such plants opens for another debate on the recycling agenda, namely that of the economic and environmental soundness in the Danish municipalities building plants to sort the collected waste before sending the sorted fractions abroad for recycling and eventually buy the secondary raw material from these plants again. Before economic soundness of such plants is ensured, municipalities working (or willing to work)

together on collecting waste need to evaluate whether enough waste can be collected locally to allow for the plant to run, for instance. In spite of this interesting perspective on the topic, this debate will not be discussed any further in this paper, given that it is beyond the scope of the thesis' study. Based on this short summary of current activities taking place on the recycling of household waste agenda, it is thus argued that this paper's findings remain activities, which should occur in the coming years, if the Danish recycling rates are to increase towards the European Union's goal of 50% by 2020.

The following section will briefly comment on the entire paper and the process of writing it. It will assess the strengths and possible weaknesses of the study and its findings, and will reflect on what may have been done differently in order to strengthen the findings. The purpose of the study was to gain an overview of the many current thoughts on the issue of the recycling rates in Denmark, how to increase these, and subsequently to discover the perceived most important factors to be changed to allow for this to happen. Thanks to the study's findings, the paper is thus believed to successfully having answered the research question and to fulfill the purpose of the study. The investigative nature of the study is viewed as a strength in that it gathers a portion of the many diverse thoughts on the topic of a transition towards a circular economy and increased recycling rates in the country. Furthermore, the theories chosen for this thesis has helped produce the required activities by backing up data gathered and suggesting reasons for certain behaviors, as was the case for Bansal and Roth's paper on reasons for becoming sustainable (2000). Thus, if for nothing else, this paper's findings may help give an overview of the most recurring worries, challenges and thoughts on the topic. Another strength of the paper may further be how the findings seem to coincide with other research conducted on the topic, and are thus rendered more credible than if they were contradictory. As seen on several occasions throughout the paper, the findings are much in line with what the Nordic Council of Ministers' reports and studies and the report by CLEAN have found through case studies in recent years.

However, while the above two factors are perceived by the researcher as strengths of the study, it is acknowledged that this is not how it may be perceived by everyone. It can be argued that the findings have already been seen before, and therefore that the study has not led to any new knowledge. The fact that the findings look much alike the identified solutions

to increased recycling in the Nordic countries by the Nordic Council of Ministers and CLEAN may emphasize this. Additionally, the investigative nature of the study produced an outcome in the form of suggestions of the most important factors to look at in the near future, and not of concrete results or solutions, such as, the absolute best way to increase recycling rates, for instance. While this may be perceived as a possible weakness, the paper lays the ground for and facilitates such study in the future. Lastly, another possible weakness of the paper and study may be the difficulty in finding specific theory on the topic. The findings' validity may have been increased, had such theory been used to back them up. However, as discussed earlier in the paper, this lack of relevant and conclusive theory was to be expected given the rather new and contemporary nature of the study. As a compensation for this, the use of different theoretical perspectives (sustainability, reasons for becoming sustainable and collaboration theories) was applied in the thesis instead.

As a last point of discussion, the following will briefly comment on the possibility to have tackled this study in a different way. Had the researcher been able to stick to the original method of gathering empirical data, the findings may have looked somewhat different. As explained earlier, the intended approach may have given the researcher the possibility to interview companies known to be part of the value chain of the plastic packaging waste collected from the Danish households specifically. Given that the Swedish recycling plant Swerec possesses data on the companies to whom they sell the recycled materials (as is required of them by law), the intention was to be able to contact certain companies on this list in order to follow the Danish waste fraction until it is no longer in use. Such a study may have given a more detailed view giving specific knowledge about the Danish household plastic packaging wastes' fate. Although this method was desired, it may have turned out to be less successful as described above. Given that the topic discussed is that of creating a circular economy of the plastic packaging waste in Denmark, and not to increase an existing circular value chain, it seems plausible to assume that the study would have led to companies outside the country's borders and most likely also incineration plants. The actual method used in the study is thus deemed reasonable given the study of the national value chain of the waste fraction. The study did remain within the Danish borders, did study the thoughts and behavior of Danish companies on the topic, and did create suggestions for required activities on a national basis.

Conclusion

The purpose of this thesis has been to understand the challenges and opportunities faced with increased recycling of household plastic packaging waste and ultimately to find the prerequisites for increasing the market for the recycled plastic material. Since theory on the topics of circular economy and recycling remain suggestive and inconclusive, and the numerous studies conducted within this field were inconclusive, this thesis has made an in-depth case study analysis of several companies active in different areas of this resource's value chain to answer the question: *How can the market for recycled plastic packaging from households be increased? What are the actions required in the immediate future to increase the use of recycled plastic packaging, and from whom are they required?*

After having described the main challenges for the increased recycling rates as set out by the Danish government and the European Union, the study identifies eight activities, which are required by both the Danish public institutions and private companies. The government should decide on whether household plastic packaging waste should be source-sorted or sorted together with other materials, evaluate whether to aim for the country to be able to handle the entire recycling process of this waste fraction locally or continue to rely on German and Swedish plants buying the material, to ensure the design of new packaging products is in accordance with the subsequent recycling of them, and lastly, to create economic incentives for private companies on the market with a view to favor secondary raw material over the virgin polymer currently employed.

The study further finds that public institutions (also including the Danish government) should ensure that industry standards do not hinder the use of recycled plastics in the production of goods, and should increase the general public awareness of the national sorting system and opportunities with waste collected from households. Lastly, the study finds that private companies already engaging in projects on increasing the recycling rates should advertise their best practices to other industry actors, and that packaging design companies should ensure that innovation within their field happens with increased recycling of the goods produced in mind.

While acknowledging that certain circular economy activities are already taking place in Denmark – some of which are mentioned in this thesis – it is concluded that these required activities are deemed necessary to take place in the coming years, if the country is to reach the goal of 50% recycling of all household waste by 2020 and speed up the transition towards a circular economy. Furthermore, the paper's findings are not believed to be an exhaustive list of all activities required to arrive at a state of circular economy, just as they are not an attempt to suggest the best way to advance the transition from the current linear economy to the future circular economy. The findings are deemed to be representative only for the specific waste fraction – plastic packaging from households – and the paper is merely representative for the studied companies in the concerned sector.

If the subject were to be continued, or should other researchers wish to study this thesis' topic any further, it is suggested to look into the specific activities conducted in Denmark and assessing these. Studying specific initiatives made by, for instance, the Danish government and certain private companies active within this topic, and following these to their execution (or failure of being executed) would give a better understanding of which behaviors actually seem to move society. Furthermore, an interesting potential study would be to evaluate how the change in government has affected or may affect the governmental initiatives within this field. Likewise, it would be interesting to follow the sorting plants being built across the country once they are established and operating. This would allow getting a sense of whether the investment in these plants were indeed profitable in the long-run, and whether the waste quality increased thanks to these investments.

References

- Aage Vestergaard Larsen, (2015). Plastic recycling Aage Vestergaard Larsen. Retrieved from <http://avl.dk/en/aage-vestergaard-larsen-plastic-recycling/>
- Ærenlund, L. (2016). *Personal communication (Aug 17, 2016)*.
- Andersen, M. (2007). An introductory note on the environmental economics of the circular economy. *Sustainability Science*, 2(1), 133-140.
- ARC. Sorteringsanlæg & eftersortering i Danmark kan give bedre genanvendelse. Retrieved from <https://www.a-r-c.dk/affald-til-ressourcer/sorteringsanlaeg>
- Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. *The Academy of Management Journal*, 43(4), 717-736.
- Bhaskar, R. (1989). *Reclaiming reality: A critical introduction to contemporary philosophy*. London: Verso.
- CLEAN. (2014). *Stimulering af markedsdrevet efterspørgsel efter returplast i udvalgte værdikæder*. Copenhagen: CLEAN.
- Clemen, J. (2015). *Phonecall with environmental consultant for the Danish Plastics Federation (Oct, 2015)*.
- Dahse, P. (2016). *Personal communication (Aug 12, 2016)*.
- Damgaard, K. (2016). *Personal communication (Jun 30, 2016)*.
- Danish Government. (2013). *Danmark uden affald. genanvend mere – forbrænd mindre*. Danish Government.
- Directive 2008/98/EC on waste (waste framework directive). Retrieved from <http://ec.europa.eu/environment/waste/framework/>

- Dyer, J., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *The Academy of Management Review*, 23(4), 660-679.
- East, P. (2015). *Recyclability by design*.
- Ellen MacArthur Foundation. (2015). *Towards a circular economy: Business rationale for an accelerated transition*.
- Ellen MacArthur Foundation. (2016). *The new plastics economy: Rethinking the future of plastics*. States News Service.
- European Commission. (1994). *EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE 94/62/EC of 20 December 1994 on packaging and packaging waste*. European Parliament and Council.
- European Commission. (2008). Directive 2008/98/EC of the European parliament and of the council of 19 November 2008 on waste and repealing certain directives. *Official Journal of the European Union*.
- European Commission. (2014a). *The circular economy: Connecting, creating and conserving value*. GB: Palgrave Macmillan M.U.A.
- European Commission. (2014b). *Towards a circular economy: A zero waste programme for europe*.
- Fors A/S. The plastic experiment. Retrieved from <http://www.fors.dk/plastforsoget>
- Fråne, A., Stenmarck, Å, Gíslason, S., Løkke, S., zu Castell Rüdenhausen, M., Raadal, H., & Wahlström, M. (2015a). *Guidelines to increased collection of plastic packaging waste from households*.
- Fråne, A., Stenmarck, Å, Gíslason, S., Løkke, S., zu Castell Rüdenhausen, M., Raadal, H., & Wahlström, M. (2015b). *Nordic improvements in collection and recycling of plastic waste*.

- Fråne, A., Stenmarck, Å, Gíslason, S., Løkke, S., zu Castell Rüdénhausen, M., Raadal, H., & Wahlström, M. (2014). *Future solutions for Nordic plastic recycling*. Denmark: TemaNord.
- Fråne, A., Stenmarck, Å, Gíslason, S., Lyng, K., Løkke, S., zu Castell-Rüdénhausen, M., & Wahlström, M. (2014). *Collection & recycling of plastic waste*. Denmark: TemaNord.
- Gregson, N., Crang, M., Fuller, S., & Holmes, H. (2015). Interrogating the circular economy: The moral economy of resource recovery in the EU. *Economy and Society*, 44(2), 218-243.
- Hazell, J., Hill, J., & Benton, D. (2014). *The guide to the circular economy: Capturing value and managing material risk*. Oxford: Do Sustainability.
- Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: Challenges and opportunities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364, 2115-2126.
- I/S Reno-Nord. (2016). Danmarks mest moderne anlæg til sortering af plast og metal indvies i dag; Retrieved from <http://www.renonord.dk/default.aspx?m=4&i=34&pi=1&pr=1>
- Jensen, K. (2016). Industrien kan bruge plastaffald fra husholdningerne. Retrieved from http://plast.dk/2016/06/industrien-kan-bruge-plastaffald-husholdningerne/?SNSubscribed=true&utm_campaign=PlastNyt%3A%20S%C3%B8ren%20Ulstrup%20fejrede%2050-%C3%A5rs%20f%C3%B8dselsdag%20%7C%20Wavin%20s%C3%B8ger%20produktionssingeni%C3%B8r%20%7C%20Mere%20bioplast%20er%20ikke%20et%20quick%20fix%20p%C3%A5%20udfordringerne%20med%20plast%20i%20havet&utm_medium=email&utm_source=Newsletter
- Kjørboe, N., Sramkova, H., & Krarup, M. (2015). *Moving towards a circular economy*. The Nordic Council of Ministers.
- Larsen, G. (2016). *Personal communication (Jun 27, 2016)*.

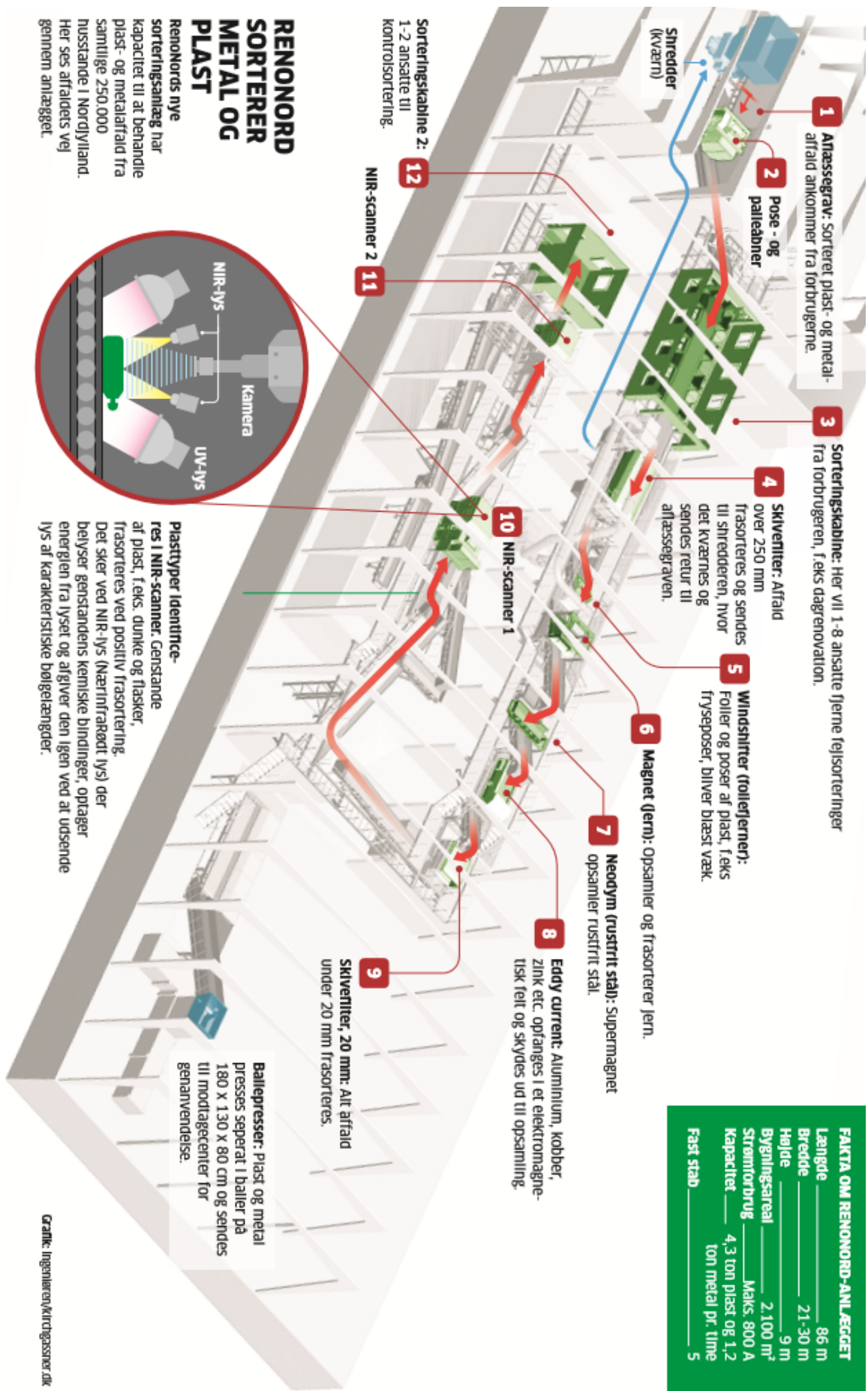
- Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, 115, 36-51.
- Malmgren-Hansen, B., & Nilsson, N. H. (2016). *Personal communication (Aug 11, 2016)*.
- Nidumolu, R., Prahalad, C. K., & Rangaswami, M. R. (2009, Sep 1). Why sustainability is now the key driver of innovation. *Harvard Business Review*, 87, 56-64.
- Nielsen. (2014). *Global consumers are willing to put their money where their heart is when it comes to goods and services from companies committed to social responsibility*.
- Nordic Council of Ministers. (2011). *The Nordic region - leading in green growth*.
- Rasmussen, H. H. (2016, May 31). Industrien bruger plastaffald fra husholdningerne. *Hadsund Folkeblad*.
- Salkvist, A. K., & Ærenlund, L. (2015). *Kundeundersøgelse "Min sortering"*. Holbæk: Holbæk Forsyning A/S.
- Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students* (2.th ed.). Harlow [u.a.]: Pearson Education.
- Snällfot, D., Leisner, I., Skovgaard, M., & Warberg Larsen, A. (2013). *Plastic zero: Market conditions for plastic recycling*.
- Stender, B. (2016). *Personal communication (Aug 12, 2016)*.
- Swerec. (2011). Swerec - recycling for life. Retrieved from <http://www.swerec.se/en/home/>
- Waste Office. (2015). *Oversigt over eksisterende afsætningsmuligheder for plast-, metal- og organisk affald*.
- World Commission on Environment and Development. (1987). *Our common future*. Oxford: Oxford University Press.

Appendices

Appendix One	Sorting plant at I/S Reno-Nord	Page 67
Appendix Two	Interview summary, Aage Vestergaard Larsen	Page 68
Appendix Three	Interview summary, DanBørs A/S	Page 70
Appendix Four	Interview summary, Teknologisk Institut	Page 72
Appendix Five	Interview summary, Danrec	Page 74
Appendix Six	Interview summary, Dansk Affald	Page 76
Appendix Seven	Interview summary, Fors A/S	Page 79

Appendix One

I/S Reno-Nord’s plant sorting on plastic packaging and metal collected from households.



Appendix Two

Interview summary, Aage Vestergaard Larsen

Interviewee: Gitte Buk Larsen, Marketing and Business Development Director

Interviewer: Camilla Fløe Cruse Henriksen

Date: June 27, 2016

Location: Aage Vestergaard Larsen's recycling plant, Mariager

The overall theme of the interview was to gain insight of the business model of the recycling plant that Aage Vestergaard Larsen is, as well as to hear the point of view of such a privately owned company on the studied topic. Its main competence is the recycling of plastic products coming from the processing industry, the production waste industry, and has been doing so since 1972. Alongside this middle class (as the received waste is classified as by the interviewee), the company has recently begun to show interest in the low class (i.e. household plastic waste) and the recycling of this fraction at AVL's facilities. For this reason, AVL is, among other plastic projects, participating in a project with Fors A/S and Schoeller Plast Entreprise A/S. Fors A/S is a private company collecting household waste in the municipality of Holbæk, and Schoeller Plast Entreprise A/S is a private company producing plastic products. Together, these three companies has engaged in a project to test the feasibility of using households' own sorted plastic packaging to produce the sorting systems for these same households. In this project, AVL has received the sorted and collected waste fraction from Fors A/S and has been responsible for recycling it into granulates, which is then sent to Schoeller Plast Entreprise A/S for the production of new products.

In addition to this project, AVL is participating in the project on building a sorting plant in Northern Jutland. I/S Reno-Nord has the ambition to build a plant that has the capacity and ability to receive all the household-collected plastic waste and to sort it into fractions. On the topic of household plastic packaging waste, Gitte Larsen is of the opinion that the main challenge is the product composition of many different fractions and materials. This is the reason for the plastic waste not being feasible to recycle at the moment. Increased recycling rates are thus a question of choosing the adequate material and fraction to produce new products. Furthermore, if the plastic packaging waste were to be sorted in clean fractions (i.e. PP with PP waste, and PE with PE waste), the recycling issue would not be much of an issue any longer. The current problem is the requirement of manual pre-sorting of household

plastic packaging waste due to the mixed waste fraction. The experience of AVL is that its customers (being the same/similar companies to the ones delivering the plastic waste to AVL) require granulate that is made of clean fractions. This is the reason for AVL not recycling the household plastic packaging waste; the waste currently is too contaminated to be worth cleaning, sorting and recycling.

According to AVL, it is not the public institutions or the government, which sets the current high industry standards, but the industries themselves. That is, it is the companies themselves require the perfectly clean fractions. Furthermore, AVL is of the opinion that the municipality freedom to choose the sorting system that suits them best is among the biggest mistakes made under this topic. Such system slows down every attempt there may be to create national goals, rules or regulations. However, now that these are well rooted in the Danish society, AVL is of the view that the increased recycling rates may best and more easily be collected from recycling centers (i.e. with the use of bring systems). These are of more or less the same size around the country, and are thus eligible for the same implementations. AVL suggests household plastic waste should be collected at the recycling centers in three or four different containers; one for each of the most common types of plastic packaging in the country (PP and PE, and possibly PVC too) and one for the products that are too mixed and should thus be incinerated. The collected amounts are much greater at the recycling centers than at the curbside. Gitte Larsen specifically suggests to print pictures of the 50 most common types of household plastic packaging with directions as to which container the waste belongs to. This would facilitate the recycling for the citizens. If this were to be the case in the future, AVL would be able to take the containers directly into their production of granulate since the purity of the collected fractions are more likely to be ensured with such system than with curbside collection. In fact, AVL welcomes the reception of household plastic packaging waste if and when it is of a quality that the company's facilities can work with (needs to be washed and sorted into fraction some place else). Since no such plants are present in the country, new technology is required to allow for companies like AVL to receive household waste.

Furthermore, during the interview, Gitte Larsen expressed the distaste in the great amount of plastic waste being exported from the country (about 130.000 tons per year) given that Denmark actually has a market for the recycled plastic. It is thus not a question of creating a

market, but of feeding the market, and eventually to make the change from incineration and exportation to recycling. It is also a question of the government's willingness to invest in the sorting of the household waste, if it is ever to be favored over virgin polymer. The companies claiming that the quality of the recycled plastic is too low and the little quantities increasing the price of it are making up excuses not to change their current activities. Gitte Larsen believes that the country still needs extensive research on the possibilities for recycling household plastic packaging waste, before jumping into finding solutions for this. It is important to ensure that it is worthwhile to pursue the solutions in mind. Lastly, Gitte Larsen is of the belief that consumers are partly responsible for the lack of interest in the recycled plastic material, given their high demands for clean products with even surfaces and the like.

Appendix Three

Interview summary, DanBørs A/S

Interviewee: Klaus Damgaard, Sales Manager and expert in plastic waste

Interviewer: Camilla Fløe Cruse Henriksen

Date: June 30, 2016

Location: DanBørs A/S office, Søborg

The purpose of the interview with DanBørs A/S was to gain knowledge on the current quality of the collected plastic packaging waste from households in order to get an overview of the opportunities with, and possibilities for, this waste fraction. DanBørs A/S is a private company acting as a sales department on the recyclable fractions in Danish waste and as a sort of consulting department for the municipalities with regards to how to best collect waste. It is thus usually through DanBørs A/S that municipalities sell the collected waste to sorting plants. With regards to the plastic packaging waste stemming from households, DanBørs A/S either sells the waste fraction to sorting and recycling plants abroad or to companies, which exports the fraction to China and USA for further use (of which there is no trace). The household plastic packaging waste is such a new topic in Denmark, that the municipalities do not really know how to handle the waste fraction in order to get high quality collected material. This is where DanBørs A/S can help find solutions to them thanks to its great expertise in the waste fraction. Klaus Damgaard shares the belief of many that the current qualities of new products are higher than the industry requirements. He believes this is due to the consumers demanding packaging similar to existing products; that looks nice and does not

contain any recycled material changing the color or texture of the products. Klaus Damgaard is convinced that recycled material could easily live up to industry standards and requirements, but that companies still choose to favor virgin polymer to be certain that the products live up to all stakeholders' standards. It is thus the consumer behavior that needs to be altered, if companies are to favor secondary raw material over virgin polymer. This is also a topic discussed by the Danish Plastics Federation, which believe that this is where the recycling thought needs to begin, alongside the composition of materials in products. Today, products are made up of too many different fractions and materials, and either gets incinerated due to the difficulty in separating these fractions and materials, or only allows for being re-used once due to the low quality in the secondary raw material.

DanBørs A/S is currently participating in several projects with municipalities focusing on collecting plastics, and with the largest Danish waste management company, Vestforbrænding, on the disposal of its plastic waste. Furthermore, DanBørs A/S has partnered up with INNOSORT (a Danish innovation consortium developing technologies for sorting and collecting waste so the country's resources may be used according to all their potentials) in an attempt to find a solution to the issue of manual pre-sorting of waste. Together they are trying to develop robots that can take over the manual sorting. With regards to the debate about the country's recycling capacity, Klaus Damgaard is of the opinion that there is not enough space in Denmark to build sorting plants, and that it would not be worth it economically unless all 98 municipalities agreed on a plant being built. He believes that it would be wiser to build several smaller sorting plants, which may not be able to sort the received waste enough for it to be used directly, but require another sorting round at the recycling plant before the waste can be turned into recycled material. Although he views this solution as more realistic for Denmark, Klaus Damgaard acknowledges the fact that this would limit the qualities of waste being used (e.g. only able to sort PP and PE but no other fractions). On another topic, Klaus Damgaard suggests the Danish municipalities engage in new sorting systems in order to be able to live up to the national and regional recycling goals, whereas private companies engage in sustainable activities to promote themselves on the green "wave", to gain legitimacy. He thinks that the greatest challenge for the increased recycling of household plastics is the misalignment between political expectations and the reality. While politicians state that plastics is of a certain value and may be recycled, the

household waste fraction currently requires so much sorting that the sorting and recycling companies end up paying to treat the waste fraction rather than gaining money from it. Further adding to the challenge, the fact that no plants able to sort the waste fraction properly exist in Denmark and it thus needs to be sent abroad, if permission is granted. He is equally of the belief that the quality of the household plastic waste is not a real issue since it is simply a matter of the price of it. The quantities, however, are currently too low to feed any market and thus needs to increase – which it is already slowly doing thanks to the different municipality initiatives. Overall, Klaus Damgaard does not believe that any great changes are necessary in order to increase the recycling rates, that the country is already moving in the right direction, and that existing initiatives should simply be continued. Continued focus should be on where the waste fraction can be discarded and subsequently recycled in order to avoid it being incinerated. Additionally, the municipalities sorting and collecting systems should continue to fall in place, and to be sorting in the same way in order to increase the homogeneity in the Danish plastic waste. Lastly, on the topic about whose responsibility it may be to ensure these things fall in place, Klaus Damgaard views it to be shared responsibility between the private and public sectors. The plastic producing companies are aware of the fractions' value and will eventually find solutions to incorporate them into the production given the economic incentives behind the use of this fraction. As to the municipalities and waste management companies, they need to be pushed to start acting on the EU recycling goals for the future that applies for all of them.

Appendix Four

Interview summary, Teknologisk Institut

Interviewees: Bjørn Malmgren-Hansen & Nils H. Nilsson, water and environment specialists

Interviewer: Camilla Fløe Cruse Henriksen

Date: August 11, 2016

Location: Teknologisk Institut Aarhus, Aarhus

The aim of the interview with Teknologisk Institut was to gain insight of the institute's knowledge on the topic of recycling and especially of household plastic packaging waste. This institute was chosen for the interview due to its participation in many projects evolving around recycling and therefore its anticipated extended knowledge in the matter. However,

the interview did not turn out as expected by the researcher given the two specialists' concentration on the ongoing projects. While an interview guide was prepared for the interview, just like for the other interviews held, to ensure that the discussed topics remained on the relevant subject, this was rejected at the beginning of the interview under the pretext that a free discussion was preferred. Likewise, the researcher was asked not to record the interview. For these reasons the knowledge and data gathered during the interview has not been used as a major source in the thesis, given the researcher's difficulty in proving any of the statements. This source has thus merely been used to back up other data. Given the circumstances under which the interview was held, a short and brief description of the topics discussed will follow.

On the topic of the Danish recycling capacity, both interviewees share the view that a recycling plant, let alone a central sorting plant, is not economically feasible to be built in Denmark. Although I/S Reno-Nord is currently building a sorting plant for the municipalities in Northern Jutland and Dansk Affald has the potential to become one for the municipalities in South Jutland, these would not be able to receive the entire country's plastic packaging waste. Additionally, if a central sorting plant were to be built in Denmark, the sorting of other materials apart from the plastic waste would be required to take place locally and not at such a facility. This would require the transportation of the waste to the plant, a factor whose importance is not to be neglected in the equation, according to the two consultants. The reason for a central sorting plant not being feasible for Denmark is due to the great fluctuations in both the quality and quantity of the collected household plastic packaging waste. The plant would thus not be guaranteed enough input to be able to run. These fluctuations partly exist because of the municipalities' freedom in choosing the sorting systems they desire. The two consultants view the future of the issue as lying in the hands of public sector. They both believe that regulations steer the market for recycling, and if these do not allow for the use of recycled material, the market will not increase. With regards to the public, several sorting plants are either being built or planned to be in the future and citizens already possess the right mentality for sorting their waste. Thus, according to the interviewees, it is a matter of a couple of years during which Denmark continues to move in the right direction, then the recycling will automatically increase on a national basis. Finally, they both acknowledge the importance of the design of the products in the recyclability of

them, and thus that the mindset behind designing products needs to be changed if recycling rates are to increase.

Appendix Five

Interview summary, Danrec

Interviewee: Peter Dahse, Technical Manager

Interviewer: Camilla Fløe Cruse Henriksen

Date: August 12, 2016

Location: Danrec plant, Karup

The purpose of the interview with Danrec was to gain insight into a company employing secondary raw materials in the production of new products. Danrec produces plastic boards for stable floors, road works and the like. Its products are entirely made of recycled plastic collected from households, optically sorted and turned into granulate at plants in Germany. When the company was established in 1992, its expertise was to treat recyclable materials (to sort and recycle them) – a business that has been stopped because it was not profitable. Today, Danrec focuses its strengths on producing plastic boards and differentiates itself from competitors thanks to its extensive knowledge in handling secondary raw materials. Its raw material no longer stems from Danish households because too little amounts are collected nationally. Even if greater amounts were to be collected nationally, the amounts would be small in comparison to what Germany has to offer, and the quality would thus vary too much for companies to entirely rely on it for their input. Danrec believes certain regulations do not represent the minimum product requirements for the products to be able to serve its intended purpose, but are set higher than what could ideally be required. Additionally, according to Peter Dahse, Danish producers often use the excuse of the recycled material being of too poor quality for them to produce adequate products of it. This is due to the existing contamination in and mixture of fractions and materials in the products. A plastic product often contains about 5-8% of other materials or fractions, used as a lid to close a container or paper label to present the product, for instance. This hinders the use of recycled plastics in the production of new products. According to Peter Dahse, the general excuses for not employing recycled materials in the production of new products in Denmark is that it is a complicated process and that, for instance, the color of new products rarely is chosen by the company and more often by the consumers. Furthermore, Danish authorities have certain

regulation set in place that does not make sense to Peter Dahse. For instance, the fact that recycled material may not be employed in the production for road pillars or floating rubber balls for slurry tanks. These are just two examples of products which could easily be made of recycled material but that may not due to current regulations. It is a challenge for Danrec to sell its boards to the construction sector where CE marking plays an important role in the choice of products. Boards of recycled materials cannot be CE marked and is thus much less attractive for construction companies to employ.

Danrec does not participate in any projects or collaborate with any companies because of the uniqueness in the company's competences and competitive advantage of those. According to Peter Dahse, another great challenge in the increased recycling goals is the lack of motivation and pressure to achieve the goals set by politicians. He views the situation as politicians setting goals in places where the motivation to change is rather small. What is lacking is thus political pressure on companies in order to initiate the transition to a circular economy. Peter Dahse also fears that the future will bring increased collection rates in Denmark while the country will not be able to sort and recycle the collected waste, given the too big investment this would require (unrealistic big investment for such a little country). Part of the reason for this fear is that Peter Dahse is convinced that municipalities will not send their waste to sorting and recycling plants without motivations for doing so. This is because the incineration plants are owned by the municipalities, and it is thus currently in the interest of the municipalities to feed their plants with the waste collected. According to Peter Dahse, it is these incineration owners (municipalities) that should be in charge of sorting the waste into fractions, since this would allow them to use the leftover and unusable waste to feed the incineration plant. In the eyes of Danrec the future for Denmark is to focus on a few fractions, and to make a national effort in collecting as much as possible of these. For this to succeed, better source-sorted systems are required. By focusing on only a few fractions, the sorting of waste would be made easier for citizens who currently often struggle to differentiate between the types of plastic. In addition to this national effort, the design phase should use as few different materials and fractions in each product as possible.

Summing up the findings from this interview, Danrec believes greater trust in the systems and regulations implemented by the government is necessary if both citizens are to start sorting

their waste, and companies think recyclability into their production and design. Furthermore incentives need to be set in place to allow for the transition from a linear to a circular economy to happen faster.

Appendix Six

Interview summary, Dansk Affald

Interviewee: Bjørn Stender, Director

Interviewer: Camilla Fløe Cruse Henriksen

Date: August 12, 2016

Location: Dansk Affald sorting facilities, Vojens

The aim of the interview with the director of Dansk Affald was to gain knowledge and insight on the challenges with household plastic packaging waste from the sorting facility's point of view. Dansk Affald was chosen over other sorting plants in Denmark due to their active participation in the debate of increased recycling rates and sorting initiatives in the surrounding municipalities. At the facilities Dansk Affald receives and sorts all recyclable material collected from households (paper, carton, foils, metal, glass and plastic). The publically owned company has a NIR machine to sort the different types of plastic from each other and wishes to increase its focus on the plastic fraction in the future. Bjørn Stender explains that the company is for sale to the private industry in the hope that this will mean greater amounts of waste (from private companies) being sorted at the facilities. According to him, it has been proven that household plastic waste that is first pre-sorted manually before being optically sorted into fractions indeed is a rather cheap way of generating good qualities of sorted fractions. These fractions can then easily be sold to the large recycling plants present in Germany and Sweden. However, Bjørn Stender sees Dansk Affald taking certain steps of the recycling process – for instance washing the received waste – into its own hands in the future. The largest portion of waste received at Dansk Affald is the mixed fraction of metal, glass and plastic. The company's technology is able to sort these three materials from each other before further sorting the plastic waste into fractions. Its technology currently sorts PP, PE and PET together in one fraction, but the aim is to purchase more NIR machines in order to be able to sort between these three fractions too. Bjørn Stender is of the belief that this mixed fraction is better than attempting to separate the materials in the sorting process. Like this, the technology available is used to ensure the purity in the fraction (i.e. to ensure no glass or

metal is left over when the plastic is sorted) rather than using power to attempt to sort the fractions from each other. The requirement of the plant for the received waste is that it should be visibly clean (that no organic waste should be visible in the waste). The mixed fraction collection system of metal, glass and plastic appears to be working just fine, and citizens seem to understand the sorting guidelines. Dansk Affald thus receives clean fractions of the collected waste. However, the citizens seem to be discarding too great amounts of these three fractions into the organic waste fraction when in doubt about the adaptability of certain plastic products. This is an issue that Dansk Affald wants to work on overcoming by enlightening citizens on what type of waste should be discarded in the metal, glass and plastic fraction.

In Dansk Affald's experience it helps municipalities to understand which sorting systems to implement and citizens how to sort their waste if the waste management company reaches out and informs about what happens to the waste at its facilities. The company finds that citizens are more willing to sort their waste if they understand what happens to it once they have discarded it. In spite of this, Dansk Affald has found a challenge in explaining citizens how clean the waste should be when it is discarded. If the company asks for clean waste, some citizens may spend several liters of hot water on washing the waste while others may not wash it at all. This is what eventually leads to impurities in the waste when received at the plant. As an attempted solution to this, Dansk Affald has asked for waste that is visibly clean only. While impurities are still found in the waste at Dansk Affald, this has helped citizens understand how much to clean their waste before disposing of it. Dansk Affald experiences that the closer to the household the collection of waste takes place, the greater the qualities and quantities the collected waste will be. This explains why the surrounding municipalities use curbside collection schemes. Moreover, Dansk Affald also views the combination of plastic fractions and materials as being one of the major challenges in increased recycling of plastic packaging waste. This waste is currently difficult and unfeasible to sort and eventually recycle. For Dansk Affald the quality of the received plastic waste is of greater importance than the quantities. The company finds it important to be able to ensure a certain quality to the recycling plants buying the waste from Dansk Affald.

Turning to the topic about the Danish recycling capacity, Dansk Affald does not think it feasible to build more than one recycling plant in the country, and therefore suggests that Denmark should continue sending its sorted plastic waste to neighboring countries rather than spending money on building one plant, which will not be able to receive the entire country's plastic packaging waste. In spite of the export of the waste fraction requiring longer transportation and therefore greater amounts of CO₂ released (which is another source of pollution), Bjørn Stender suggests that this plays a minor role in the entire recycling activity. Another issue of increased recycling lies within the product requirements. According to Bjørn Stender, these are much higher than necessary, hindering the use of recycled plastic in new products. Bjørn Stender provides the exact same examples as Peter Dahse from Danrec did, namely the road pillars and floating plastic balls for slurry pits. However, Bjørn Stender is of the opinion that companies actually are ready for the transition towards a circular economy and that it is the regulation that is lacking behind and hindering this transition. According to him, it is therefore only a matter of changing regulations to allow companies to make the changes themselves (as is already seen with IKEA and Arla, to name but two examples).

Regarding the participation in projects concerning increased recycling rates, Dansk Affald has participated in several with different institutions. Bjørn Stender views such activity as a means to increase the image and reputation of the company and to increase the company's reliability in the eyes of citizens, municipalities and politicians. Furthermore, participating in projects is Dansk Affald's way to respond to, and show its support in, the Danish resource strategy as well as to prove that greater recycling is possible. From one of these projects with INNOSORT, Saga III, Dansk Affald knows that there are much greater amounts of plastic to be collected in Denmark than the current rates, and that this waste fraction has many potentials for being recycled and enter the value chain again. Lastly, Dansk Affald confirms that there is a market for the recycled materials, and that it simply needs to be fed greater amounts and qualities of plastic packaging. The recycling plants in Germany to which it sells the sorted plastic guarantees the waste is being sold to companies interested in using the recycled granulate and that it is not being incinerated.

Appendix Seven

Interview summary, Fors A/S

Interviewee: Lærke Ærenlund, project manager of the plastic project

Interviewer: Camilla Fløe Cruse Henriksen

Date: August 17, 2016

Location: Fors A/S office, Holbæk

The purpose of the interview with Fors A/S was to understand the ongoing project of using households collected plastic packaging waste to create new sorting systems for these same households as well as to understand the drivers for this project. This private company collects waste from the municipality of Holbæk, and deals with heat, water and wastewater from the municipalities of Lejre and Roskilde too. Some of the plastic packaging waste collected from households in Holbæk is used to feed the above-named project. It is sorted manually before being sent to AVL in Northern Jutland for recycling. For the purpose of this project, only manual sorting is applied, given that this gives the best quality in the recycled material. If the project proves to be successful and is considered to be up-scaled to several municipalities and possibly eventually the entire country, such sorting is not economically feasible. Better optic sorting technologies are required. According to Lærke Ærenlund, the project manager on this project, the greatest challenge in the use of recycled household plastic packaging is the lack of sorting plants in Denmark; plants, which are able to sort different types of plastic from each other. In her opinion, the reason for this situation is due to the lack of a market for the recycled material existing. Fors A/S is thus of the opinion that there currently does not exist a market for recycled plastic packaging. Equally, the company's reason for introducing the plastic packaging in the households is not rooted in economic benefits or incentives, but is solely for the environmental equation. Lærke Ærenlund views the solution to these challenges to build a sorting plant in Denmark, which is able to sort the entire country's household plastic packaging waste at a reasonable cost. That is, municipalities will only be willing to sell the collected waste to such plant if it is cheaper than the current discarding methods applied.

According to Fors A/S, the best way to collect the concerned waste fraction is to source-sort it and collect it at the curbside. This is thought to give better and cleaner fractions of packaging waste. Backing up this statement is the belief that sorting machines, which sort mixed fractions (i.e. different materials from each other) do not lead to 100% pure fractions, and

sort waste in a lower quality than if the waste was source sorted. Furthermore, the citizens are believed to be confused if they are asked to sort their waste in mixed fractions. Lærke Ærenlund deems that it is easier to communicate simple and clear sorting systems to them. On the topic on what is required to increase the national recycling rates, Lærke Ærenlund expresses the need for a national effort. More specifically, she believes that further studies should be made with regard to what the opportunities for the household waste are, and that regulation with clear and concise goals should be created. She believes that companies and institutions are currently good at talking about the issues and what needs to be done, but do not act upon what is being said. Action is thus required.

Turning to the plastic project mentioned above, the purpose was to test whether the plastic packaging waste collected from households had the potential to create new products. Furthermore, Fors A/S wanted to implement a new sorting container for the household metal and plastic, but needed to confirm that it would be worth it to implement the container. In collaboration with 2,000 households in the municipality, Fors A/S noticed that people did not understand that their waste could become a resource. The company therefore decided to show people what the waste has the potential to become. Furthermore, Fors A/S has the ambition of creating a symbiosis with other companies. These two reasons led to idea of creating sorting systems for the households themselves made of the household collected plastic packaging. The sorting system created is produced of recycled household PP, which was the largest fraction in the collected waste. The system is currently being tested in 2,000 households in Holbæk, on which an evaluation will determine whether to implement this system to the entire municipality. The reason for this project only concerning one waste company and one municipality is because Fors A/S is not allowed to receive household waste from any other municipalities. If other municipalities and companies were willing to follow the project undertaken in Northern Zealand, and the project proves to be working, this sorting system could be a future for the entire nation.