Working with Loops in Plastic Waste Management

Circular economy and cleaner production in plastic waste management Northern Jutland

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Envrionmental Management & Sustainability Science
Master Thesis - 2019

AALBORG UNIVERSITET

AALBORG UNIVERSITY
STUDENT REPORT

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Title: **Working with Loops in Plastic Waste Management: Circular economy and cleaner production in plastic waste management Northern Jutland**

Semester: **4. Semester - Spring 2019**

Theme: **Master Thesis**

ECTS: **30 points**

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Pages: **81**

Date of completion: **June 7, 2019**

Synopsis:

This master thesis investigates the possibilities for introducing circular economy in plastic waste management in Northern Jutland by using cleaner production and open innovation.

Research Question:

"How can companies in Northern Jutland collaborate to improve their reuse and recycling of plastic and ensure a high plastic quality is maintained?"

Conceptual framework: By using cleaner production, the focus has been on circular economy and how to close, slow or narrow the plastic loops in Northern Jutland. In order to do this local partnerships and open innovation has been applied to create a collaboration and pilot project in plastic recycling. The United Nations 17 Sustainability Goals was used to create a strategic starting point. The empirical data for the master thesis were literature studies, interviews, observations and a waste screening.

Results: The preliminary test showed potential for recycling of VCI plastic instead of incinerating it. A full-scale test will be conducted in order to explore the possibilities for recycling VCI plastic and help in closing the loop. The project showed potential for new local partnerships in Northern Jutland and the opportunity for Network for Sustainable Business Development NorthDenmark to create a platform to promote local circular solutions.

Preface

This master thesis is written by two students from the master programme Environmental Management and Sustainability Science, Aalborg University.

The purpose of the research has been to examine the implementation of circular economy in plastic waste management at MAN Energy Solutions. The research has been conducted through a research design rooted in principles from Techno-Anthropology and post-phenomenology, with the use of qualitative methods for gathering empirical data.

We would like to thank Network for Sustainable Business Development NorthDenmark, Genplast A/S, Aage vestergaard Larsen A/S, Claus Sørensen A/S and MAN Energy Solutions for the participation in this master thesis. And especially thanks to Kim Nørgaard for allowing us to use our conceptual framework at MAN Energy Solutions and showing us trust by participating in the pilot project with Aage Vestergaard Larsen A/S.
In addition, we would like to thank the employees we have been in contact with at MAN Energy Solutions for their active involvement in the project.

Finally, we would like to thank our supervisor, Arne Remmen for his inspirational input and his positive approach to our project and the results it has produced.

Resumé

Dette speciale omhandler mulighederne for at introducere cirkulær økonomi i håndtering af plastaffald i Region Nordjylland. Ved at anvende cirkulær økonomi, cleaner production, open innovation og FN's verdensmål, har det været formålet at reducere affaldsmængderne af plastik som bliver sendt til forbrænding. Dette blev gjort som et forsøg ved MAN Energy Solutions i Frederikshavn, hvor virksomheden først blev affaldsscreenet efter principperne fra cleaner production. Prøver fra affaldsscreeningen blev leveret til en genbruger, hvilket resulterede i et pilotprojekt mellem Aage Vestergaard Larsen A/S og MAN Energy Solutions. Pilotprojektet havde til opgave at undersøge muligheden for genbrug af en specifik type VCI-plastik, som bliver brugt i det maritime erhverv. Denne type plastik er hidtil blevet sendt til forbrænding på grund af de tilsætningsstoffer, som der bliver tilføjet plastikken. Empiri er blevet indsamlet gennem litteratur studie, interviews, observationer og analyse af affaldsdata

Affaldsscreeningen af MAN Energy Solutions og den viden genbrugsvirksomhederne har bragt frem, har vist et potentiale for øget genbrug af plastik i Region Nordjylland ved hjælp af lokale partnerskaber. For at understøtte disse partnerskaber er det blevet foreslået NBE skaber en åben platform for vidensdeling mellem firmaer i Region Nordjylland.

Contents

Chapter 1

Introduction

This report began with wondering about the rise of consumer related-regulations in plastic and growing individualisation of responsibility regarding sustainability:

> *"When responsibility for environmental problems is individualized, there is little room to ponder institutions, the nature and exercise of political power, or ways of collectively changing the distribution of power and influence in society to, in other words, think institutionally."(Maniates, 2006)*

An increasing number of regulations are focused on removing single-use plastic from our daily lives and as consumers, we are asked to switch to sustainable solutions. In March 2019, The European Parliament voted 560 to 35 in favor of banning ten single-use plastics (Roth and Kerry, 2019). This was a response to China banning the import and processing of plastic waste forcing action from EU.
But what about companies around the world? They are also producers of plastic waste and as consumers we are starting to demand action. One of these companies is MAN Energy Solutions located in Frederikshavn, Northern Jutland, Denmark. They contacted Network for Sustainable Business Development NorthDenmark or *NBE* in order to perform a waste screening as the initiating step in developing a strategy based on the United Nations 17 Sustainability Goals or *SDG's*.

Through NBE's collaboration with Aalborg University, the researchers of this report was connected with MAN Energy Solutions to help. The focus of the report became how companies in Northern Jutland can collaborate to improve the reuse and recycling of plastic waste to increase their sustainability. To do this circular economy as a concept was chosen as the framework to guide the research. This is also the strategy EU has chosen to combat the growing plastic problems with their "Closing the loop: New Circular Economy Package" (European Commission, 2018).

Chapter 2

Problem Analysis

The Problem Analysis will investigate and on elaborate the problems associated with plastic. The first part introduces the problems with the growing demand for plastic before going into initiatives in a European context and how it is implemented on a national level in Denmark. In the end of the chapter, the relevant actors will be introduced in order to narrow down the problem so a research question can be formulated.

2.1 Problems with the rising demand for plastic

Plastic is a common word for many different materials made of either fossil fuel or bio-based materials. In Europe, the total amount of oil used to produce plastic is 4-6% (PlasticsEurope, 2017). Plastic is mostly used in common household items and for packaging. Due to the low cost, the resistance against water and the ease of manufacturing the global demand for plastic has been increasing. Plastic is used as a solution to many problems and when used responsibly it can benefit the environment. Packaging can prolong the lifetime of foods, reduce food waste and being lightweight it is easier to transport. As shown in Figure 2.1 the demand over the last 40 years has increased over tenfold. In 2016 the amount of plastic produced was 335 million tonnes with 60 million tonnes produced (PlasticsEurope, 2017).

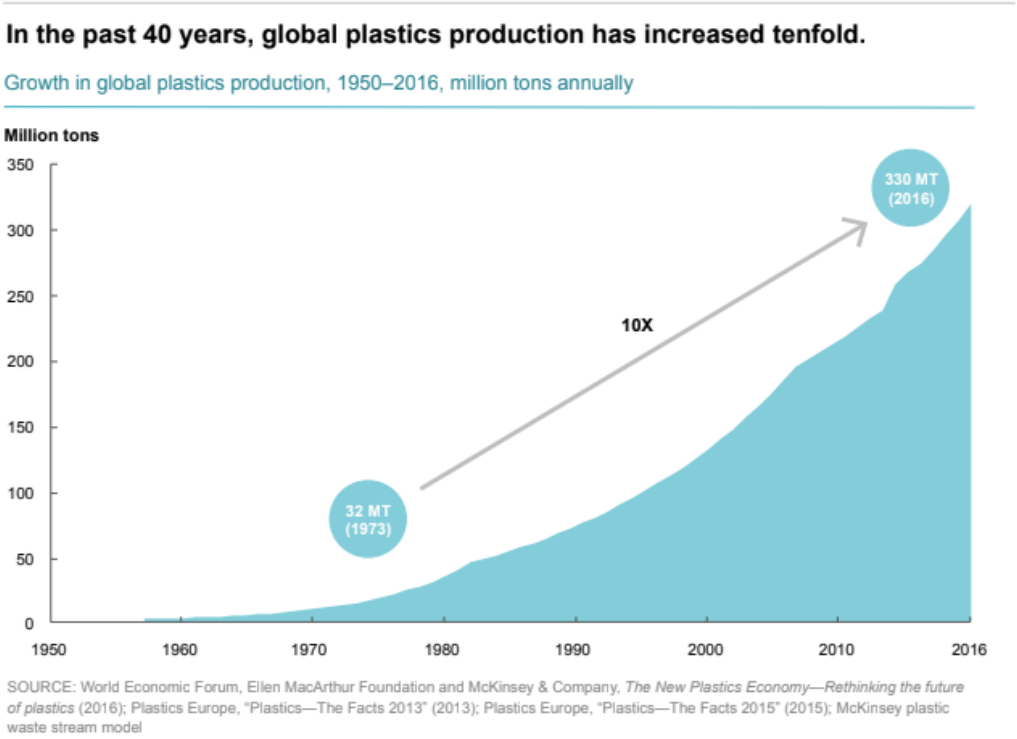

Figure 2.1: The increased demand for plastic globally (PlasticsEurope, 2017)

As a result of the growing demand and use, plastic waste generation has increased significantly. The result is several challenges in plastic waste handling and the recycling of plastic. In 2017 around 25.8 million tonnes of plastic waste was generated by the Member States of the European Union and only around 30% was recycled (PlasticsEurope, 2017). It is estimated that each year at least eight million tonnes of plastic leak into the oceans, hurting marine life and the surrounding ecosystems. An estimated 150 million tonnes of plastics has already leaked into the oceans. The main problem with this is plastic not being organic material and therefore does not decompose. According to European Commission (2018) land-filling and incineration of plastic waste are at 31% and 39%. Which is a potential loss of benefits from recycling both from an economic and environmental perspective.

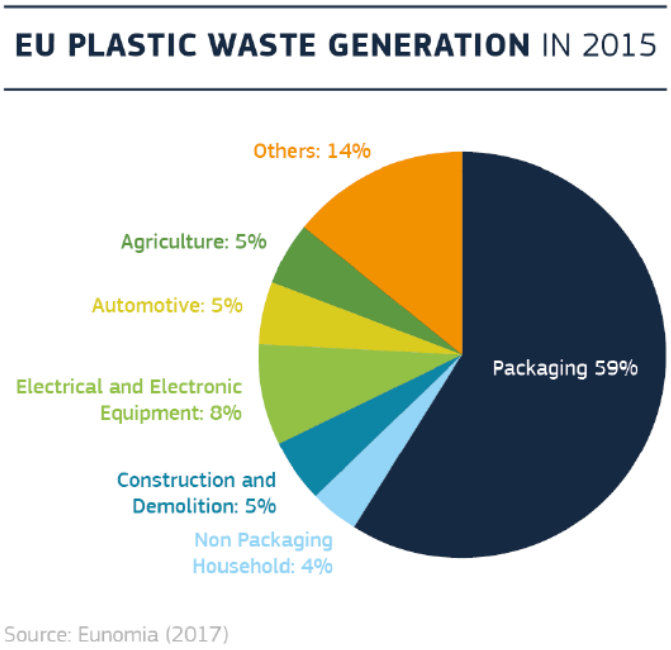

Figure 2.2: Plastic waste in fractions based on use (PlasticsEurope, 2017)

According to PlasticsEurope (2017) 59% of the plastic waste produced today is from packaging as shown in Figure 2.2. Ellen MacArthur Foundation (2018) estimates a doubling in production of plastic packaging within 15 years and a quadrupling by the year 2050. This is due to plastic replacing other packaging materials because of the lightweight and low cost. This will increase the plastic waste generation and the need for better waste management. In order to meet the growing demand recycling of plastic can satisfy some of the demand for virgin materials. This means that the involvement of the relevant stakeholders to act on this challenge and opportunity for improving plastic waste management is needed more than ever before.

2.2 Waste management in EU

The overall framework for waste handling in The European Union is Directive 2008/98/EC (European Commission, 2008). It "*defines key concepts such as waste, recovery and disposal and puts in place the essential requirements for the management of waste*" (European Commission, 2008). It sets the definition for waste used in EU "*'waste' means any substance or object which the holder discards or intends or is required to discard*" (European Commission, 2008). Directive 2008/98/EC uses the waste hierarchy to set a priority order for how to handle waste:

Figure 2.3: The waste hierarchy according to EU (European Commission, 2019b)

One of the main problems with this definition is that products can become waste regardless of the condition of the product. Once it is thrown out it is considered waste. Gharfalkar et al. (2015) did an analysis of the waste hierarchy and the problems associated with it. Gharfalkar et al. (2015) also mentions the problem with products becoming waste just because they are unwanted by the user. They propose the removal of the phrase '*intends to discard*' from the definition in order to open up new possibilities in resource management. Another problem is that everything below the red line in Figure 2.3 is defined as waste. Moving it one down would mean products that can be reuse would not be considered waste and thereby opening up for new possibilities.

Even moving it under recycling and treating it as a resource instead of waste could change how it is handled, increasing the possibilities for successful recycling. Regarding plastic waste this means that once the user intends to discard it, it is seen as waste. If it was treated as a resource instead it could increase the chances of recycling. Gharfalkar et al. (2015) argues that waste should be treated as a recoverable resource to prevent the loss of materials in the commonly used linear resource flow. This is shown in Figure 2.4:

Measure in Hierarchy of Resource Use (Figures 2 and 3)	Treatment (Operation/Measure)	Applicable to Waste or Non-Waste
1	**Replacement**	Non-Waste
2	**Reduction**	Non-Waste
3	**Recovery**	
	3.1 Preparing for reuse	Waste
	3.2 Reuse	Waste
	3.3 Reprocessing	Waste
	3.4 Other Recovery	Waste
4	**Rectification**	Waste
5	**Return**	Waste

RESOURCES

Figure 2.4: How all waste should be treated as a resource (Gharfalkar et al., 2015)

But even here it can be argued the red line in 2.4 should be moved below recovery in order to maximise the reuse and recycling of resources.
The European commission published a strategy in 2018, which focused on circular economy for plastic within the EU. The strategy is a focused on closing the loops and addressing issues within the plastic industry, and the disposal of plastics (European Commission, 2018). The main focuses of the plastic strategy are to ensure the economic potentials of plastic recycling and the ban of single-use plastic to prevent leakage into the oceans. The focus on circular economy in plastics arise from the need for closing the loops and a better utilisation of resources through reuse and recycling. The idea is to prevent plastic from being either incinerated, land-filled or leaking into the environment. The strategy has a substantial focus on primarily the collection and recycling of waste, especially within the innovation of reuse and recycling.

There are multiple areas in the strategy focusing on increasing the motivation for the industry and authorities to improve the recycling of plastic products, the main ones are:

- Promoting the economy and quality of the plastics going in circulation.
- Improve quality of plastic through design, and especially through use of one type of plastic in products thereby increasing the recyclability.
- Increase, and innovate the sorting of plastics to ensure high quality of materials in separate fractions in order to increase value and quality of the recycled plastics. (European Commission, 2018)

The different areas has the purpose to reduce single-use plastics, increase the lifetime of plastic products, and increase the recycling of plastics that are not reusable.
One regulative approach that has been used in other product categories, for example within Waste from Electrical and Electronic Equipment *WEEE*, are Extended Producer Responsibility *EPR*. This system as a regulatory tool also has disadvantages:

> *"However, despite the extensive use of EPR systems, especially for packaging waste streams, Hage (2007) concluded that although this system provides clear incentives for material substitution and related output effects, it proved to have low impact on improving the design for recyclability."* (Milios et al., 2018)

Milios et al. (2018) states that it is important to focus on multiple different initiatives to ensure the best possible solutions. The EPR as a regulative tool can ensure the collection of plastic but the main focus when innovating waste management should be on promoting circular economy through innovative designs, and an improved infrastructure.

A potential issue regarding EPR systems is the lack of motivation towards innovation in the design and recycling of products, as the EPR only ensures the collection of the product (Hage, 2007).

As seen in the case made by Hage (2007) and also the WEEE Directive is the fact that it only promotes the most cost effective way to gather waste. Afterwards paying the lowest price possible for the end of life handling, whether that is incineration, landfill, or recycling. This is because most EPR systems only cares about weight in collection and not the condition products are delivered in. If a higher recycling rate is wanted there needs to be a focus on motivation towards innovation in the design of products and in infrastructure to sort waste efficiently. It is up to the individual Member States how to implement the initiatives made by EU on a national level.

2.3 Plastic recycling in Denmark

Denmark is a large consumer of plastic materials. In Denmark there is almost no primary plastic production where oil or gas are made into plastic (Vingwe et al., 2019). The majority is imported as finished products or plastic granulate that are processed into products. The mass flow analysis done by Vingwe et al. (2019) showed 548.000 tonnes of raw plastic materials are supplied in 2011 but they estimated only 54.000 tonnes was reused, 104.000 tonnes was incinerated, 60.000 tonnes was recycled, and 51.000 tonnes was exported Meaning a large unused potential economically and environmental. Exiobase is based on data from 2011 and Vingwe et al. (2019) extrapolated the data to 2017. Shown in Figure 2.5 is the 2017 model that shows the flow of plastic in Denmark and where plastic waste is processed.

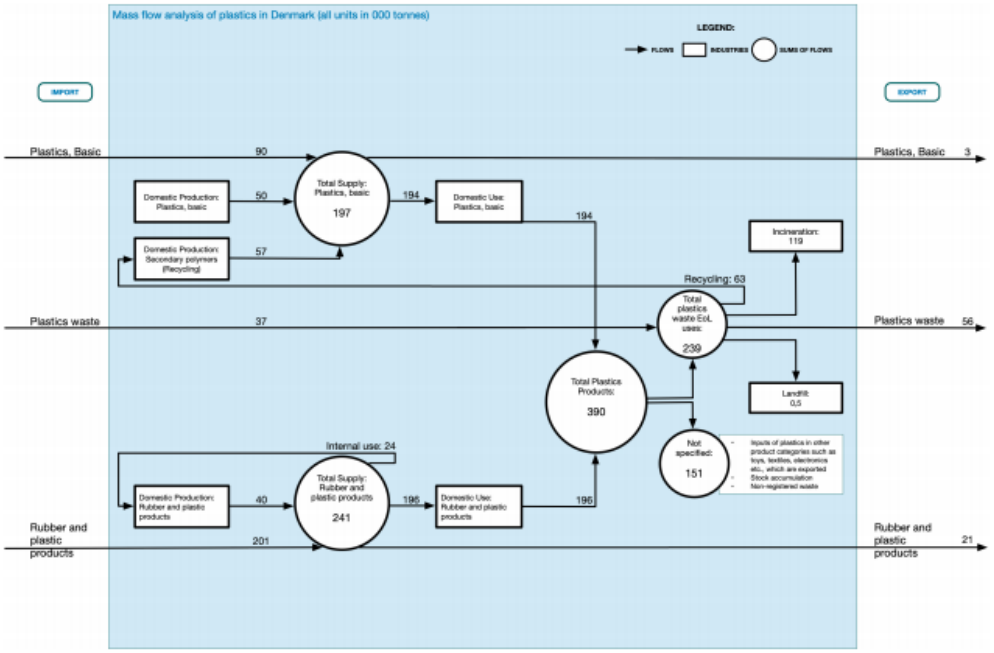

Figure 2.5: Extrapolated data from Exiobase (Vingwe et al., 2019)

Vingwe et al. (2019) does argue it is likely that the amounts of plastic waste are underestimated in the report and the actual amount of plastic waste is larger than that. This is because plastic in some industries sometimes are classified as other types of waste because they are mixed with other fractions. They mention the construction industry as an example, where plastic can be classified as construction waste and therefore not accounted for in the same statistics. In 2019 a technical report by Andersen et al. (2019) analysing new opportunities in plastic waste management. They also did a massflow analysis shown in Figure 2.6.

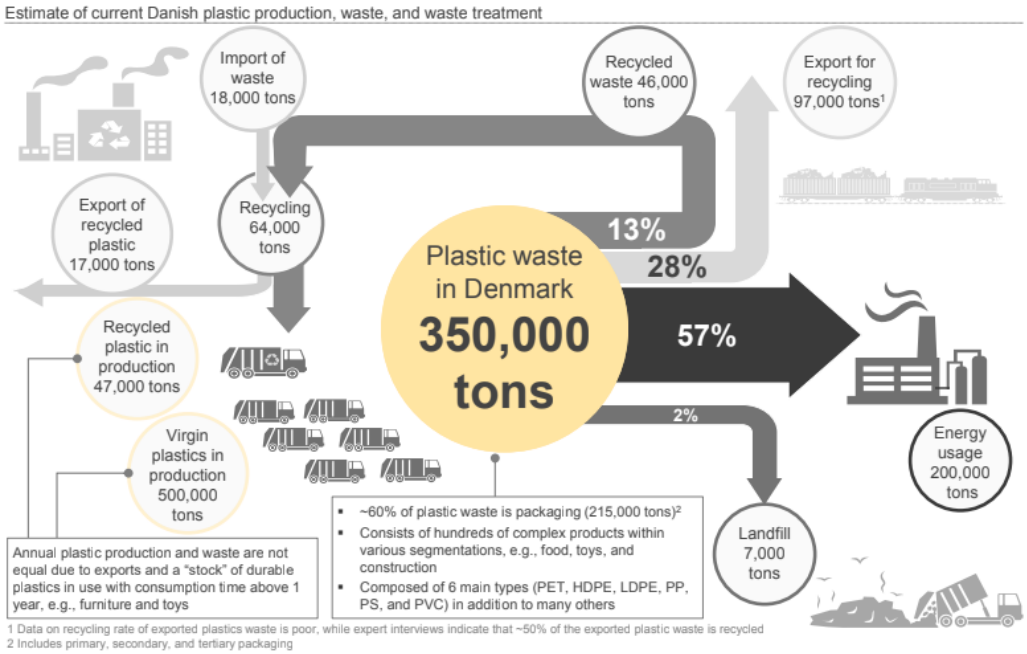

Figure 2.6: Mass flow of plastic waste in Denmark (Andersen et al., 2019)

Comparing the numbers there are some disagreements mainly in the different quantities. Andersen et al. (2019) estimates 200.000 tonnes are send to incineration where Vingwe et al. (2019) estimates 119.000 tonnes. They agree that around 50% of plastic waste is send to incineration. Though they are both estimates it is clear that correct amounts for plastic waste in Denmark is difficult to get exact numbers. One thing they do agree on is that far to little plastic waste is send to recycling.

Because of the low recycling rate the Danish Government made the action plan "Denmark without waste" (Justesen and Nielsen, 2014) with new targets for national recycling rates. One of the strategies is *"Partnerships for plastic waste, where companies, knowledge institutions etc. work together to promote treatment technologies that increase recycling.* Translated" (Justesen and Nielsen, 2014).

The strategy has strong focus on plastic waste:

- 22.5% of the plastic packaging waste is recycled
- 50% of plastic waste from Danish households must be collected for recycling
- The recycling of plastic packaging from the service sector is increased by one quarter. Today, approx. 53%. The expected level is 70% in 2018. (Justesen and Nielsen, 2014)

The targets are focused on increasing the recycling rates of plastic but without a strong emphasis on the quality of plastic.
If you want to study the plastic problems and waste management in the industry it is important to get an overview of the involved actors. This report focuses on actors located in Northern Jutland.

2.4 The actors within plastic handling in Denmark

The following section will lay out the relevant actors within the supply chain of plastics, covering both the linear approach, and the recycling approach. Understanding the actors and the relevant connections, is important in order to create the necessary change within the value chain of the plastics in order to secure the best possible handling of the plastics, thereby increasing the recyclability, and reduce the amount that goes to incineration or landfills.

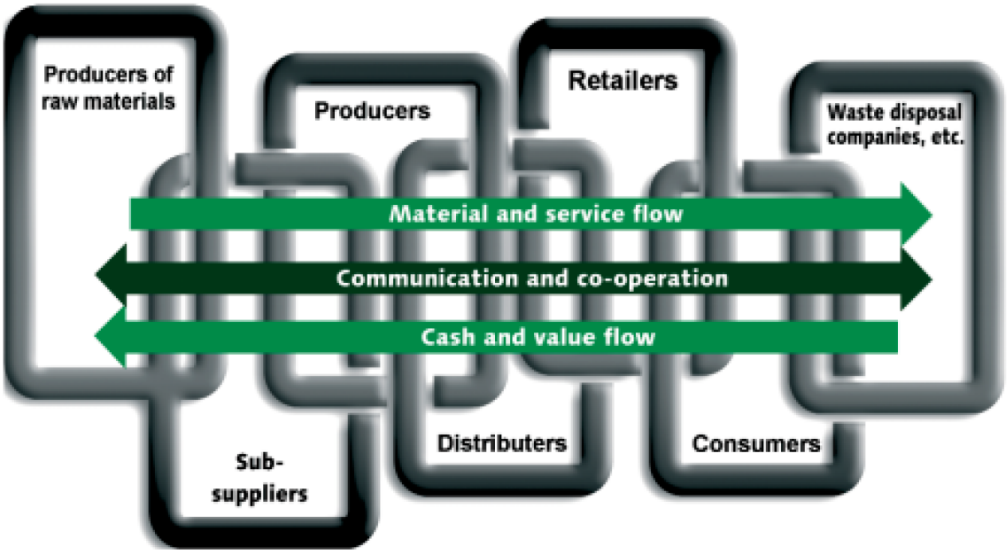

Figure 2.7: An illustration of the plastic from source to end of life (Remmen and Münster, 2003)

Figure 2.7 gives an overview of the most important actors in the supply chain. Remmen and Münster (2003) uses figure 2.7 to show the flow of materials and value in form of cash. It also shows the importance of communication and collaboration throughout the value chain, in order to evolve and innovate the product and service. Remmen and Münster (2003) elaborates that this connection between the links of the chain with a focus on both material flow, and a focus on environmental practises can be a challenge. Later in the report relevant actors from the supply chain will be interviewed to understand their specific role and what potential in new collaborations and solutions they see in Northern Jutland.

Public Authorities:

Public authorities have an interest in plastic waste being recycled instead of incinerated and landfill in order to reach the national targets set by the waste strategy. Public Authorities in form of the government would mostly use mandatory or voluntary policy instruments to try an affect the supply chain. EPR systems as a mandatory policy tool is commonly used.

Another example of a policy tool in Denmark is the tax on incineration to motivate companies to recycle rather than use incineration. In this report NBE is included because of their work in Northern Jutland. "*The network is a private-public cooperation between the municipalities in Northern Denmark, local business bureaus, Eniig Energi, Aalborg University and private companies.*" (NBE, 2019). In this report NBE will be interviewed regarding their role and the challenges they meet in their work to promote sustainability in Northern Jutland and what they could do in order to get more companies involved.

Industry Consumers:

The industry consumers are the actors who has to initiate waste management systems to handle the plastic waste. They hire waste disposal companies to handle the responsibility because of the economic implications in doing the sorting and transporting. Sorting waste is not the primary task for most workers and it is something they have to do besides their normal work if they want to sort it in cleaner fractions. Instead most companies in Denmark use waste disposal companies like STENA or Marius Pedersen A/S because they offer to handle all fractions of waste. Some companies do their own sorting and are able to send their plastic waste directly to the recyclers. One instance of this will be elaborated in the analysis as a case study on how to improve waste management within a company. Because most companies outsource their waste sorting they already have contracts with the waste disposal companies, so in order to either send the plastic directly to the recyclers or improve their recycling rate in plastics they have to switch collaborative partners or change contractual agreements. This can in some instances end up in a conflict of interest because they either have to switch who they collaborate with or introduce higher demands to the one they already use. The problem with higher demands is that it often has a higher cost or more labor are associated with better sorting of waste.

Waste disposal company:

The waste disposal companies main job is to collect waste from companies that do not handle it themselves. They offer different kinds of services and package solutions within waste handling. Often they rent containers to companies and collect waste according to a contract. They then sort the waste and sell what they can to recycling companies. As mentioned the core capacity of these companies is their ability to handle various waste in large bulks, which they sell in the quality they collect it in. This creates a loss of importance for high quality sorting of waste at the companies as the employees seldom has motivation to sort waste for recycling, as it is not their primary job function and they have a small financial incentive.

Recyclers:

The plastic recyclers task is to buy different kinds of plastic waste and process it into a usable resource. One of the main challenges and focus point for recyclers is the quality of plastic they receive. The quality and sorting of the plastics has a influence on the quality of the granulate they can create. Therefor will the recyclers buy better sorted, and high quality plastic waste at a higher price. In the current supply chain the recyclers have very little chance of knowing where the plastic originates from due to the waste disposal companies mix different fractions of plastic from different companies. If there is an error in a company's waste sorting it is impossible to track down where the error occurred and it lovers the whole bulk of plastic waste quality, and the possibility of proper recycling.

2.4.1 Initiatives throughout the value chain

Understanding the value chain for plastic and the underlying stages, uncovers different opportunities for reducing the environmental impact. These opportunities can be prioritised through the waste hierarchy 2.3. The top priority is prevention of waste. For the industry customers this means looking into initiatives that reduce the amount of plastic packaging they use, environmental friendly materials or products that can be reused several times. The plastic producers have an incentive to use more recycled plastic and reducing the amount of virgin materials they use but they have to make sure quality is high enough. For some types of plastic this means that instead of being recycled they are down cycled and used in a lower level product where plastic quality does not have an influence.

The four actors identified will be in focus. There are several potential challenges in the supply chain, that needs to be solved in order focus on circular economy. Milios et al. (2018) found four main challenges in the supply chain:

1. Low demand for recycled plastics, including both the low demand from producers because of price and quality issues, and the low demand from consumers for products made with recycled plastic
2. Limited market communication and lack of value chain coordination, which ultimately results in lack of traceability of plastics along the value chain
3. Technical barriers for better recycling
4. Legislative barriers affecting the market of recycled plastics.

Milios et al. (2018) further concludes that increased cooperation in the value chain could be used as a tool for increasing the recycling of plastics.

The four challenges identified by Milios et al. (2018) shows similarities with the five main challenges by World Economic Forum (2018) regarding plastic packaging:

1. Opaque value chains – Lack of transparency on material origin, content, condition and destination
2. Linear product design – Circular design alternatives are often not understood, considered or contextualized
3. Linear lock-in – Difficulties developing viable circular business models in yet linear systems
4. Inefficient collection and reverse logistics – Material leakage and fragmentation impeding economies of scale
5. Insufficient sorting and pre-processing infrastructure – Lack of efficient facilities delivering the mono-streams needed for high quality recycling (World Economic Forum, 2018)

When investigating the supply chain of plastic use and plastic recycling it is clear that industries still operates with an linear approach without proper communication between actors. Plastic follows the Make-Use-Despose linear economy with single-use plastics and lack of sorting. As mentioned earlier the prevention of plastic waste is the first step in approaching a circular economy within plastics. This could be done by substituting plastic with more environmental materials or designing lightweight packaging to reduce the amount needed.
This report will focus on actors in Northern Jutland and their work with plastic waste and plastic recycling to gather information about the plastic flow in Northern Jutland and create a better understanding of what happens with the plastic. To do this interviews will be conducted with the relevant actors, and two companies hwo actively work with plastic waste will be investigated.

Chapter 3

Problem Formulation

Reviewing current research there is an agreement for the need of investigations of the supply chain of plastic to switch from a linear flow to a circular flow of resources. This aligns with OECD literature highlighting the need for specific cases in order to simplify the complexity of the concepts needed to transform to circular economy (Evans, 2015) According to Vingwe et al. (2019) actors from different parts of the supply chains lacks knowledge on how to handle their plastic. Milios et al. (2018), Vingwe et al. (2019) and World Economic Forum (2018) all mention limited market communication and lack of cooperation in the plastic supply chain. In order to recycle more plastic this report will look into opportunities between different actors to work together and form partnerships.

3.1 Research question

How can companies in Northern Jutland collaborate to improve their reuse and recycling of plastic and ensure a high plastic quality is maintained?

3.1.1 Sub questions

- What are the current capabilities of plastic recyclers In Northern Jutland?
- How can Man Energy Solutions improve their plastic handling to better work together with the other actors in the industry?
- How can partnerships and open innovation between the different actors promote better plastic recycling in Northern Jutland?
- How can the UN's 17 Sustainable Development Goals be used as a tool to promote circular economy?

3.1.2 Delimitations

This section will explain the boundaries set by the researchers in order to limit the study.

Plastic

Plastic is a word for many different materials and not all of them is suited for recycling.
Plastic is generally divided into two types thermoplastics and thermosets. The main difference is how they react to heat. Thermoplastics can be reshaped by heating them and recycled into new products. Polyethylene or PE is the most commonly used plastic since it is an inexpensive plastic to manufacture, and because of its chemical properties it is flexible at room temperature and resistant to water. The two types High-density polyethylene *HDPE* and Low-density polyethylene *LDPE* are the most used forms of plastics because of the applications in packaging. The different types of thermoplastic makes up for close to 76% of the total plastic consumption with the different PE types being the most used (Biron, 2016). The biggest problem in recycling is when the different types of thermoplastics are mixed with each other or other materials.

Thermosets differentiate from thermoplastics, because they form irreversible chemical bonds in the production phase. When heated enough thermosets do not melt but instead decompose and become unusable upon cooling. In this report will the focus be on PE forms of plastics as these are highly used in packaging in the industry and are recyclable.

Northern Jutland

This report has chosen to focus on Northern Jutland, and actors within this area, this has been done in order to ensure possibilities for local partnerships in regards to using circular economy. This has aligned with NBE's focus on a circular Northern Jutland in which resources loops are located in this region to make local partnerships.

Qualitative study

The empirical data collected has been qualitative and the same with the methods chosen. As stated in the problem analysis quantitative data on plastic flows in Denmark er hard to get. The company used is the report did not have any waste data from before 2019 so it was not possible to study waste data prior to that. This means the focus became qualitative methods in order to collect the empirical data.

Chapter 4

Research Design

In order to address the research question and how to answer it. It was necessary to gather empirical data from the different actors and investigate literature to identify the proposed research question and justify how this report contributes to the research field of handling plastic waste in a circular way. The problem analysis outlined the current problem with waste generation from the rising demand for plastic and the need for more research.

4.1 Methodological Framework

The data in this report was acquired through a qualitative methods in order to give a holistic view of the problem. As stated in the research question the problem is companies not collaborating in order to recycle more plastics. The methods used in the report are influenced by the researchers academic backgrounds in Techno-Anthropology and Environmental Management and Sustainability Science having the research rooted in post-phenomenology and the assumption that our reality is constructed through our interactions, unlike positivism that believes in one independent reality separated from the human interpretation of it:

> "*Human beings are what they are by virtue of the way in which they realize their existence, and their world is what is is by virtue of the way in which it can manifest itself in the relations humans have to it*" (Verbeek, 2005)

This is the ontological and epistemological approach taken in the report. Another important concept is the interdisciplinary work done to understand different realities and views on the problem. The recyclers interviewed in this report has one view on the current situation whereas companies will see it a different way. This distinction is important in order to get the holistic view this report seeks. This is important in order to include the different roles of expertise the different actors has to offer. This is what is called interactional expertise according to Collins and Evans (2002) "*this means enough expertise to interact interestingly with participants and carry out a sociological analysis.*". The methods chosen in the report was to support this view and to bring in different kinds of knowledge and expertise.

4.1.1 Literature Research

Literature research was used as a base of knowledge and to investigate state of the art research in plastic and the problems associated with it in the problem analysis. Research to gain insight into the theories used and how to use them on the specific problem was also done. The primary databases used to gather the literature was: Aalborg University Primo database, Google scholar and Scopus as an citation database to investigate peer-reviewed literature.

4.1.2 Interviews

Interviews were used to gather empirical data from the different actors involved in the field of study. This was done to gather context depended data and to get their view on the challenges associated to the topic. The project studies the connections and potentials of plastic sorting within Northern Jutland. Therefor it was relevant to interview the actors identified in the Problem Analysis.

The interviewed actors being: Two different plastic recyclers, NBE (public authority) and two companies with plastic waste that can be recycled in different stages.

The specific interview method used was semi structured interview, which is in between a strict structured interview, and a loosely structured interview (Brinkmann and Tanggaard, 2010). The semi structured interview is based on a conversation which is steered by an underlining thematic guide, with the goal to secure the knowledge wanted within a certain field. This is done by defining a set of research questions which are the basis for the interview. Often these questions are to complex or long to ask directly, and therefore each research question is divided into shorter interview questions (Brinkmann and Tanggaard, 2010). In the semi structured the researcher has the ability to go off topic, or lead the conversation in another direction if the interview would benefit from if relevant topics are mentioned.

As a part of the analysis these interviews will be meaning condensed in relation to the research questions from the interview guides. Meaning condensation is a method used to compress the interview into opinions, in which the quotes from the interview are shortend into the core meaning of the interview, in order to quickly understand the position of the actor interviewed (Kvale and Brinkmann, 2009). According to Kvale and Brinkmann (2009) there ae five steps within meanings condensation. The first step being, to go through the entire interview, to create an overview of themes, and meanings, the second step focuses on the researcher defining different meanings, as they are presented by the interviewed person. Thirdly is the act of reformulating the meaning into a short sentence capturing the meaning as understood by the researcher. The fourth step is to ask questions based on the purpose of the research in the light of the meanings. Last the main themes are connected to descriptive statements from the interview (Kvale and Brinkmann, 2009).

The following persons were interviewed:

- Morten Jensen. Site Manager Claus Sørensen A/S
- Sebastien Pedersen Bouchara. Project Manager NBE.
- Franz Cuculiza. CEO Aage Vestergaard Larsen
- Stig Larsen. CEO Genplast
- Upper Management MAN Energy Solutions

Each actor can be called experts of their respective field and their knowledge and insight is important in order to answer the research question.

4.1.3 Observation and Participation

As part of the data collection a waste screening was conducted at MAN Energy Solutions to gather empirical data about how waste management currently are carried out at the facilities. This was done to follow the steps of cleaner production (Thrane and Remmen, 2007), that will be elaborated in the conceptual framework. Thrane and Remmen (2007) mentions that "*Making a walk-through of the production facilities is recommended in order to get first hand from the employees regarding waste of resources and obvious good housekeeping lapses*". The waste screening was a simple guided tour of the facilities with focus on waste management. Simple participant observation was done under the waste screening. Participant observation can be divided into different forms and degrees. The different degrees of participation depends on how the researcher interacts with the field. (Spradley, 1980) divides participant observation into degrees of involvement, where participation can be either complete, active, moderate, passive or no participation. The waste screening also gave the opportunity to have "*formal conversations with the participants in the field, which you can access to observe and be with*" (Brinkmann and Tanggaard, 2010). The idea was to observe and ask questions about how waste management was done but also to allow the participants to come with their own views and ideas.

The methods discussed above made it possible to uncover tacit knowledge and daily practices which had an influence on the waste management procedure. Tacit knowledge and daily practices are often impossible to uncover in interviews because it covers the daily routines the employees does not think about.

4.2 Conceptual Framework

Different concepts was chosen in order to explain and promote sustainable development and innovation. The concepts will be aimed at improving the resource use in order to ensure a sustainable strategy. Both circular economy and UN Sustainable Development Goals are popular within public authorities, companies, and universities. The reason for the popularity is the possibility to apply them to a wide range of contexts and still promote a specific sustainable development. The following sections will elaborate on how this application is possible, and what can be done to apply them. The latter part of the conceptual framework will focus on sustainable production, and collaboration between actors in order to create innovate solutions, which has the possibility to promote the sustainable development.

4.2.1 Circular Economy

Circular economy will be outlined to give an understanding of what is meant when using the concept in the analysis.
Circular economy has gained popularity as the solution to the overspending use of resources happening in the linear economy. It is also the concept the European Union have chosen in their "Closing the Loop" action plan and further developed in "A European Strategy for Plastics in a Circular Economy", in order to combat the growing problems with plastic (European Commission, 2018). Circular economy is a reaction to the linear economy that currently dominates how resources are used and businesses are run. In short linear economy is as displayed in Figure 4.1:

Figure 4.1: The three steps in linear economy (Yamla-or, 2018)

The linear economy can be split into three different steps:

- **Take**: Resources are extracted at the lowest cost possible
- **Make**: The resources are then used in the making process for products
- **Dispose**: Consumers use products until they are disposed and become waste. (Yamla-or, 2018)

Linear economy is problematic as it is based on the assumption that resources are infinite and there will always be a place to dispose our waste. The linear economy ignores the implications from the growing demand for plastic and what happens when resources become scarce. Circular economy is often mentioned to combat these implications. It has roots in different schools of thought ranging from ecological economics, environmental economics and industrial ecology. The definition EU has chosen in their Closing the Loops action plan is from Ellen MacArthur Foundation (2015), which defines circular economy as "*an industrial economy that is restorative or regenerative by intention and design*". The overall concept is shown in Figure 4.2:

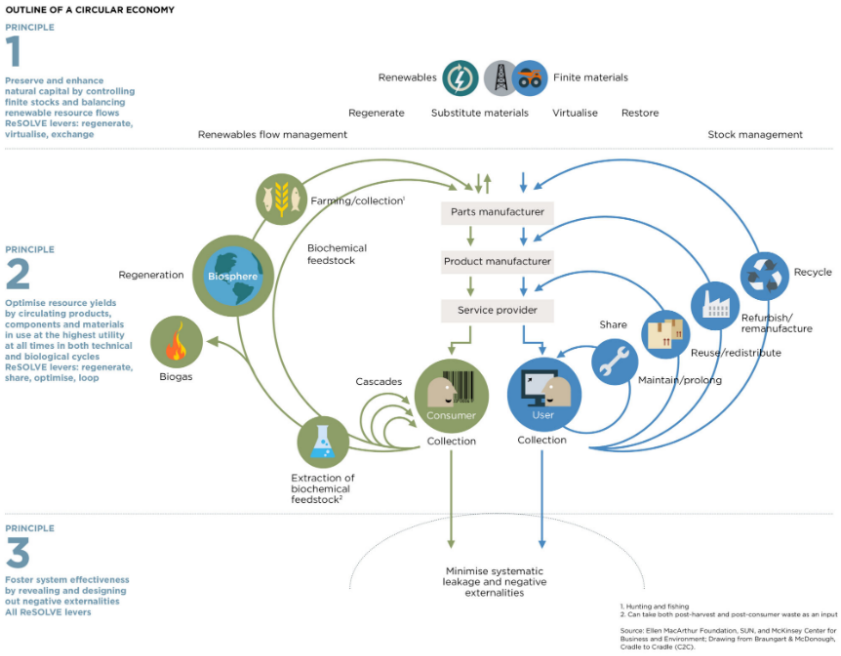

Figure 4.2: Visualisation of the circular economy (Ellen MacArthur Foundation, 2015)

Geissdoerfer et al. (2017) did a review on different articles to make *"conceptual clarity by distinguishing the terms and synthesising the different types of relationships between them circular economy to further develop a clear definition"* and they define circular economy as:

> "*As a regenerative system in which resource input and waste, emission, and energy leakage are minimised by* ***slowing***, ***closing***, *and* ***narrowing*** *material and energy loops. This can be achieved through long-lasting design, maintenance, repair,* ***reuse***, *remanufacturing, refurbishing, and* ***recycling***" (Geissdoerfer et al., 2017)

Geissdoerfer et al. (2017) mentiones the three concepts of *slowing, closing,* and *narrowing* the loops as shown in Figure 4.2.

This report will use the definitions from Bocken et al. (2016) to clarify the differences between the three concepts, as it plays a vital role in designing a strategy for a production, and the connecting waste management.

- **Slowing the loop:** Slowing resource loops focuses on product life extension through the design of products, or creating services for repair, or in other ways prolonging the working lifetime of a product and thereby slowing down the flow of resources (Bocken et al., 2016). In the case examined in this project would it mean to find other alternatives to the plastic packaging used, this could be other materials, or change the transporting procedures in order to remove the need of the plastic.
- **Closing the loop:** By recycling materials, and thereby using products that are at end of life, in the production of new products. Creating a circular resource flow resulting in less virgin material used (Bocken et al., 2016). Closing the loop will have the primary focus in this project as plastic packaging is difficult to reuse and through improved waste management it is possible to recycle plastic.
- **Narrowing the loop:** Refers to using as few resources per product as possible. By using less resources the flow is narrowed and thereby becomes more efficient (Bocken et al., 2016). Narrowing the loop in plastic management would focus on optimising the use of plastic packaging by reducing the amounts of plastic used. This could be through adaptation of packaging materials to fit each product, as some products are shipped in packaging larger than necessary.

  (Geissdoerfer et al., 2017)

The main goal is to close the material and energy loops by reducing new resource inputs into the system and leakage out of the system. In Figure 4.2 recycling is the last loop and therefore the least desirable loop and way to handle plastic. Ideally products are designed to be repaired and maintained thereby slowing the loop, but that is not feasible with plastic packaging since it is mostly designed as single-use. Instead of single-use plastics the packaging can be designed of other materials that last longer.

How products are packaged can be changed in order to use less plastic. This is also the reason why the European commission banned the use of single-use plastic.
This report mainly focuses on plastic packaging and other waste products in the industry. This means closing the loop by keeping the plastic waste as clean as possible and separate different fractions in order to recycle it. As stated in the problem analysis this is difficult since different types of polymers are mixed to create plastic products but through better design plastic products could be made to contain single polymers. However it is possible to work towards closing the loop by recycling plastic at a better rate to reduce the amount of virgin materials needed. In order for a circular strategy to work it is important"*stakeholders collaborate to maximise the value of products and materials, and contribute to minimising the depletion of natural resources and create positive societal and environmental impact*" (Bocken et al., 2018). Bocken et al. (2018) also highlights the need for collaboration if a circular strategy is to succeed.

In order to promote collaboration and shared goals the United Nations made the 17 Sustainable Development Goals.

4.2.2 United Nations Sustainable Development Goals

The United Nations Sustainable Development Goals consists of 17 goals focused on ensuring sustainable development on a global scale in order to eradicate poverty, inequality, and hunger, whilst promoting a sustainable lifestyle globally (United Nations, 2015). The 17 goals as seen in Figure 4.4 are the main focuses for the development on both a global, national and local level. They should be seen as a guiding tool for both policy makers and for companies of all sizes to ensure sustainable development.

Figure 4.3: The 17 sustainable development goals from the United Nations (United Nations, 2015)

The 17 SDG's are quite broadly defined and can be hard to act on in specific situations, the goals has further been divided into 169 targets to elaborate the goals. The result are 232 different indicators, that has been connected to the goals in order to ensure the progress made by companies and states are measurable (United Nations, 2015).

Le Blanc (2015) has in a article mapped which goals are affecting each other through connecting or similar targets within each goal. By showing the interconnectivity and network of the targets is it apparent that working with the SDG's should be a holistic strategy to sustainable development that ensures a broad focus on multiple issues.

According to Le Blanc (2015) SDG goal 12 is the one with most connections with influence on 14 other goals. SDG goal 12 is focusing on sustainable production and consumption and has impacts on both environment inequality and poverty. With the focus on plastic waste it is relevant to investigate which targets are relevant. Specifically target number 12.5 focusing on waste management, reuse and recycling. By achieving a higher recycling rate of plastics this goal is directly affected as well as several others. This interconnectivity of the goals is a strength that is often missed when it is used. The goals puts multiple issues as well as solutions into perspective of each other and it is impossible to only focus on one target of one goal, without having to act on issues regarding connected goals.

SDG 9 Build resilient infrastructure, promote sustainable industrialisation and foster innovation:
Has a focus which is primarily aimed towards changing industries through sustainable development. One of the main drivers within this goal is innovation through entrepreneurs that enables change through their products. This report will use collaboration through partnerships in order to reach goal 12.

SDG 12 Ensure sustainable consumption and production patterns:
The focus within this target is predominately focused towards production and consumption of resources. This is sought to be achieved through targets focusing on the processes connected to both consumption and production. The focus is on food waste, recycling, and other sustainable practises within companies. This goal is important in regards to a sustainable consumption of plastic and how it is disposed.

SDG 13 Take urgent action to combat climate change and its impacts:
Taking action against climate change is an critical goal to implement in most sustainability strategies. As it has become apparent that climate change is happening and it is therefore important to educate employees and citizens about the impact. The focus is on ways to both reduce the change but also how to handle the changes coming. One strategy to combat this is the circular economy as it has the potential to reduce the amount of virgin materials needed through closing, slowing and narrowing the loops.

SDG 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development:
Even though this goal is not a direct focus in this project it is still a relevant goal to prioritise and one that has a relevant connection to other goals. This is because of the work in maritime at MAN Energy Solutions but also because of its location on a harbour. These issues are apparent especially when working with waste management, where correct disposal and recycling could reduce the amount of plastic leaking into the oceans.

SDG 17 Strengthen the means of implementation and revitalize the global partnership for sustainable development:
In order to successfully complete the SDG's using partnerships are crucial on all levels. The targets are mostly focused on collaboration on a international level and helping third world countries. But within circular economy is also a demand for action from multiple actors and collaboration even though this is done locally.

Figure 4.4: The five sustainable development goals connected in this report (United Nations, 2015)

The five goals highlighted has a strong connection with the work Man Energy Solutions are doing and therefore an emphasis on these is needed but in order to make an overall strategy all the goals should be included.

4.2.3 Partnerships

In this project the partnerships are between actors that has a influence on the recycling and potential reuse at MAN Energy Solutions. Working with partnerships are important in order to achieve circular economy:

> "However, acting alone they are likely to achieve considerably less than working in cooperation, providing collaborative leadership. Collaboration and partnerships between businesses and other actors are going to be crucial in promoting economic, environmental and social improvements that contribute to sustainable development"(Young, 2005)

There are different understandings of partnerships, and what the concept covers. Partnerships between actors within sustainable development is not a new concept. According to Evans (2015) this focus can be found in the RIO earth summit in 1992, and it plays a role in the SDG's. These partnerships has been both between public, private, organizations on a international and national level. Evans (2015) argues that there is a large potential within private partnerships, where actors collaborate across networks in order to produce environmental solutions. One of the main arguments for the impact through private partnerships is the economic power placed internationally as the majority of cash flow and jobs are from private companies (Evans, 2015). This project will focus on local partnerships with multiple actors in order to highlight how partnerships between both private, and public actors can promote circularity in plastic waste, and thereby promote sustainable development. How MAN Energy Solutions can collaborate through networks will further be elaborated in the analysis, where the benefits of local partnerships can promote a circular and reduce their environmental impact.

4.2.4 Cleaner production in a network perspective

The following section will explain how sustainable development in a company can be improved through a cleaner production and collaboration in a network. Søndergaard et al. (1997) suggests in order to understand how a company can develop a cleaner production, is it important to understand how a company operates, and what the motivation for the change is. Søndergaard et al. (1997) argues that a production company can be boiled down to input and output. Input is the resources that goes into producing a given product, and output being split into two streams, which are the product, resource waste and emissions Thrane and Remmen (2007). When focusing on the company as a single actor, there are six main principles in which they can work to reduce the impact:

- Process optimization
- Substitution of materials
- Reuse and recycling
- Technology change and innovation
- Development of new products
- Good housekeeping rules

  (Thrane and Remmen, 2007)

This report will focus on the waste output from the company, and how it can be recycled in order to closing the loop but also narrowing the loop by reducing the amount of plastic used pr product. The first step in cleaner production is *planning and organisation*, where it is important to get the upper management on board and setting up a team tasked with the assignment (Thrane and Remmen, 2007). In *pre-assessment* it is necessary to analyse input and output of the data. In this case it is analysing the company waste data. Here a *walk-through* of the facilities is also recommended to get first hand experience (Thrane and Remmen, 2007).

In *assessment* it is necessary to get an overview of the problems and find the causes. Here it is important to include the employees when brainstorming for ideas since they can have tacit knowledge about daily routines and practices (Thrane and Remmen, 2007). Good housekeeping rules will be investigated to cover some of the simple changes the company can make to raise environmental awareness from employees and process optimization through better waste management (Thrane and Remmen, 2007).
Cleaner production does contain two more steps *feasibility analysis* and *implementation and continuation*. Where the most feasible options are analysed and a plan for timing, tasks and responsibility needs to be made (Thrane and Remmen, 2007).

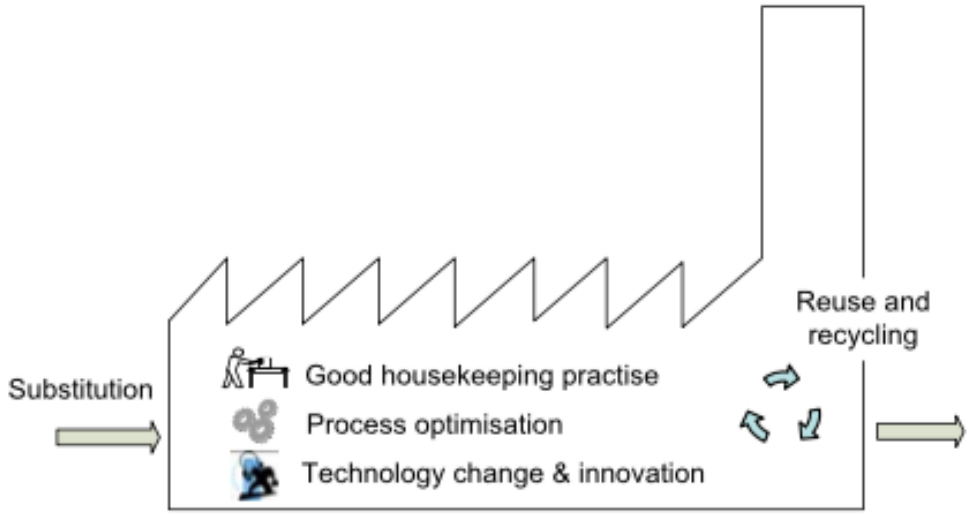

Figure 4.5: Different types of solutions in cleaner production (Thrane and Remmen, 2007)

These solutions can either be incremental, radical, or systemic. Incremental changes are small and simple, such as good housekeeping rules. Whereas the radical change would be a change in materials to replace the plastic or reduce the amount used. Systemic changes often require outside collaboration since it affects the whole system and not only the company. At some point, the incremental changes will meet a limit for improvement with the current technology (Søndergaard et al., 1997).

When the incremental changes limit has been met, the company needs to focus on radical or systemic changes.
Søndergaard et al. (1997) has defined three network relations, that has an effect on the innovation of technologies. These are: A business network, a regulatory network, and a development network as shown in 4.6

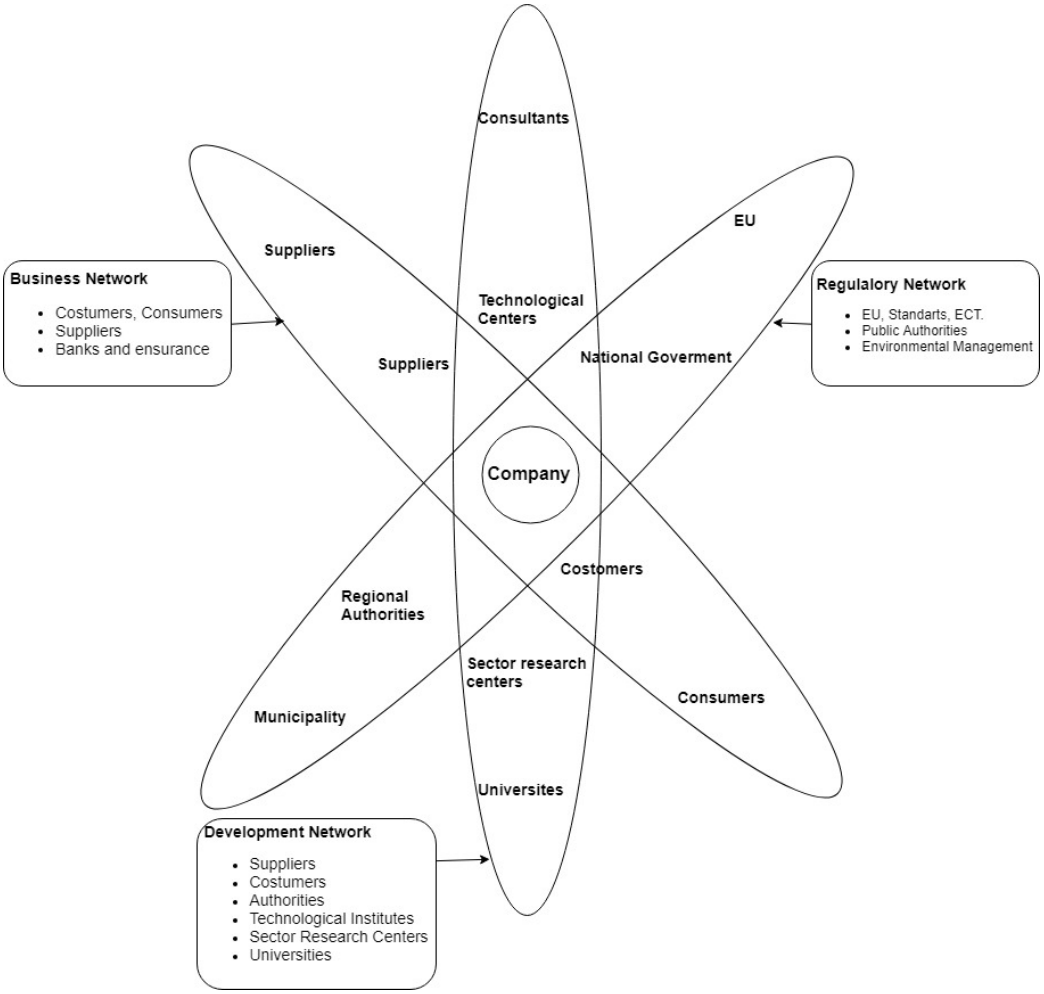

Figure 4.6: Network relation model. Adopted and translated from Søndergaard et al. (1997)

The three networks in which the company interacts are important if radical or systemic changes are to be succesful.
The business network defines the actors that influence the company from a business perspective in order to make environmental changes.

This could be collaboration with suppliers for cleaner products. In the case of plastic this could a focus on substitution or having demands to the quality used. For example no single-use plastic, no mixed polymers or thresholds for recycled plastic used. On the other end is the buyers. Here the company can have demands to what happens at the end of life, how the waste is treated or buyback systems in place.
In the regulative network is the laws and regulations that can change the production within the company. In the case of plastic this is the European plastic strategy and how it is adopted on a national and municipal level. Examples of regulations regarding plastic waste are the incineration tax and mandatory collection rates. The regulative network can also support innovation through funding of projects. The EU has allocated 350 million euros to plastic projects through Horizon 2020 (European Commission, 2019a).
In the knowledge network is state of the art knowledge and research from different institutions such as universities and authority ordered research for available technology or BAT (Søndergaard et al., 1997). Part of the knowledge network is also consultants which in regards to plastic can be the recyclers or waste disposal companies.

The networks are relevant when a company wants to innovate their practices and work with waste management of plastic. It has been argued in order for circular economy to succeed collaboration across the network is needed since it would be a systemic change. In the next section, open innovation will be explored as a way to work on innovating how to handle plastic and how the actors can work together to make changes.

4.2.5 Open Innovation

Open innovation is chosen as a concept because it promotes collaboration between actors in an innovation process. Open innovation builds on the foundation that innovation processes are more effective and successful if they consist of multiple actors with different expertise's. It is therefore a strategy that is beneficial if conducted between multiple actors who work with different aspects of a process or product. This is in contrast to a more traditional innovation process that occurs within a single company, or even a single department (Barrett et al., 2011). This collaboration creates a need for openness which can be deceived as a negative factor in larger cooperation's. This openness towards a platform of actors creates possibilities for the promotion of ideas, knowledge, and sharing of competencies which in turn can create possibilities for the entire network of actors.

Open innovation has been popular within software and, tech development, as collaboration between actors with a technological platform, and different software companies create possibilities for fast and effective innovation. An example of this is as shown by Barrett et al. (2011) is the app store on an IPhone, where Apple offers a platform for app developers to reach costumers. Which in return can offer Apple innovative apps, that they would not develop them selves.

4.2.6 Network models supporting the innovation process

One of the key principles behind open innovation, and the underlying innovation ecosystem is the ability to co-create through partnerships, both intra- and inter-organisational. Therefore is it critical to allow research and design teams, to become part of partnerships, in order to create innovative sustainable solutions. Barrett et al. (2011) has in their business brief identified four different models, that has the purpose to integrate several actors. They can be seen in Figure 4.7:

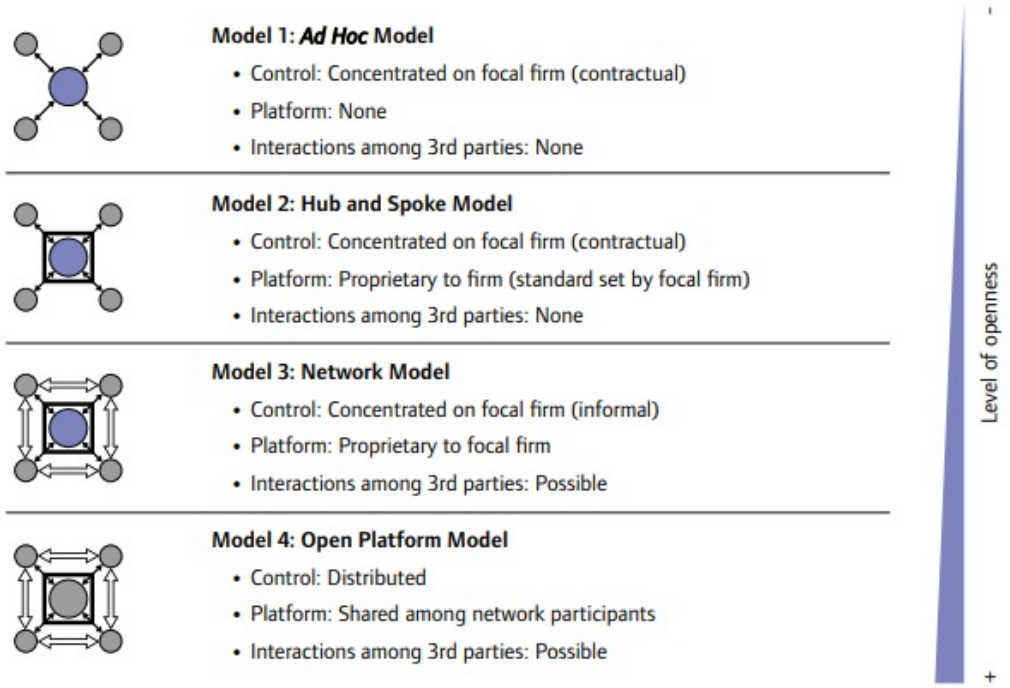

Figure 4.7: Four models for different degrees of open innovation (Barrett et al., 2011)

An important aspect in Figure 4.7 is the gradually increasing openness of the models.

- **Model one:** Is the least open of the four models and is often characterized with internal communication, where the focal company is communicating outwards to the actors. There is no contact between the actors. The model is concentrated around the focal company in means of contracts. There are no standard policy or platform to engage with partners (Barrett et al., 2011).
- **Model two:** Is based around a closed platform with the focal firm in the center. In this model it is possible for different actors to communicate and interact with each other through. The control remains at the focal company through standards of interaction between actors as well as the focal firm (Barrett et al., 2011).
- **Model three:** Is based on the same aspects as model two. The difference between model two and three are the enablement of third-party actors. These actors are able to interact with each other within the platform created by the focal firm (Barrett et al., 2011).
- **Model four:** Is best described as an ecosystem, where innovation is made between all actors and as such are there no focal company, but the control is distributed between the actors participating in the network. There is no standard for communication or collaboration. It is based on connections and happens between actors (Barrett et al., 2011).

Before starting the process of partnerships through open innovation, or setting up a innovation ecosystem, is it essential that the core organisation has defined how open they are willing to be. Since the most beneficial model further affects the actors who will be part of the innovation ecosystem.

4.2.7 Roles within an innovation ecosystem

Dedehayir et al. (2018) has in their review identified different roles for the actors, in different points in time, these often ensure the progress and success of the innovation ecosystem. The roles vary through the lifetime of the ecosystem. This is partly because of changing dynamics, but also because of an increasing number of actors within the ecosystem. As this project focuses on initiating partnerships in plastic recycling, will the focus be to identify actors for the initiating roles of the partnership. The timeline for an ecosystem is by Dedehayir et al. (2018) put into three distinct phases: *Preperation*, *Formation*, and *Operation* within each of these phases actors has certain roles. By identifying the most relevant actors it is possible to promote and enable these actors within the emerging ecosystem. The roles of the actors can be divided into four main categories in which there are multiple sub roles and transitioning roles during the lifeline of the project (Dedehayir et al., 2018).

Leadership:

The leadership is one of the actor categories that have a key role within all three periods of the ecosystem (Dedehayir et al., 2018). In the preparation phase the leader is identified to create the needed platform and linking partners. Further in the process, in the formation phase the leader has the task of coordinating actors and actions within the formation of the partnerships in the ecosystem. Last in the operational phase the role of the leader is to ensure the right resource flow and stimulate partnerships in the innovation process.

Direct value creator:

This group focuses on the actors which are physically working with the product or service, and as such has competences needed in innovating the product in order to create value. *The user* is an actor who is contributing from beginning to end within the direct value creators (Dedehayir et al., 2018). The user of the innovation has the role of defining the requirement specifications for the product and thereby also the target for the ecosystem. In the formation phase the user provides insight and ideas to solutions, together with new actors that could be deemed relevant in order to fulfill the requirements. If the innovation process is successful the user will change the service or product.

Value support actors:

Value support is the group that generate knowledge and connections without having a direct outcome of the product or service. They are focusing on creating new knowledge and partnerships. Experts are within this group of actors and are not directly implicated in either the creation, production or purchase provided by the ecosystem. Actors in this group supports the other actors with knowledge and connections (Dedehayir et al., 2018). Experts are often universities or other organisations tasked with creating knowledge and help the ecosystems with research and in return they are able to gain access to a specific area.

Entrepreneur ecosystem actors:

This group is occupied with start-ups within the framework of the innovation ecosystem and are therefore relevant as a partner actor. They are highly motivated to create products or services within the field and are innovative. They can take on multiple roles in form of; networker, finding solutions, exploring different ideas etc.(Dedehayir et al., 2018). These start-ups or entrepreneurs also need assistance of different kinds such as investors, or physical assistance as they are not established or fully functional.

They can therefore not be used as a substitute or an actor group who independently can solve the tasks. Dedehayir et al. (2018) argues that some of the tasks held by an entrepreneur be the same ascan the leadership actors. This does not mean the entrepreneur and leadership actors are the same, but rather has a supportive role in the formation.

This chapter has presented the methods and conceptual framework that will be used to analyse the empirical data. If companies in Northern Jutland wants to implement a circular economy, they need to collaborate and initiate local partnerships in order to combat the problems with plastic waste.

Chapter 5

Analysis

The first part of the analysis will introduce Claus Sørensen A/S and their work in plastic waste management to investigate good housekeeping rules and how they collaborated with in order to recycle their plastic. The results from this will be used on the MAN Energy Solution case to identify the relevant actors and how their waste management could be improved. The actors will be placed in the roles from open innovation in order to foster improvement on a larger scale and show the possibilities in Northern Jutland.

5.1 Claus Sørensen A/S

Claus Sørensen A/S is a cold and frost stock company with several departments in Denmark. Three of these are located in Northern Jutland, with one site in Hirtshals consisting of four departments with different services. The site in Hirtshals is particularly interesting as this site has shrimp repackaging service, where shrimp mainly from Greenland is repackaged into the plastic bags it is sold in. This process creates large amounts of plastic and cardboard waste. Prior to 2019 they had no waste management system in place to produce recyclable waste and it was incinerated. There were multiple waste disposal companies handling different fractions of the waste. The waste was mainly transported to Affaldsselskabet Vendsyssel Vest for incineration in large containers not being fully utilized. The cardboard waste fraction was handled by a third waste disposal company.

In fall 2018 Claus Sørensen A/S decided to look into opportunities for environmental improvements and how to improve their recycling. From 2019 and forward several improvements has been made within waste management on one of the sites.

5.1.1 Collaborating with actors in the network

Claus Sørensen A/S had different waste disposal companies for different departments and waste fractions. They decided to reach out to the knowledge network in form of Aalborg University since they needed knowledge they did not have in their organisation. The first step was to get an overview of the actors in the business network by identifying the competencies each actor had and what contracts Claus Sørensen A/S had. This was done to see who was qualified to improve the waste management.
Several issues was identified when multiple actors were collaborating on improving the waste management. In an interview with Morten Jensen the site manager mentioned "*the devil is often in the details*". He elaborated that the project required attention after implementation as the new partnerships created new tasks for the employees when sorting the waste. They had to pay attention to what the correct waste bin was instead of throwing it all in small incineration. The change of practice often halted the project and needed attention. These small changes in tasks are besides what could be called standard work tasks and are context depended. Morten mentioned these details are important to recognize and find solutions for by collaborating in the network and to coordinate tasks so they are not neglected. If there are several actors, it is likewise important to promote a platform that secures communication between different actors, as this can help eliminate small miscommunications.

Although they have had some issues after implementation it has been a success. According to Morten this has resulted in a decrease of incineration transports by 80%. The result is a reduction of plastic waste being incinerated and the amount of transports dramatically decreased, which has a positive environmental impact. In the interview Morten emphasized the importance in reaching out to actors with similar values in order to create a partnership that would last.

5.1.2 Cleaner production at Claus Sørensen A/S

Claus Sørensen A/s had different waste handling companies for waste fractions. The initial screening was focused on how well the waste was sorted and how much was recycled. This was done by investigating waste bins and the invoices from each waste disposal company to identify where the waste ended up. This showed that the majority of waste was incinerated. In total the invoices showed that containers was transported to incineration 73 times in 2018 from one location. The container was often full of plastics and weighing an average of 700 kg pr pickup. One invoice showed a container weighing 10 tonnes meaning the 700 kg average was a inefficient use of resources. A collaboration was established with a Recycler to ensure that plastics and cardboard was recycled. A container was set up for the pressed plastic and a local haulier was hired to transport the plastic and cardboard because of the reduced amount of transports needed.

Figure 5.1: A picture showing the incineration container which prior to the project was emptied 73 times pr year

Figure 5.2: A picture of the content indside the incineration container shows it is mainly plastics, and a smaller amount of cardboard

The Cleaner Production project at Claus Sørensen A/S focused on the management of waste at the different departments. Including the implementing of new waste bins that has the ability to compress larger amounts of plastics. The full bags was pressed in a bale pressing machine thereby reducing the size. The new plastic bins made the sorting of plastic waste more intuitive, by presenting an easier alternative to dispose of it. The bins was strategically placed to make it easy to dispose of the plastic.

Figure 5.3: The new waste bin and the old alternative, which was manually emptied into an incineration bin

Figure 5.4: An after picture where the old incineration bin was emptied. The majority of the waste being clean plastics

As the plastic is sorted at the source it is possible to sort it on quality. This ensures that each fraction of plastics are clean and separated. For example clean clear wrapping plastics and colored plastics contaminated with shrimps can be sorted into two fractions. This enables the recycler to maintain the quality of the clear plastic. Another optimisation was to keep the plastics dry in storage, as water would mean an excessive use of energy when making the granulate.

A concern in the transition was a negative response from the employees who had to handle the waste. This was both the workers physically handling it and middle management who was skeptical as they believed that it would require more time, and thereby be a larger expenditure which they were accountable for. In order to raise environmental awareness from the employees education regarding the use and the end of the life cycle was needed to secure proper handling. It can be hard to see the effects of sorting waste and if you believe it is all incinerated anyways sorting will not become a priority.

Another important factor was the design of the new setup. As it had to be intuitive and preferably easier than the old system. At the bare minimum is it important that the new set up, does not require more work than the old system.

5.1.3 Sub-conclusion

The incremental changes in processes and implementation of good housekeeping rules has lead to optimisation of waste management. The employees empty the waste bins less and a reduction in incineration waste has been made. In 2018 there were 73 pick-ups of waste whereas the first three months of 2019 only had three. This change has already had an economic effect as Claus Sørensen A/S pays 500 DKKR pr pick-up going to the incineration plant. If the trend continues Claus Sørensen A/S will save 30.000 DKKR on the transport of incineration waste. They are now paid between 600 DKKR and 1300 DKKR pr ton of plastic going to recycling. Based on input numbers it was estimated to be 13 tonnes of plastic at 600 DKKR, and four tonnes at 1300 DKKR annually. Before they would have paid 8500 DKKR for the incineration of 17 tonnes of plastic and are now paid 13.000 DKKR, thereby saving 21.500 DKKR.
Instead of following the linear resource flow, the plastic is now collected and delivered to a plastic recycler assisting in closing the loops through recycling. If Claus Sørensen A/S wanted to work with slowing the loop they need to innovate together with the supplier. This could be to remove single-use plastic wrapping from the pallets, or make plastic wrapping that can be reused. In promoting cleaner Production, it is important to follow the steps mentioned by Thrane and Remmen (2007). One of these steps is planning and organisation where a team is tasked with the specific project. In Claus Sørensen A/S the task of the implementation was placed on someone outside the organisation and this created issues after the end of the collaboration in the implementation and continuation phase, as no one was tasked with the continuation of the project. There was no clear definition of who had the responsibility leading to misunderstandings. This was also pointed out in the interview with Morten by saying "*the devil was in the details*".

5.2 MAN Energy Solutions

MAN Energy Solutions is an international company with headquarter in Augsburg, Germany. They are mostly focused on making large diesel engines and machinery for marine and stationary applications. In this report, the facility in Frederikshavn is investigated. They contacted NBE to get a waste screening in order to see how their waste management could be improved and what opportunities there was for improving their sustainability. The facility in Frederikshavn consists of four sub-departments, which are; production, storage, testing, and shipping.

5.2.1 Collaborating with actors in the network

In order to identify potentials within the waste management the different actors has been interviewed and will below be analyzed. This has been done in order to highlight their role within improvement of the waste management and specifically how they will assist in working with circular economy.

Network for Sustainable Business Development North Denmark

The sustainable development in Northern Jutland is assisted by the collaboration within NBE. The network is a collaboration between the public and private sector, which main goal is to promote and assist in the sustainable development. This is done with multiple different initiatives ranging from networking, sharing ideas for sustainable production, educational meetings, screenings of companies and helping with funding if any opportunities should arise through the screenings. The network can be described as a key actor in developing new strategies and creating a platform for open innovation. There are several collaborators tasked with the role of supporting actors for the members of the network. These include Aalborg and Hjørring municipality, Aalborg University, and Eniig Energy which is an energy provider in the region. All of these actors will in many cases assume roles needed in open innovation platforms. This will further be elaborated in section 5.2.4.

NBE created a new project from early 2019, which focuses on creating a circular Northern Jutland. This will mainly be achieved by local partnerships between companies to ensure the best possible end of life for all products. This project will initially focus on waste streams to ensure the best usage by identifying new partnerships that can use the waste products.

Recyclers

The recyclers are the final actor before the plastic re-enters the production of new plastic products. The task of the recyclers is to receive the waste, either directly from companies or from waste disposal companies. The recyclers then process the plastic materials by shredding it into granulate. This granulate is mixed into the production together with virgin plastics. According to the interviewed recycler some aspects when creating high quality granulate is how sorted the plastic arrives and the cleaner it is the higher quality of granulate is created. Stig from GenPlast showed some examples of how different the same type plastic can be delivered. One being directly recyclable and another he has to send to Germany in order to recycle.

Figure 5.5: Non sorted plastics delivered directly from a waste disposal company

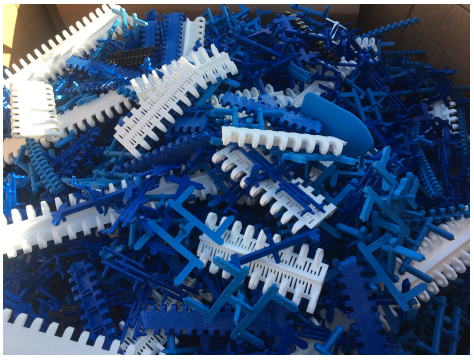

Figure 5.6: Semi sorted plastic delivered by waste disposal company

Figure 5.5 is the result of a single hard plastic container from a waste disposal company. Stig stated that the problem is the plastic not being sorted at the company and it arrives mixed with other sources.

In such a case the plastic will be shipped to Germany, where some of the plastic can be sorted and the leftover will be incinerated. In Figure 5.6 the plastic is sorted well enough that simple techniques can recycle it.

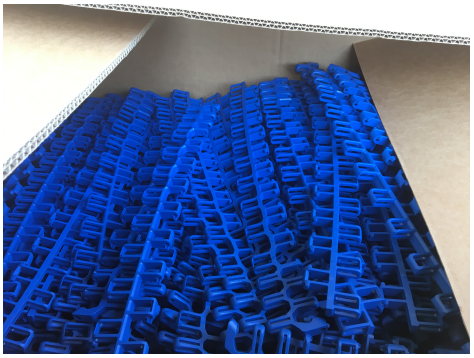

Figure 5.7: Completely sorted plastics from the company.

Figure 5.8: A sign used to ensure that only the right type is in the box. The text says: Plastic bobbins for recycling: Yes to plastic bobbins, no to everything else.

In Figure 5.7 the plastic is completely sorted and ready for recycling. In such a case it is possible for the recycler to directly recycle the plastics and pay the company a higher price for it. Stig empathised the need for sorting early on to keep plastic fractions clean and to be able to give feedback about possible mistakes in the sorting. Optimally, the plastic fraction should be delivered with 98% plastic and 2% being other waste types such a paper labels or the quality will deteriorate. According to him it requires a close dialogue between the company and recyclers from the start.

The issue regarding the cleanness and quality when the plastic is bought from waste disposal companies were further supported by Aage Vestergaard Larsen. Franz Cuculiza the CEO of AVL mentioned that the key problem for the recyclers is that the plastic that is handled by the waste disposal companies often lose some of its value, as it is either wet, dirty, or not sufficiently sorted. He pointed out that one contaminated fraction could pollute otherwise clean plastic. One solution mentioned was to collaborate directly together with companies in order to ensure the highest plastic quality through education and to provide direct feedback.

Feedback can be a complicated in the current linear resource flow as the waste disposal companies collect in bulk and store large amounts of plastics before delivering to the recyclers.

Waste disposal companies

MAN hired Marius Pedersen as waste disposal company to handle the collection and disposal of waste at the four departments in Frederikshavn. When the waste bins are full MAN energy Solutions can request an emptying

Figure 5.9: Waste bins placed by waste disposal company outside of Man Energy Solutions

online or a driver from Marius Pedersen will empty them in specific time slots. According to employees at Man Energy Solutions this happens three to four times a week. After the waste is collected Marius Pedersen will sort it to get the most value and the different fractions are sold to other companies for recycling and the rest is incinerated. At this point MAN Energy solutions are contractual obligated to use Marius Pedersen in two years. Marius Pedersen offers a total waste management package which they can fit to the needs of the company.

This is an easy solution for a production company where Marius Pedersen takes all waste, and disposes it as they see fit. The waste disposal companies are used as consultants about proper waste management and do workshops for the companies.

The different actors affecting MAN Energy Solutions

The actors mentioned above fits into the network regarding waste management at Man Energy Solutions. Each of these actors supports different directions with their own agenda. Below each actor will be placed in the network according their influence on MAN Energy Solutions.

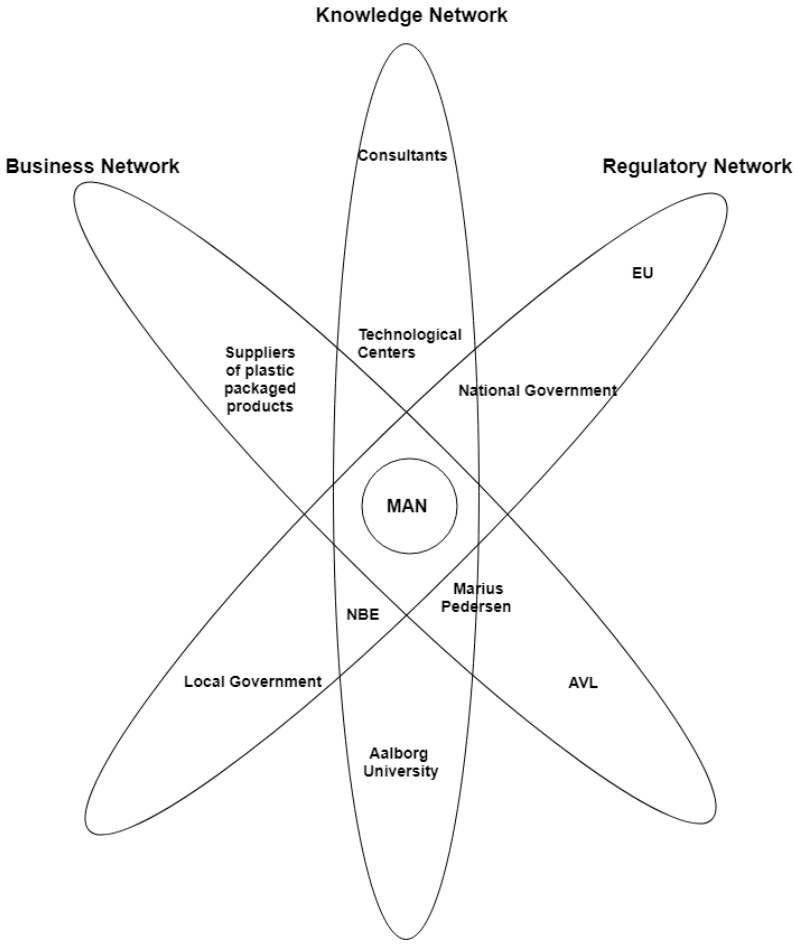

Figure 5.10: Network relations based on the case with MAN Energy Solutions adopted from Søndergaard et al. (1997)

In the business network several actors has a direct influence on how MAN Energy Solutions manages their waste. MAN Energy gets their products from different suppliers all over the world using different types of plastic. The main actor in waste management is Marius Pedersen A/S since they handle all the waste. Further out is the recyclers that receive the waste from Marius Pedersen. This is however a sub-optimal solution since the recylers are not able to give Man Energy Solutions feedback about the quality of plastic. This means Marius Pedersen both acts as a consultant in the knowledge network and partners in the business network. An example of this was a workshop about proper waste handling where two consultants from Marius Pedersen was present as experts in waste handling.
The business network is currently influenced by a waste disposal company with a main focus on their own business and continuing a linear resource flow through the transport of waste, instead of working towards reducing waste since they are paid pr collection. In order to promote a circular strategy where the fractions are seen as resources instead of waste, Man Energy Solutions needs to investigate how to collaborate with the recylers.
The knowledge network is where Man Energy Solutions can seek guidance about their waste management and until now they have used Marius Pedersen as consultants. The knowledge network has other actors MAN Energy Solutions could and should involve more in the process. One of these actors is NBE because of their strong network in Northern Jutland. NBE also interacts with the regulatory network since it is a public private partnership where MAN Energy Solutions can seek knowledge about potential local companies in order to form partnerships. Aalborg University is also part of the knowledge network and is connected with NBE. Here MAN Energy Solutions are able to seek knowledge about state of the art research an help through outside investigation of their waste management.
The regulatory network are actors affecting MAN Energy Solutions with laws and regulations. In the specific case of waste management in Frederikshavn the focus will be on local and national actors. NBE interacts with the regulatory network, as it consists of municipalities who are working on initiatives to create sustainable development. The municipalities will try to push the national waste strategy and what is decided on a municipal level.

5.2.2 Cleaner production at MAN Energy Solutions

The project was initiated when the upper management agreed to developing a sustainable strategy. Part of the planning and organisation step was to create a team in charge of improving the plastic waste management. The team included actors from top management and employees in charge of specific areas. The overall organisational plan was to include the 17 SDG's as part of the strategy.
As part of the pre-assessment the waste data from MAN Energy Solutions was investigated. Waste data prior to 2019 was according to MAN Energy Solutions inadequate and limited. From 2019 and forward Marius Pedersen has been in charge of the data collection. According to the data from Marius Perdersen they have collected 283 tonnes of waste from the 1st of January to the 31th of march from the four departments. In Figure 5.11 the waste fractions is shown. Fractions like wood and iron accounts for a large part of the total amount. The wood mostly comes from pallets to transport products and the iron is from production and broken or discarded products. In this period they registered 30 tonnes of small incineration waste which would put Man Energy Solutions at an estimated 144 tonnes of annually. In this three month period only 50 kg of plastic recycling has been registered. This number is low for a company the size of MAN Energy Solutions and it was decided to do a waste screening was part of. the pre-assessment. Like the case of Claus Sørensen A/S most of the plastic was likely going into small incineration.

Wastecode/Beskrivelse	EAK-kode	Affaldstype	Mængde/kg
E03 / Forbrændingsegnet	200301	Småt brændbart affald	5.920
E03 / Forbrændingsegnet	200301	Småt brændbart affald	25.260
E03 / Forbrændingsegnet	200301	Stort brændbart affald	4.640
E03 / Forbrændingsegnet	200301	Småt brændbart affald	310
E04 / Deponeringsegnet	191212	Ikke brændbart affald t/deponi	70
E04 / Deponeringsegnet	191212	Ikke brændbart affald t/deponi	70
E05 / Papir inkl. aviser	200101	Papir til makulering	180
E10 / Emballage pap	150101	Bølgepap	1.060
E10 / Emballage pap	150101	Bølgepap	10.190
E10 / Emballage pap	150101	Papir og pap, blandet	70
E10 / Emballage pap	150101	Bølgepap	110
E13 / Emballage plast	150102	Plastfolie 1A	50
E15 / Træ	030105	Træ, blandet/behandlet - A2	10.140
E15 / Træ	030105	Træ, blandet/behandlet - A2	82.050
E15 / Træ	030105	Træ, blandet/behandlet - A2	3.040

Figure 5.11: Overview of waste data from MAN Energy Solutions in Danish

The focus of the waste screening was to identify possible problems and *"obvious good housekeeping lapses"* (Thrane and Remmen, 2007). The waste screening showed some problems leading to the low amount of plastic collected. The first step of the waste screening was a tour of the facilities checking the different waste bins and seeing what types of plastics was used. The tour showed small incineration bins filled with plastic as shown in 5.12 and 5.13. One of the worst sorted bins was located in the warehouse where only incineration bins was placed. The warehouse is where new products are received, unpacked and registered. The reason given for only having incineration bins was lack of space.

Through observations, and participation at a waste management workshop for middle management some issues due to the daily routines and practices of the employees was identified. Firstly there is according to employees, as well as management, a space issue inside the facilities and outside. This means that most of the waste bins are located outside as shown in 5.9 and only small incineration bins are located inside. Waste sorting was seldom prioritized because of the distance to the correct waste bins and as several employees noted "*The small incineration bin eats all kinds of waste*".

Figure 5.12: Incineration bin filled with plastics

Figure 5.13: Incineration bin filled with plastics and cardboard

When talking to an employee from management with direct contact to the waste disposal company, he reveled that he had done a test where he emptied a bin similar to the one in figure 5.12 he found that up towards 70% was plastic and cardboard suitable for recycling. One problem with plastic and cardboard going into the incineration bins is they need to be emptied two to three times a week. If the plastic and cardboard was pressed and put into the correct bins Man Energy Solutions could reduce the frequency.
Another problem was insecurity about when plastic and cardboard was to dirty for recycling. Because of the work done on machine parts oil is usually found on waste. Most employees noted that when in doubt they just threw it into the small incineration bins as they did not have time to consult anyone. It was clear from the waste screening that the infrastructure for sorting waste made it hard for employees to make the right choice. The workshop between middle management and Marius Pedersen was to clarify any problems that might have occurred within the three first months of the contract and find Solutions to the problems. A short presentation was done about what happened with each waste fraction if sorted correctly. The most significant issues were the amount of recyclables put into the incineration bins. The main reason were space issues for the different waste bins. Another issue being confusion of which fractions were recyclable, and which were not. Multiple different types of plastics was used at the facilities.

Emptying an incineration bin

Because of the observations and conversations from the waste screening a small incineration bin was tested for the contents. The comments from employees, stating that "*the incineration bins eats everything*" and the data showing only 50 kg of plastic being collected in three months indicated that Man Energy Solutions had large amounts of plastic going to incineration. A randomly selected incineration bin from their warehouse was chosen. The almost full incineration bin is shown in Figure 5.14:

Figure 5.14: The randomly selected incineration bin from their warehouse.

The content of the waste bin was sorted into the correct fractions on the floor to see what should have been sorted into cardboard and plastic bins. Figure 5.15 shows a large amount of the waste not sorted correctly. To the right in Figure 5.15 are plastics, which were both clear plastic wrapping and VCI plastics. The clear plastic wrapping is already collected separately, but as pointed out by the employees the correct bins are farther away and the plastic often ends up in the closest incineration bin. The waste bin contained three kilos of clear LD-PE plastic suitable for recycling. The waste bin also contained VCI plastic that needs to be handled separately, it will be elaborated in the next section.

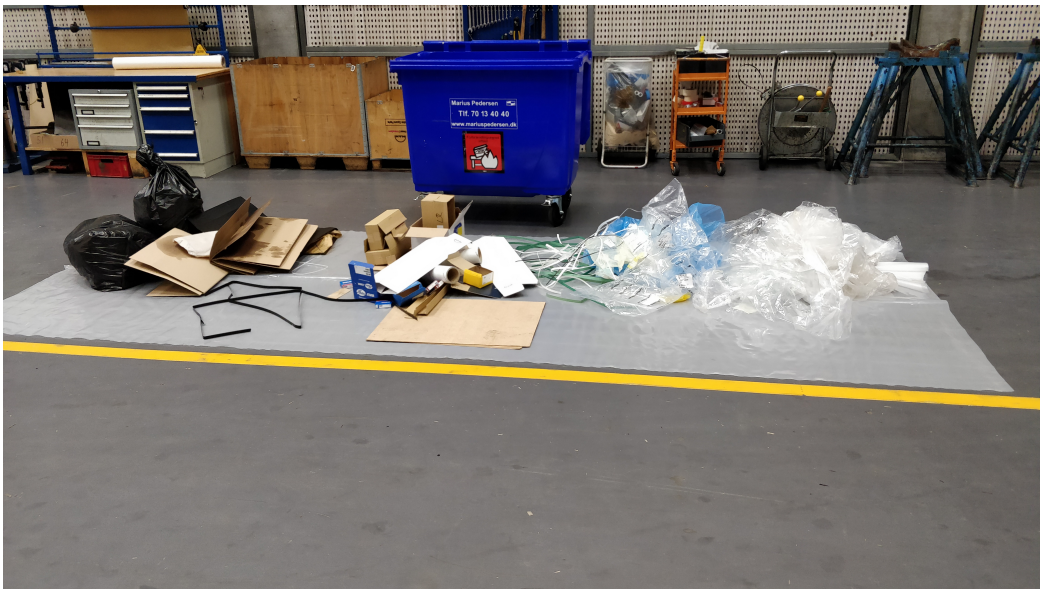

Figure 5.15: The incineration bin from storage that was emptied to show the content in separate fractions

In the middle of Figure 5.15 are clean cardboard that should have been in the recycling bin. After the bin was sorted all the waste was put into the correct ones and the result is shown in Figure 5.16. Around 50% of the waste found should have been recycled and put into other different fractions and the result is now a small incineration bin only half full.

Figure 5.16: The waste bin after sorting the waste correctly

Plastic fractions

During the waste screening and sorting of a small incineration waste bin at MAN Energy Solutions several different types of plastics was identified which are not recyclable if mixed together. MAN Energy Solutions has suppliers from all over the world that uses different types and colors of plastic. The plastic they receive is mainly HD-PE and LD-PE, but there are also hard plastic types which could be recycled. One of the largest fractions of plastic identified is a plastic called Volatile Corrosion Inhibitors plastic or VCI. VCI is used to ensure metal parts do not corrode during the transportation.

The type of VCI used by MAN Energy Solutions is made from a LD-PE plastic which is then treated with VCI materials to ensure the anti corrosion effect. As shown in Figure 5.17 and Figure 5.18 depending of the supplier the

Figure 5.17: Yellow VCI plastic from a shipment

Figure 5.18: MAN Energy Solutions own blue VCI plastic

VCI plastic comes in different colors. In the waste screening four different colors was identified from suppliers. During the workshop with Marius Pedersen it was mentioned that recycling of the LD-PE VCI plastics was not possible, because of the anti corrosion materials. The result is a linear resource flow where the VCI is incinerated. VCI is a standard in the industry to protect products and is used in high volume. Because of the uncertainty about the recyclability of VCI plastic, different samples was collected for testing.

In order to close the loop of VCI plastic a feasibility analysis was done by delivering the samples to a recycler, to run tests on the applicability for recycling. The result of the preliminary test in their laboratory showed potential for recycling. The VCI used to ship materials from the site in Frederikshavn, is made from LD-PE plastic of a high quality and a type normally regarded suited for recycling. The results of the preliminary test were promising but not decisive. In order to be certain it is possible to remove any contamination it was decided to run a full scale test with one tonnes of VCI plastic. This provides a possibility to use different methods to isolate and remove the chemicals used in the VCI treatment. MAN Energy Solutions agreed to do the test and started collecting VCI plastic at key locations. The test includes oil contaminated plastic. One demand from the recycler was that they needed to get the plastics directly from MAN and it did not go through a waste disposal company with a risk of contaminating it further.

5.2.3 Economic and Environmental Potential at MAN Energy Solutions

This section will explore the potential at MAN Energy Solutions based on the data collected, the interviews with different actors and result of preliminary tests. The waste data from Marius Pedersen showed only 50 kgs of plastic collected and 30 tonnes of waste being incinerated. The waste screening and workshop showed that all VCI plastic is incinerated and the emptying of a waste bin showed a large amount of clear plastic being incinerated. A conservative approximation of the annual total would be the 30 tonnes in the first quarter multiplied by four which leads to 120 tonnes of small incineration a year. If just 10% of that small incineration is plastic then MAN Energy Solutions is burning around 12 tonnes of plastic that could be recycled. Interviews with the two plastic recyclers showed they are willing to pay 600-2000 DKKR pr tonnes of plastic depending on the quality and cleanness of it. Prices from Frederikshavn Forsyning (2019) shows that the incineration fee is 490 DKKR pr tonnes meaning that even if the plastic is of the lowest quality the difference is 1090 DKKR pr tonnes of plastic.

MAN Energy Solutions could save 13080 DKKR on the 12 tonnes of plastic alone not accounting for transport or with the prices quoted by AVL up to 29880 DKKR a year. As in the case of Claus Sørensen A/S the reduced transportation would also result in money saved. Before optimising the waste sorting and collection Sørensen A/S had 72 pickups a year and in the first quarter of 2019 only two pickups. Looking at the environmental benefits from reducing the emission of greenhouse gases there is also potential. The numbers below shows calculations from Exiobase:

- Production of 1 kg plastic: 3.82 kg CO2 Eq/kg plastic waste
- Recycling in Denmark: -2,14 kg CO2 Eq/kg plastic waste
- Incineration in Denmark: 0,82 kg CO2 Eq/kg plastic waste

(Vingwe et al., 2019)

This means the production and later incineration of plastic would release 3.82 + 0.82 = 4.64 kg Eq/kg, while production and recycling would release 3.82 – 2.14 = 1.68 kg Eq/kg (Vingwe et al., 2019). A difference of 2.96 kg Eq/kg. This would mean MAN Energy Solutions could reduce their environmental impact by 35520 kg CO2 Eq/kg with only the 12 tonnes of plastic waste or the same amount of CO2 7.7 cars emits a year (United States Environmental Protection Agency, 2019). This is under the assumption that the recycled plastic would reduce the production of new plastic. If the plastic would be down cycled as in some cases at GenPlast the calculations would be different but it would replace the production of other materials.

5.2.4 Open Innovation and Partnerships

This section will focus on the actors from the network relation model they have created a foundation for a change in the handling of plastic waste. First part of promoting this type of innovation is to investigate, and ensure that the relevant roles can be handled by actors to promote the use of open innovation.

The following section will place the actors in the roles identified in the conceptual section regarding open innovation. The researchers has played an active role in the creation of the project. Thereby initiated different roles, which should be adopted by other actors so the project does not run into the same problems Claus Sørensen A/S did with assignments being neglected.

In the future when the network is running the innovation process will evolve with the upper management at Man Energy Solutions as the platform managers in a leadership role. It is their job to maintain and follow through with the project being the leading direct value creator in a partnership with the recylers.
The recyclers as direct value creators refines the plastic into a granulate which circulates back into the system. This refinement process is an direct value creation, which gives a value to the waste and making it a resource instead. This creates the motivation for MAN to secure the best possible quality. Further has the recyclers acted as experts. This has primarily been within the identification of which types of plastic are suitible for recycling and how to manage the plastic so it becomes a resource.
NBE has showed an interest in the project focusing on how this is referable to other companies. As such they have offered themselves as platform manager and become value support actors. By using the knowledge gained from the project they can support innovation with more actors in the future. Through their project focusing on circular economy in Northern Jutland, they are also representing themselves as a potential network leader by providing a platform on which different companies can enact.

Barrett et al. (2011) has created four platforms which promotes different levels of openness. Currently the platform at MAN Energy Solutions can best be described as Model one, as the interaction is based on contractual agreements, and there are no platform which the actors can communicate through.

The lack of platform can be explained with the stage the project is in. The project is relatively new and has not yet had the opportunity to create communication platforms, which would be beneficial. In order to move towards a more open model on a regional basis NBE can adopt the responsibility as leaders in a model four platform. Where different actors can create local partnerships. This model has however not been utilized within waste management because waste is not treated as a resource.
In order to create other projects like this in the region it is important to promote the collaboration between companies within NBE. There are multiple possibilities in chaning the linear plastic flow into a circular, and thereby creating value if a innovation platform is fully implemented with NBE as a leader.

5.2.5 Sub-conclusion

The pilot project at MAN Energy Solutions is still in its early phase with VCI plastic being collected. However the results from using the first steps of cleaner production showed potential for improved waste management. The pre-assessment and waste screening showed that waste handling at MAN Energy Soltuions follows a linear flow with most plastic being incinerated. In order to close the loop of plastic waste, a pilot project was initiated in order to do a feasibility analysis on the recycling of VCI plastic. The preliminary test resulted in agreement to run a full-scale test. If successful it will benefit MAN Energy Solutions since they no longer have to incinerate large amounts of plastic. The positive results from the pilot project could also provide a platform for pushing circular economy and local partnerships in Northern Jutland through the help of NBE.

5.3 Using the UN Sustainable Development Goals to support waste management

The SDG's can be used by companies to support environmental development and setting targets to work towards. The upper management from MAN Energy Solutions mentioned in one of the first meetings that they want to incorporate them in the future strategy. As mentioned in 4.2.2 it is important to actively use the underlying targets, as these ensure that active work is being done towards the goals. In order to work with the targets, one must measure the results in order to secure that ones work is actually promoting the targets, thereby making the large goals relevant in the context of MAN Energy Solutions. In order to do this a set of Key Performance Indicators or KPI's is needed. KPI's is a tool to help the company assess how well it performs and if it achieves its goals.
The first step for Man Energy Solutions and the development of KPI's should be to secure waste data of high quality to understand what the current status is and are able to track the progress. From the interviews Man Energy Solutions stated that up until the contract with the new waste disposal companies there has not been any tracking of waste streams in Frederikshavn *"We don't have historical data in regards to waste management, but it is something we are focusing on in the future. It is mainly hazardous waste, incineration, and steel for now" Translated MAN Energy Solutions, 2019.* From 2019 they changed their contract to a waste disposal company,who measures the different fractions and registers which department is responsible for that waste. As such it is now possible to identify some overall waste streams and collect quantitative data. This data will be used as a foundation to set up KPI's for MAN Energy Solutions that are relevant in order to meet the targets and thereby overall goals.

Working with SDG Goal 12 Sustainable Consumption and Production is evident for MAN Energy Solutions as a production company. Two of the underlying targets relevant for MAN Energy Solutions are:

- 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
- 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle (United Nations, 2015)

They already have numbers for their waste, so measuring progress towards reducing that is already available but in order to work with circular economy through prevention and recycling they need new KPI's to monitor. A simple KPI for waste reduction would be:

- **Reducing the amount of incinerated waste in tonnes.**

But if the goal is to follow circular economy they need to measure how much plastic they use in order to prevent and reduce that number in order to work towards slowing the loop. Working towards more recycled plastic is trying to close the loop. According to Bocken et al. (2016) primary recycling would try to maintain the quality of the plastic so it can be used again, this could be through the partnership with AVL where the plastic waste is made into new granulate that can be used again. The results from the pilot project will give MAN Energy Solutions more knowledge about what solution is more feasible but if they want to incorporate circular economy a KPI:

- **Percentage of plastic waste being sent to primary recycling**

This would require them to measure how much plastic they use and last becomes waste and is used for recycling. In order to achieve this and working together with the recyclers directly ties together with other SDG's such as Goal 13 climate action as resources and Goal 14 and 15 life on land and under water.

As mentioned in the problem analysis plastic waste in the oceans is a big problem. The focus regarding life under water is one of high importance for MAN Energy Solutions as they are a company in the marine industry, and deliver parts to shipping companies. This was also mentioned in the interviews with MAN Energy Solutions because a lot of the product they send out is to ships and they fear it could end up in the oceans as waste. It is repair kits as shown in Figure 5.19: They are already investigating

Figure 5.19: Repairkit from MAN Energy Solutions

solutions for biodegradable plastic but these are not suitable for water and could prove to be a poor solution making people believe it is okay to discard it in the oceans. They could work towards reducing the amount of packaging and setting demands to the buyers about what they do with the waste. This would work together with the targets in Goal 14:

- 14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
- 14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels (United Nations, 2015)

The SDG goals are broadly defined, and often focusing on international actions and third world countries.

As such it mould be beneficial to include some of the goals even if the underlying targets does not comply with the context. Goal nr. 17 regarding partnerships are a clear example of this, as the goal invites to solving issues through partnerships. This is also in alignment with the national and international work being done in maritime. World Maritime University (2019) highlights nine of the 17 goals as a focal point in the maritime industry and Danish Shipping (2018) gives priority to four goals.

- Goal 8: Decent Work and Economic Growth
- Goal 13: Climate Action
- Goal 14: Life Below Water
- Goal 16: Peace, Justice and Strong Institutions

However, these four priorities have not been connected with other goals and no targets or KPI's to support the work with the chosen goals is mentioned. The section above shows how a strategy related to the SDG's needs to understand the connection and relation between them. The focus on connecting the goals and setting targets is important for MAN Energy Solutions in order effectively work with the SDG's. This approach also enables work towards improving on specific tasks and projects rather than having a focus on the overall goals.

Chapter 6

Discussion

In this chapter, the results of the analysis will be discussed in relation to the actor's place in the network and how they can work together towards the circular economy through open innovation and partnerships. The second section will discuss our role as researchers in the network and report. Last an outlook regarding further action and potentials will be done.

6.0.1 Moving from Linear to a Circular Economy

As stated in the research design and the waste hierarchy, the goal of circular economy is to first prevent and then reduce the amount of waste created. Once the waste is created the goal is to reuse and recycle it to stop it from being incinerated or land-filled. Hence the call for seeing it as a resource instead of waste.
The data from MAN Energy Solutions showed 30 tonnes of waste being incinerated and only 50 kilos being recycled in the first three months in 2019. Current practices are far from circular and follow a linear flow where resources are taken, made and disposed of through incineration. In order to change this linear flow the network relations model from Søndergaard et al. (1997) was used on MAN Energy Solutions to investigate what actors they are connected with and to find new ones that could benefit them in Northern Jutland. Through the waste screening, different plastic fractions was identified with unused potential since it was all incinerated.

An interview with AVL identified them as a potential business partner for recycling the plastic fractions. Moving towards a circular model is a systemic change (Bocken et al., 2016). Since for Man Energy Solutions it would require a new waste management and a new business partner in the network. This gave the opportunity for a pilot project in order to improve waste management, helping in closing the loop through recycling. The pilot project was set up in order to introduce small incremental changes to collect the plastic before any radical changes were made. Good housekeeping rules about waste sorting and improved collecting was put in place based on the positive results from Claus Sørensen A/S. Bocken et al. (2016) emphasises the need for an overall vision before developing towards a more circular model. Here the SDG's was used as a starting point in order to develop such a strategy and KPI's. The benefit for MAN Energy Solutions is the goals provides a more focused direction on achieving their sustainability goals and helps to communicate them to employees but also business partners. The upper management in MAN Energy Solutions mentioned more than once in the interviews that " *We are okay with increased expenditure if the environmental benefits are worth it*" (Translated, Management MAN, 2019). But the case of Claus Sørensen A/S shows that the economic and environmental benefits can be combined. Claus Sørensen A/S reduced the need for waste collecting and are now getting paid for their plastic and cardboard waste instead of paying for incineration. The calculations done in the analysis showed MAN Energy Solutions can turn an expense into an economic benefit. Both from selling their plastic but reduce the number of waste collection.
The waste disposal companies have been operating in both the business network and the knowledge network. Since companies use them as consultants for good practices. In a sense they have become gatekeepers of the linear economy and slows down the transition to a circular economy. Their business model and interest lay in transporting waste and as many collections as possible. In order to be part of circular economy they need to do radical changes in their business model to fit into the new systemic changes for circular economy. Their consultancy should focus on reducing collections and on the quality of the plastic they collect in order to maximise profit from it. The same is true for other waste fractions. Instead of being a waste disposal company they should be a *"resource management company"*.

In order to promote circularity and closing the loop on a regional level in Northern Jutland, NBE could focus on an open platform model with themselves as an owner of the network. This is perhaps a slightly different angle than the one promoted by Barrett et al. (2011), as the focal company would be substituted by NBE. However this public-private partnerships have the potential if fully open to promote the intentions of NBE's project with a circular Northern Jutland.
This project has mainly focused on closing the loop through improved waste management and recycling of plastic but a focus on slowing or narrowing the loop of plastic should also be done. Bocken et al. (2016) mentions solutions that actively seek to reduce end-user consumption. For MAN Energy Solutions this could be working with suppliers in order to reduce the amount of plastic they receive and actively look into reducing the amount of plastic they send out.

6.0.2 Our role as researchers

The outset of this report was to conduct interviews with the different actors in order to get their view on barriers and potentials in plastic waste management. In the meetings with MAN Energy Solutions it was clear they wanted consulting so a negotiation about what each could expect from each other was done. This secured our role would not be consultants in the network but instead a collaboration. This ensured that the waste screening was to benefit both of us, as researchers we got the empirical data needed and MAN Energy Solutions got information about the current waste situation. The information sharing was mostly done in meetings with the upper management and by presenting the empirical data. The presentation from the waste screening and emptying was also valued by the upper management as an eye opening in the current situation and it sparked engagement in setting up the pilot project quickly. The pilot project was also a collaboration between the researchers, MAN Energy Solutions and AVL. In the first week of the pilot project MAN Energy Solutions collected six bags of VCI and nine with clear plastic which is an improvement from the first three months. This shows the potential in a network of actors collaborating together in order to develop new practices and solutions.

The next step would be to involve NBE and present the results as they are part of the knowledge network and a platform to share the results with other companies in Northern Jutland. This model four platform could be used to motivate other companies and open for new partnerships working with circular economy.
A limitation to the research is time and length of the pilot project since it will go on for longer than the time period of this semester. It would be interesting to see the results of the pilot project and see if a lasting partnership is made between MAN Energy Solutions and AVL regarding the plastic fractions. A positive outcome would motivate them into looking into other fractions of waste.

6.0.3 Future outlook

This project has primarily focused on plastics, however the potential can be applied onto other waste fractions and companies by following the same steps. MAN Energy Solutions has a large amount of both steel and wood waste which is sorted and collected by Marius Pedersen. It was mentioned on the workshop that they do not have any requirements for where the waste fractions were sold to. This means Marius Pedersen is free to sell the waste to anyone regardless of distance. Here it could be beneficial to look into partners in Northern Jutland that can use wood and steel fractions to minimise the transport and make sure the fractions are used accordingly to circular economy and securing local loops. Stories like this could also be used NBE to motivate and show other companies how investigating their waste could be a benefit for both the company and new business partners.

Chapter 7

Conclusion

This report has investigated the current and future possibilities for collaboration between companies in Northern Jutland in order to answer the research question:

- *How can companies in Northern Jutland collaborate to improve their reuse and recycling of plastics and ensure a high plastic quality is maintained?*

In order to investigate this a collaboration with MAN Energy Solutions placed in Frederikshavn was carried out.
The first step was to investigate the current capabilities of plastic recyclers In Northern Jutland. It was found that the recyclers could recycle larger amounts if the plastic was sorted better. One recycler elaborated this by showing three different batches. One directly delivered without any sorting and two completely sorted at the company. The recyclers identified that when a waste disposal company was used the plastic was delivered without being sorted and *"200% more polluted"*.
The second issue was traceability of the plastic waste. When waste disposal companies handle the plastic it is impossible for the recyclers to identify which company polluted plastic comes from. A direct link between the company and recycler would allow them to provide feedback about improving waste handling. These issues are related to the limited and linear flow of plastic as it is now.

The second step was a waste screening at MAN Energy Solutions to investigate the potentials for improvement at MAN and a collaboration with the recyclers. It was found through this screening that the majority of the plastic from MAN Energy Solutions was incinerated due to insufficient waste management. Different plastic fractions were identified and a large amount of VCI plastic was found in the waste. Up until now MAN had been told to not sort the VCI plastic. Samples were collected for a recycler. The preliminary tests showed possibilities for recycling.
A pilot project was initiated, in which MAN has to collect one tonne of VCI to run a full-scale recycling test. In the first week of sorting plastic, six bags each of approximately nine kilos of VCI plastic had been collected and nine bags of clear plastic wrapping. This was the result of a few changes in both the infrastructure regarding waste management and an increased focus good housekeeping rules. Via a partnership with AVL, MAN Energy Solutions has the possibility to become more sustainable and increase the amount of plastic they recycle but also the quality of the plastic. If they get correct feedback from AVL. If the waste disposal companies want a role in the new network they need to adapt to circular economy and consult companies in treating waste as a resource and to create new partnerships locally.

The third step was how actors in Northern Jutland can promote better plastic recycling and it is concluded that NBE could establish an open innovation network focusing on improvements within waste management in order to improve the circular economy. The model four approach as described in this report with NBE owner of the network can enable local partnerships to better reuse and recycle resources in order to slowing, narrowing and closing of loops in Northern Jutland. Open innovation offers a platform where knowledge is available across the value chain by introducing companies in the innovation process and letting them communicate freely.
The last step was to include The United Nations Sustainable Development Goals in order to develop a strategy without the goals being selected alone and taken out of context. In order for MAN Energy Solutions to work with the goals in practice, a strategy connecting the goals is needed. It is not enough to select a few goals and tag them onto projects.

Working with plastic waste is only going to be part of an overall strategy even with plastic working under more than one goal. To measure this KPI's was suggested that uses circular economy since it is now enough to just measure weight.

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