Recycling of Household Plastic

Public-Private Partnership Solutions For Recycling of Plastic for I/S Reno-Nord

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Recycling goals have been set both by the EU and the Danish state, in which 50 percent of dry household waste needs to be recycled either by 2030 or 2022 respectively. In order to see how these goals can be met, a case study of I/S Reno-Nord will be made. I/S Reno-Nord operates a sorting facility that separates collected household plastic waste into four plastic fractions and a residual waste fraction of unidentified waste. The waste fractions have a purity between 85-90 percent. This plastic waste needs to be utilized, but the market interest for recycled household plastic is low and as such public-private partnership is being proposed as an option.

Problemformulation: *How can public-private partnerships be useful in optimizing the recycling of household plastic waste?*

Results: Three appropriate companies were found in Denmark. The study concludes that partnerships will be possible with at least two of them, as the preconditions necessary to facilitate this exists. These partnerships will create environmental benefits, and keep the plastic in a semi-closed loop within Denmark.

Contents

Preface

This master thesis was made by two Environmental Management and Sustainability Science (EMSS) students at Aalborg University, Denmark. Both students have a bachelor background in technoanthropology, which is the qualitative study of human interaction and use of technology. The report was written in spring semester of 2018.

The purpose of this study was to identify potential private partnerships with I/S Reno-Nord in order to find environmental beneficial solutions to the sorted household plastic waste at I/S Reno-Nord. As plastic waste is an underused resource, this report aims to showcase how to increase recycling of municipal plastic waste. Hopefully this report will provide clarity for decisionmakers of I/S Reno-Nord, and provide insight into the potential opportunities public-private partnerships provides, in an environmental and circular economy perspective.

We'd like to thank our supervisors Søren Løkke, and Edward Vingwe for their guidance and help throughout this project. We'd like to thank I/S Reno-Nord for their cooperation and help. Furthermore we'd like to provide a special thanks to Henrik Kirkegaard (I/S Reno-Nord), Hanne Risgaard (Quantafuel A/S), Kim Dalsgaard (Dansk Affaldsminimering ApS), Gitte B. Larsen (Aage Vestergaard Larsen), and Arne Remmen (Aalborg University), for participating in interviews.

Chapter 1

Introduction

Plastic is an important part of our daily lives as it can be found everywhere, from our phones, to food packaging, sewer pipes, and kitchenware. It contains many excellent qualities, it's cheap, durable, flexible, waterproof and light. Since the 1960's the global production of plastic has increased by 20 fold, reaching 322 million tonnes in 2015. It's estimated to be doubled in 20 years (European Commission, 2018a). While the production and usage increases, the end of use handling is still lacking, as less than 30 percent of the plastic waste in the EU is recycled (European Commission, 2018a). The figure below shows the plastic productions since 1950, and highlights of how much the production of plastic has increased since its discovery.

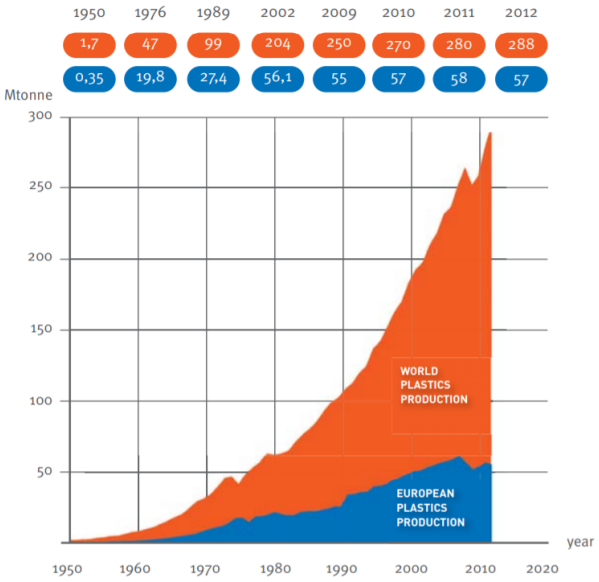

Figure 1.1: Figure of the plastic production in the world since 1950 (PlasticsEurope, 2013).

As waste is currently an unexploited source of resources, the EU would like its member states to recycle more (European Commission, 2018a), for both environmental as well as economical reasons. The potential environmental benefits of recycling is massive as a tonne of recycled PE-plastic saves 1500 kg of CO_2, and 1750 kg of CO_2 for PET-plastic (Plastindustrien, 2017). Furthermore an estimated 150.000 to 500.000 tonnes of plastic waste from the EU enters the ocean every year, which harms marine life (European Commission, 2018a). There are several places of key focus, each with their own set of challenges. The plastic waste areas can be divided into industrial and household. In Denmark the industrial plastic waste is being handled relatively well, as 64 percent is recycled which makes it the fourth best in the EU. However the recycling of household is at only 15,1 percent, which makes Denmark the worst in the EU (Plastindustrien, 2017). In order to rectify this, household plastic waste in Denmark should be given special focus. In Denmark the total amount of plastic waste is 323 tonnes, where only 1/3 is recycled, the remaining 2/3 is incinerated or landfilled (Plastindustrien, 2017). Thus this will be a study into what a specific municipal waste management is doing, and what can be done to improve the recycling of household plastic waste.

Chapter 2

Problem analysis

This report is investigating the waste management of municipal plastic waste. Various target objectives and directives regarding the recycling of plastic waste has been made on a national and international level. In order to reach these targets, waste management actors are looking into new methods. The casework is the municipal waste management company I/S Reno-Nord. This report is looking into the benefits and detriments of these partnerships, in order to determine if this will enable I/S Reno-Nord to reach their targets of improving the recycling of municipal plastic waste.

2.1 Recycling Agendas of Recyclers in Europe

To understand the current situation, it's necessary to look in-depth about the current strategies and agendas employed to reach higher recycling rates in Europe, by some of the most prominent actors, on a national level, as well as international level.

2.1.1 Waste & Resources Action Programme

The Waste & Resources Action Program (WRAP) is a registered charity organization based in UK, and was founded in 2000. The purpose of WRAP is to help businesses, individuals and communities become more circular and a part of a circular economy. This is done by helping the business reducing their waste, develop sustainable products and be more efficient in the use of resources (WRAP, 2014).

WRAP has in a research project looked into the technical viability of recycling mixed plastic packaging waste from domestic sources on a commercial scale in the UK. In the research WRAP investigated three aspects regarding the recycling of plastic. These aspects were:

- The sorting of plastic, and how it can be separated from other materials in a Materials Recovery Facility (MRF)
- The role of the collection of plastic at retail outlets
- Sorting of the mixed plastics into different plastic types such as HDPE, LDPE, PP, PVC, PS (Dvorak et al., 2009).

There were three MRF's involved in the research project. These facilities were selected because WRAP needed more knowledge about how the facilities sort the mixed plastics, and the quality of the output. The

second part of this research project was looking into collecting schemes for household plastic packing at supermarkets and finding the challenges in the systems. They used data and experience from the collection of 20 tonnes of mixed plastics. Here it was experienced that the consumers had difficulties following the instructions. According to WRAP, if this take-back scheme should provide a high-quality product, a well-functioning system has to be setup, which include minimizing the transport and contamination of other waste sources (Dvorak et al., 2009). The high-quality product can be send to a Plastic Recovery Facility (PRF), where the plastic is sorted out in the various plastic types such as HDPE, PP, PS, PVC, PET. For the facility to have the high-quality output, it's required that it is only plastic waste and there is a very little contamination of other waste types. Otherwise it is more advantageously to send the waste to a MRF. The plastic waste at the PRF is sorted out by using a Near Infra-Red (NIR) scanner, and some trials to sort the plastics into the different plastic type was quite successful according to WRAP. However, the NIR scanner had some problems identifying black plastic (Dvorak et al., 2009).

The conclusion of the project was that recycling of the mixed plastics is technically viable solution on a commercial scale, and the recycled plastic materials was used successfully in various products afterwards. The achievable material recovery expected in the research project was 55 percent, and could possible increase to 60 percent according the WRAP. Furthermore, the study showed that there is a market for the recycled plastic, as around 95 percent of it was sold afterwards (Dvorak et al., 2009). The project and strategies from WRAP shows that their focus is more towards sorting than eco-design as a problem solver to recycling the the plastic waste.

2.1.2 Dansk Affaldsforening

Dansk Affaldsforening (Translated: Danish Waste Association) is an association of 53 municipality members or municipality associated waste companies, in which they represent and is their leading voice of the waste management agenda (Dansk Affaldsforening). As a part of this they published a summary, outlining their strategies and intentions for the future of waste management on a national level in Denmark.

Dansk Affaldsforening disagrees with the current political agenda of privatizing the waste management business, as they believe the current system works and should instead be build upon. They argue the current system should be transformed towards a circular economy approach where 99 percent of all waste is re-used, recycled, or incinerated with "green energy recovery". Dansk Affaldsforening agenda aims towards making waste management more efficient, environmentally and economic, by (Dansk Affaldsforening, 2017):

- Demanding increased requirement of "better" produced products. By better means simpler, in terms of the handling at the end of use, for example by being easy to disassemble. The development of this should be guided through the many already available tools, such as fees, taxes, tax rebates, etc.
- Finding the value in waste. Waste management should be a last resort, as waste prevention is a better solution, because when a product becomes waste, it loses value that can be difficult to reestablish. Waste only have value when in large uniform waste flows which is why investing in waste management is necessary, as well as a working system is necessary to handle the many different types of waste (Dansk Affaldsforening, 2017).

This is to be able to better handle what they describe as the main challenges of the future for the waste management in Denmark. These challenges are according to them:

1. Increased consumption which also means increased waste production. Not only increased consumption per citizen but also an increased population.
2. Increased complexity of products, for example use of different types of plastic in meat packaging products which presents difficulties in recycling.
3. Harmful chemicals. It has mostly been seen in the construction business, for example asbestos that was quite commonly used but have now been phased out due to its detrimental effects on human health (Dansk Affaldsforening, 2017).

In order to tackle these challenges the association and its members have identified *"principles for the future waste management"*:

1. Only have one waste collector in order to avoid increased complexity that will reduce the quality of the different waste streams.
2. Connected value chains, as parts of the value chain of recycling waste is expensive, but if its handled by the same connected chain it becomes an acceptable loss as economic value can be gained elsewhere in the chain. Furthermore encourages connected value chain greater innovation, as private actors may feel encouraged to use the cheapest option rather than the environmental best option.
3. Intelligent use of the market. Private corporations should be allowed to participate in the connected value chain, but only under specific rules and guidelines to avoid "cherry pickers".
4. A single waste stream - private corporations should be allowed to buy access to the municipal owned waste, as the combined infrastructure will be beneficial for both private and public waste management companies. Furthermore will the single waste stream be better able to handle the volume needed for an effective circular economy.
5. As the waste management sector have few actors, and large entry barriers and is asymmetrical, it's under massive risk of corporate monopolies which is detrimental to the public interest. Thus the waste management should be the responsibilities of municipality owned companies, as they can better ensure security of service, consumer protection, environmental considerations, etc. Furthermore when the municipality is responsible, transparency is secured.
6. Circular economy is currently, in Denmark, less economic effective than incineration, but value is created elsewhere. The benefits are found in environmental considerations, public health, and the greater human cohesion, when the community works together towards a common goal.
7. Measure the effects of increased recycling rather than the percentages of waste recycled (Dansk Affaldsforening, 2017).

In conclusion, Dansk Affaldsforening wants to work towards a more circular economy perspective. However as they represent the municipalities and municipal waste management companies, it can be seen in their agenda and strategies. While they are interested in collaborating with private corporations, they want to be in control of the waste flows and market, thus being able to dictate the terms private corporations work under.

2.1.3 European Recycling Industries' Confederation

The European Recycling Industries' Confederation (EuRIC) is a confederation comprised of three European Federations, namely:

- The European Ferrous Recovery and Recycling Federation (EFR);
- The European Recovered Paper Association (ERPA);
- The European Metal Trade and Recycling Federation (EUROMETREC).

The EuRIC represents companies in Europe involved in the collection, processing, recycling, transportation and trade of recycling (EuRIC). The EuRIC published the paper; "Strategy on plastics in a Circular Economy EuRIC position" in which they outline their agreement of the European strategy of plastic recycling.

> "EuRIC welcomes the introduction of the roadmap laying down the European Commission's *"Strategy on plastics in a circular economy"* ('the roadmap')." - (EuRIC, 2017)

They agree that the main reasons for low recycling rates of plastic is:

1. Lack of incentives to stimulate the market of recycled plastics
2. Lack of eco-design requirements that will ease the recyclability of plastics
3. Insufficiently coherent or predictable policies which makes long term investments risky

The EuRIC address each of the three barriers for increased recycling of plastic and their take on how to overcome these challenges.

2.1.3.1 Incentives

The volume of recycled plastic is too low to meet the demands for a stable flow of plastic needed in production. The EuRIC believes that incentives could be the solution to achieve a more stable functional market of recycled plastics (EuRIC, 2017). The examples the EuRIC presents are;

- Green Public Procurement - Green Public Procurement is a voluntary tool in which public authorities can through their purchasing power choose environmental friendly options, and stimulate the market towards a more environmental and circular economy future (European Commission).
- Setting market mechanisms - Through marked mechanisms which rewards the environmental benefits of recycled plastics, in terms of energy and CO_2 savings.
- Rewarding and investing in research and development - Public actors can invest or reward research and development into tracing plastics waste flows or setting recycled content targets (EuRIC, 2017).

2.1.3.2 Eco-design

The dismantling of post consumer plastic is challenging, but some of the challenges can be minimized by:

- Increased information - For example can visual markers make manual sorting of plastic waste easier. Likewise color coding could be a solution in which automatic machines will be better able to sort the plastic waste into the respective types of plastic.

- Cooperation between producers and waste managers - By cooperation between the producers and the waste managers to understand and overcome each others challenges and issues, the barriers for increased recycling can be overcome, by designing the products to maximize each others priorities (EuRIC, 2017).

2.1.3.3 Coherent and Predictable Policies

The EuRIC feel there is regulatory policy conflicts within the EU. The EU is pushing increased recycling of waste, but at the same time also restricting the usage of various chemicals. Some of these now restricted and banned chemicals can still be found in old products which is not allowed to re-enter through the waste streams, which complicates the recycling process. However they offer no solution or strategy for solving the issue (EuRIC, 2017).

The EuRIC is not opposed to increased recycling but believes the barriers are currently too great. Standardization, eco-design requirements, and streamlined predictable policies, along with increased incentives from national and public stakeholders are necessary to reach higher rates of recycling.

2.1.4 The Nordic Council

The Nordic Council, also known as Norden, is a Nordic cooperation between Denmark, Finland, Norway, Sweden, Iceland, Åland, Greenland and the Faeroe Islands. As part of the Nordic Council's green growth initiative: "The Nordic Region – leading in green growth", they published in 2015 a report on future solutions for Nordic plastic recycling. This report identified potential solutions for increasing the collection and recycling of plastic waste from households and other municipal owned waste sources, within the already existing collecting and recycling system (Fråne et al., 2015).

The report identified three main conditions that needs to be improved in order to increase the recycling rates of municipal plastic waste. More of the plastic waste generated needs to be collected for recycling by:

- Increased source-separation opportunities outside of households homes. By expanding the system used in homes to public areas more plastic waste will be collected.
- Increased collection by combining plastic packaging and non plastic packaging waste.
- Sorting mixed household waste through recycling facilities capable of handling mixed waste streams.
- A denser net of public drop-off points and increased availability for source-separation of plastic waste at the kerb.
- Accept plastic waste from other municipal sources than households at public drop-off points.
- The recycling of plastic waste needs to be effective, and flexible in order to meet market demands.
- A market for the recycled collected plastic needs to exist and absorb the materials in order to stimulate the innovation and increase market demand (Fråne et al., 2015).

> "A condition to increase recycling of plastic is to collect more of the generated plastic waste in the dedicated collection and recycling systems, and thus avoid plastic waste in waste fractions to incineration." - (Fråne et al., 2015)

The Nordic Council advice and strategy for the future seems to be expanding upon current systems. These improvements they believe will be able to increase the recycling rates of plastic waste of municipal waste.

2.1.5 Ellen MacArthur Foundation

The Ellen MacArthur Foundation is a non-profit organization that promotes circular economy. As a part of promoting the circular economy framework, the Ellen MacArthur Foundation released the report; The New Plastics Economy - Rethinking the Future of Plastics. The aim of the report is to promote circular economy in the plastic industry and waste management of plastic (World Economic Forum et al., 2016).

> ”This report is designed to initiate — not conclude — a deeper exploration of the New Plastics Economy. It provides an initial fact-base, shared language, and sense of the opportunities derived from the application of circular principles, and a plan for concerted action for the next three years and beyond.” - (World Economic Forum et al., 2016)

The report identifies several key issues that needs to be overcome in order to change the plastic economy into a more circular framework.

- Increase the economic value, and the quality and uptake of recycled materials.
- Scale up the use of reusable packaging.
- Scale up the industrial use of compostable packaging.
- Improve collection, storage, and reprocessing waste management infrastructure in high-leakage countries.
- Increase the economic incentive and value of recycled materials.
- Incite investment towards innovative materials and formats with reduced negative environmental impact during leakage (World Economic Forum et al., 2016).

The Ellen MacArthur Foundation suggest that these key issues could be overcome through four initiatives.

- Mobilizing large scale ’moon shot’ innovations, by the leading businesses, academics, and innovators. Examples of innovation could be bio-benign materials, higher recyclability, chemical recycling, etc.
- Develop insights and build an economic and scientific database. Studies needed for the database could include investigating the economic and environmental benefits of a circular economy framework regarding plastic.
- Engage policymakers in developing a common system and vision for a circular plastic economy.
- Coordinate and communicate across the entire value chain in order to find best practices, opportunities and recommendations (World Economic Forum et al., 2016).

The Ellen MacArthur Foundation main purpose is promoting circular economy, as such their agenda regarding plastic waste is a circular plastic economy. They believe it can be done by involving all actors of the value chain along with academics and national actors.

2.1.6 State of the Art

There are a lot of different interest groups, each representing and promoting their own agenda. However despite their differences they somewhat all agree that circular economy can provide economical and environmental benefits. They also agree that in order to reach a more circular system, changes needs to be made, through initiatives and incentives, but the focus is on different aspects and the incentives favours different approaches. WRAP focused mostly on the economical viability of circular economy, which have shown positive results. The EuRIC wants national actors to favour environmental friendly options when making public procurement and increase spending into private research projects. Thus their focus is counterintuitively to increase the incentives for the plastic industry to use recycled materials. This is in contrast with Dansk Affaldsforening that wants legislation introduced that will incentivize eco-design, making products easier to disassemble and handle by recyclers. The Nordic Council's focus lies at the public sector, as they believe if the public system expands it will increase and stimulate the market for recycled plastic, which in turn will boost the overall recycling. Lastly is the Ellen MacArthur Foundation which is focused more theoretically on a grand scale. They do however agree with certain points with all the different actors summed up.

In order to increase the possibility of change, their agenda of getting various incentives, implementation of initiatives, and who and how they should be in control of the market, the various actors needs to harmonize their expectations and agenda, or the very least not conflict, as that can cause difficulties.

2.2 Ban of Plastic Waste Import Into China

The attempts of moving towards a circular plastic economy is more necessary than ever, not just for environmental reasons, but also practical and logistic reasons. The 18th of July 2017 China announced to the World Trade Organization that it would implement a ban on the import of 24 kinds of solid wastes into China. This included plastic waste from living sources, waste, pairings, and scraps of plastic, including unsorted waste and scrap. The Ministry of Environmental Protection of the People's Republic of China found large amounts of dirty or hazardous waste mixed into solid waste imported, which was polluting its environment (Ministry of Environmental Protection of the People's Republic of China, 2017).

> "To protect China's environmental interests and people's health, we urgently adjust the imported solid wastes list, and forbid the import of solid wastes that are highly polluted." - (Ministry of Environmental Protection of the People's Republic of China, 2017)

The ban on the waste was proposed to be enforced by September 2017, but was first enforced at the end of 2017 (World Trade Organization, 2017). This caused a massive disruption of the plastic market as somewhere between 50-60 percent of all collected plastic waste in EU was exported to China (Davis and Ding, 2018)(Tamma, 2017). As the recyclers of Europe had less than 6 months to prepare for the sudden development many was forced into stockpiling or burning the plastic waste. The disruption have been met with very mixed views (Tamma, 2017).

Secretary general Emmanuel Katrakis of EuRIC (The European Recycling Industries' Confederation) have announced that he believes Europe needs to step forward towards a circular economy in order to address the challenges (EuRIC, 2017). As such he shares the same intention as the European Union which recently published their Plastic Waste Strategy for a more circular economy oriented Europe. The Danish plastic recycler Aage Vestergaard Larsen A/S (AVL) believes this in the long term is a great opportunity for Danish companies. Franz Cuculiza, CEO of AVL believes that everyone, including themselves have been too slow innovate and exploit the money in plastic waste, as its been easier to just export it to China. They are currently exploring the construction of a recycling facility capable of handling the dirty plastic from household waste, as part of a partnership with municipalities (Høy, 2017). Others however don't believe the disruption will benefit recyclers, but rather the producers or shift the export of waste that previously went to China to other nations.

> "The ban of scrap/waste plastics is definitely positive for polyethylene producers as there will be a shift of consumption from recycled polyethylene to prime virgin polyethylene," said J.P. Nah, director of polyolefins at IHS Markit Chemical (Peng, 2017).

The think tank IHS Markit believes this will boost the demand for virgin materials, as production will shift away from recycled plastic.

The United Nations Regional Information Centre (UNRIC) have cautiously published that it believes this will either just shift the export of the waste to other southeast Asian countries, such as Vietnam or Indonesia, but also could be the disruption needed for implementing more effective and green recycling of plastic waste (United Nations Regional Information Centre, 2017).

The CEO of Danish Waste Association Jacob Hartvig Simonsen, understands the Chinese decision, as the plastic sent was usually the discarded scraps that European recyclers was unable to handle or find value in. Thus it was sent to China were it often was incinerated or landfilled (Dansk Affaldsforening, 2018).

The disruption have forced the various waste management actors in Europe to look for alternative solutions to the plastic waste. The attitude towards this shift varies a lot, some sees it as the beginning of transition towards circular economy, while others sees it as a boost to the virgin material producers.

2.3 The European Union Circular Economy Action Plan

The EU have for some time wanted its members to transition to a more circular economy in order to become more competitive, and resource effective. It will also make it easier to reach the environmental goals specified in General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' (European Parliament & the Council, 2013). The transition is encouraged and specified through the Circular Economy Action Plan (CEAP) which identifies various hotspots. The 2015 CEAP identified plastic as one of the key priorities of waste management in the EU.

In January 2018, the European Strategy *'Plastics in a Circular Economy'* was adopted. The strategy is designed to transform the way plastic products are designed, used, produced and recycled in the EU. The CEAP substantiates the selected strategy due to the way plastic currently are produced, used and

discarded, which fails to capture the economic benefits of a circular approach. This in turn harms the environment, for example due to micro plastic in the ocean, or improper landfilling. The CEAP and EU Plastic Strategy wants its members to provide incentives to producers, corporations, and waste management companies to improve designs of plastic products which will make higher and better recycling rates of plastic waste (European Commission, 2018b).

> ”The Strategy is part of Europe’s transition towards a circular economy, and will also contribute to reaching the Sustainable Development Goals, the global climate commitments and the EU’s industrial policy objectives. This strategy will help protect our environment, reduce marine litter, greenhouse gas emissions and our dependence on imported fossil fuels. It will support more sustainable and safer consumption and production patterns for plastics.” - (European Commission, 2018a)

The intention is to ensure that all plastic packaging is recyclable and half of all plastic waste is recycled by 2030. A goal that needs the commitment of all key players of the plastic industry, retailers, producers, consumers, and waste management companies in order to succeed. The strategy contains several more goals it intends to achieve but for the context of this report, only the main goals focusing on the plastic waste will be elaborated.

While the strategy have a long list of goals it would like to reach it does not have any mechanisms to enforce compliance to the goals. Instead it specify other tools, initiatives and programs that currently exists, and how they should be used. They are listed in the Plastic Strategy as themes it intends to address.

2.3.1 Design for Recyclability

The Plastic Strategy pledges to work on a revision for the requirements for placing plastic packaging on the EU market. The objective of the revision would be to ensure that all plastic packaging is reusable or recyclable by 2030 (European Commission, 2018a).

> "To support improved design while preserving the internal market, EU is essential." - (European Commission, 2018a)

This revision would encompass increased Extended Producer Responsibility, by maximizing the impact of new rules and developing economic incentives that rewards the most sustainable designs. Other areas of production uses plastic as well but often contains other chemicals that makes it more difficult to recycle or decreases its value. As such the EU Commission would like to accelerate the work being made into identifying chemicals in the plastic waste flow. However they do not clearly specify what this work encompas (European Commission, 2018a).

Lastly the EU Commission is committed to developing product requirements under the Eco-design Directive with the focus of circular economy. This means making requirements and mandatory design functions that makes the products easier and safer to dismantle, reuse, and recycle (European Commission, 2018a).

2.3.2 Boosting Demand For Recycled Plastic

The demand for recycled plastics is very weak, and remain a major obstacle for increased recycling and closing the loop. The lack of demand can be traced back to a few key reasons;

- Due to market uncertainties of profitability and outlets, the investments into developing the upscaling and modernize the recycling in the EU market have been lacking. However the recent developments in the international trade of plastic waste, new opportunities and challenges have arisen to develop the European market, which increases the demand and urgency of innovative solutions.
- Manufacturers fear that the quality of recycled plastics are insufficient for their needs for a reliable high-volume supply with specific quality specifications. Plastic is often recycled by smaller often regional facilities and a standardization of the industry and the quality of its products would thus be beneficial.
- Concerns of the chemical composition due to lack of information or incidental contamination of the recycled plastic has discouraged the demand of recycled plastic. To address these concerns the EU will finance research and innovation of projects looking for ways to better identify contamination and decontamination of plastic waste through the Horizon 2020 funding program.

These factors coupled with the lack of knowledge of the benefits and the disadvantages and challenges of recycled plastic have caused the manufacturers to resist change (European Commission, 2018a).

2.3.3 Better and More Harmonized Separate Collection and Sorting

The market of recycled plastic is held back by the insufficient volumes and the quality of sorting and separation of plastic waste. The latter also plays part in accidental contamination. Reducing fragmentation and disparities in the collection and sorting schemes used is thus a key part in securing a bigger market. The EU Commission will issue guidelines on separation and sorting of the waste in order to encourage standardization (European Commission, 2018a).

2.3.4 Establishing a Clear Regulatory Framework for Plastics with Biodegradable Properties

Due to the high amount of plastic leakage into the environment, particularly marine litter, biodegradable and compostable plastics have started to be developed and used in small scale by parts of the plastic industry. While it has environmental advantages, it also comes with disadvantages that needs to be addressed. Most available plastics labeled biodegradable, requires very specific conditions to degrade, which may not always be found in nature, thus still causing environmental damage if leaked. Likewise, compostable may require industrial composition techniques in order to compost probable. Lastly both the biodegradable and compostable plastic will have a degradation effect on the quality if mixed with conventional plastic during its recycling process (European Commission, 2018a).

The EU Commission believes that clear rules, standardization, and informing consumers, what constitutes biodegradable and compostable plastic, and that it is not put forward as a solution to littering. Applications for environmental benefits will be found, for example through life cycle assessment, and the

Commission will on a case by case basis attempt to stimulate innovation and market developments into the identified and chosen cases (European Commission, 2018a).

2.3.5 Conclusions of the European Union Plastic Waste Strategy

The EU Plastic Waste Strategy is ambitious and will require a strong commitment by the EU Commission and the member states of the European Union. As they don't intend to enforce it through regulations, laws or directives, but by encouraging innovation and market developments through various funding, it will have to invest heavily in order to reach the goals. Through the Horizon 2020 EU Research and Innovation programme, it has secured 350 million Euros for research and development in areas directly related to the goals. Furthermore the European Structural and Investment Funds have contributed 5,5 billion Euros for developing the EU recycling capabilities, and improving waste management. However the EU Commission have estimated the costs necessary to reach the goals as somewhere between 8,4 billion to 16,6 billion Euros (European Commission, 2018a). As such it is underfunded, and it's uncertain if they will reach the intended goals.

2.4 The Waste Hierarchy

In the EU and subsequently Denmark, environmental decisions in waste management are based on the waste hierarchy, which is defined by the EU directive 2008/98/EC on waste (European Union, 2008). The waste hierarchy is organized such as the waste should be prioritized, and defines basic concepts and definitions linked with waste management. There are five levels in the waste hierarchy, which can be seen on figure 2.1.

The hierarchy prioritizes waste prevention as the most desirable option, and landfill as the least desirable option.

1. Prevention is measures taken before a product, material or substance becomes waste.
2. Re-use is any operation where a product or components are re-used for its original purpose.
3. Recycling is any recovery of waste materials, which are reprocessed into products, materials or substances which can be used, with the exception of being used for fuel or backfilling.
4. Energy recovery is any operation where the waste is used to produce energy, such as incineration, chemical treatment, biogas, etc.

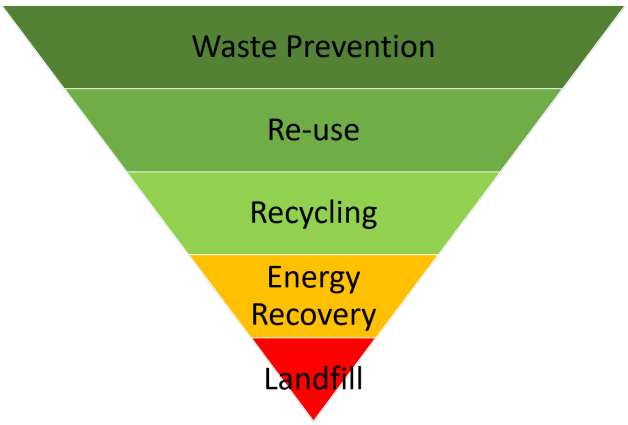

Figure 2.1: The waste hierarchy

5. Landfill is an operation where the waste is disposed in designated areas in the ground. Often hazardous waste that cannot be allowed to re-enter the system (European Union, 2008).

This also makes the basis of the environmental decision making in plastic waste management.

2.4.1 Plastic Waste Hierarchy

In context of recycling of plastic waste, the various treatment methods are referred to as being *'primary', 'secondary', 'tertiary',* or *'energy recovery'*, in relation to what is most environmental desirable, in that order.

- **Primary Recycling (Recycling with no degradation)**
  - Primary recycling is when the plastic waste is reprocessed with no impurities such as other types of polymers. This is considered a closed loop, but requires very high purity of the sorted waste (Rahimi and García, 2017).
- **Secondary Recycling (Recycling with Degradation)**
  - Secondary recycling is when there is a downcycling or degradation in the quality of the recycled plastic. This can be due to mixed types of polymers which affects the properties of the plastic (Rahimi and García, 2017).
- **Tertiary Recycling (Chemical Recycling)**
  - Tertiary recycling uses chemical processes to recover the plastic waste, by turning it into oil based products such as synthetic oil or synthetic fuel (Rahimi and García, 2017).
- **Energy Recovery (Incineration)**
  - The last option is energy recovery, where the plastic waste is incinerated in order to generate heat. This heat can be used for example for district heating or electricity. However the material is lost, and emits greenhouse gases. Furthermore shows studies that the energy generated compared to the energy saved through recycling is less (Rahimi and García, 2017).

  "For example, the heating value for plastics is 36,000 kJ kg−1, whereas mechanical recycling conserves 60,000– 90,000 kJ kg−1. Therefore, recycling plastic waste ultimately conserves more energy than the process of incinerating plastic waste can generate." - (Rahimi and García, 2017)

According to Plastindustrien (Translated: The Plastindustry), an industry association for plastic producers in Denmark, 206.000 tonnes of plastic waste is incinerated every year in Denmark (Plastindustrien). Thus if the cost of the primary, secondary, and tertiary recycling methods can be cost effective it will unlock the potential to be much more environmental beneficial, and energy effective.

2.5 Waste Strategy of Denmark

In 2013 the Danish waste management strategy “Danmark uden affald” (Translated: "Denmark without waste") were implemented. The strategy is valid from 2013 till 2018. The focus of the strategy was to create more recycling, and especially on the household waste, because a lot of the danish household waste was incinerated until then. Numbers showed that 55 percent of the Danish household waste was incinerated in 2013 (Toft et al., 2015). In this strategy there was a focus on seven fractions from the household waste, and it is within these seven that the recycling percent should be at least 50 percent in 2022. These seven fractions are, food waste, wood, glass, metal, plastic, cardboard, and paper (Miljøstyrrelsen, 2013).

The responsibility to reach these targets lies with the municipalities. They have to make plans and strategies themselves to reach these goals. When the current plan was made in 2011 the recycling percent of these 7 waste fractions was only 22 percent for all of Denmark (Miljøstyrrelsen, 2013). According to the Danish Environmental Protection Agency, the recycling had increased to 33 percent in 2015 (Toft et al., 2017).

2.6 Advisory Board for Circular Economy in Denmark

In 2016 the Danish government established the *Advisory Board* for circular economy. This advisory board consists of 12 leaders of different sized companies in Denmark. The reports and recommendations made by the Advisory Board should act as a successor to the action plan Danmark uden affald, see section 2.5. In June 2017 the advisory board created their vision and 27 recommendations of actions necessary to reach a more circular future, where the resources are used more effectively (Miljø- og Fødevareministeriet, 2017). Flemming Besenbacher, the chairman of the advisory board has made the following statement about how to create a future with circular economy:

> "But in order for Denmark to truly become an international frontier in the field of circular economy, businesses, the public and citizens need to work together to create value that benefits not only their own interests but, rather, the whole community. Businesses must take corporate social responsibility and not just create value based on narrow short-term goals." - (Miljø- og Fødevareministeriet, 2017)

The transformation towards circular economy is not only beneficial for the environment, but it also creates economic growth, new jobs and increased export. If the transformation succeeds, this could increase wealth of 45 billion DKK in 2035 according to The Ellen MacArthur foundation (Miljø- og Fødevareministeriet, 2017).

The advisory board made as mentioned before 27 recommendations, which are divided into four different themes. These themes are:

- The circular value chains
- Design and production
- Consumption
- Recycling

The recommendations are supposed to be implemented towards either 2020, 2025 or 2030, to successful create a more circular Denmark(Miljø- og Fødevareministeriet, 2017).

The advisory board has made five recommendations related to recycling and how we can recycle more of the material we use. These five recommendations are:

- Streamline the municipal collection of household waste to promote recycling.
- Establish clarity about the waste sector's framework conditions and a better supply of recycled raw materials.
- Improve competition on the market for waste and recycled raw materials through uniform classification and enhanced risk-based waste control.
- Extend selective demolition of construction.
- Introduce a more circular producer responsibility for electronics waste (Miljø- og Fødevareministeriet, 2017)

According to the Advisory Board, one of the barriers for more recycling is the different collecting schemes of household waste in Denmark. As it is now, it's the municipality, who design the collecting schemes, and therefore it's difficult to get a large scale effect and be more efficient in the treatment of the waste. According to the Advisory Board, there are more than 20 different combinations of seven different waste fractions in the 98 municipalities. Therefore a streamlining of the collecting schemes of household waste would create several advantages. Here among others it would create large scale effect and better quality in the recycling of the waste, and it would also create better prices for the waste and better exploitation of the resources(Miljø- og Fødevareministeriet, 2017).

2.7 Aalborg Municipality

As mentioned earlier both the EU commission with the circular economy package, and the Danish resource strategy, have made plastic waste a priority, along with the advice given by the Danish Advisory Board. As part of these strategies, various actions and initiatives have been taken by the different municipalities of Denmark. As part of this Aalborg Municipality launched their own strategy plan based on the national governments. In the Strategy Plan 2018-2021 from Aalborg Renovation, it describes how it intends reach the target set by the Danish government in the national resource strategy. The strategy called "Aalborg uden affald" (Translated: Aalborg without waste), includes targets and identified actions, which help them ensure fulfillment of the target objectives (Aalborg Forsyning, 2017). In the waste management plan, Aalborg Renovation made several main targets to generate more recycling. The relevant targets are:

- Digitalization of customer orientation – The waste sorting systems creates a need for better communication with the citizens of Aalborg municipality.
- Investment in waste management systems from businesses and Housing associations in Aalborg municipality – They want to create economic incentives for businesses and housing associations to invest in wastes management to improve the recycling of the waste.
- Waste in public space should be collected in underground containers (Aalborg Forsyning, 2017).

One of the main initiatives from Aalborg Renovation, was to sort the plastic and metal waste separately from the household waste. Together with the two municipalities Jammerbugt and Mariagerfjord, they build a high tech sorting facility, to treat the subsequently plastic and metal waste that would be collected (Miljø- og Fødevareministeriet, 2015). Aalborg Renovation had earlier done some test schemes with the plastic waste, and results showed that sometimes up to 40 percent of the waste was non-plastic, due to being wrongly sorted by the citizens. The quality of the plastic waste was so bad, it had to be sorted manually afterwards or incinerated. Another challenge experienced was the mixed metal and plastic fraction could not be compressed too much, by the waste truck as some of the metal could become wrapped around the plastic, which make it very difficult to separate afterwards at the sorting facility (Miljø- og Fødevareministeriet, 2015). Some of these challenges have been subsequently solved and the facility is running relative smoothly and producing sorted plastic waste of a decent quality, but there is still some challenges, which Aalborg Renovation and I/S Reno-Nord is facing. The recent ban of import of plastic into China have been part of these challenges which includes finding new buyers of the sorted waste, capable of utilizing it in an environmental and circular economic way. One solution is a partnership with a relevant company, capable of utilizing the plastic waste. By partnering up, it's possible to create innovation and finding a solution to the current challenge. A handful of private companies specialized in plastic recycling exists within Denmark, and as such could be ideal candidates for establishing a public-private partnership with the goal of finding a solution to the sorted plastic waste from I/S Reno-Nord.

2.8 Public-Private Partnerships

Public-private partnerships (PPP) is cooperation model, where parties from both the public and private sector cooperate. There is no clear definition on how PPP is being done, and the cooperation could be in a broad range of areas. However a normal partnership can provide the following benefits;

- Increased innovation by finding new ways to address problems
- Achieve sustainability goals, as both partners gains access to new resources, technology and knowledge
- Gain access to new skills
- Increase legitimacy (Network for Business Sustainability, 2013)

If done successfully these benefits will be able create to innovation in one of three dimensions; *Operational optimization; Organizational transformation* or; *System building*. See figure 2.2 below.

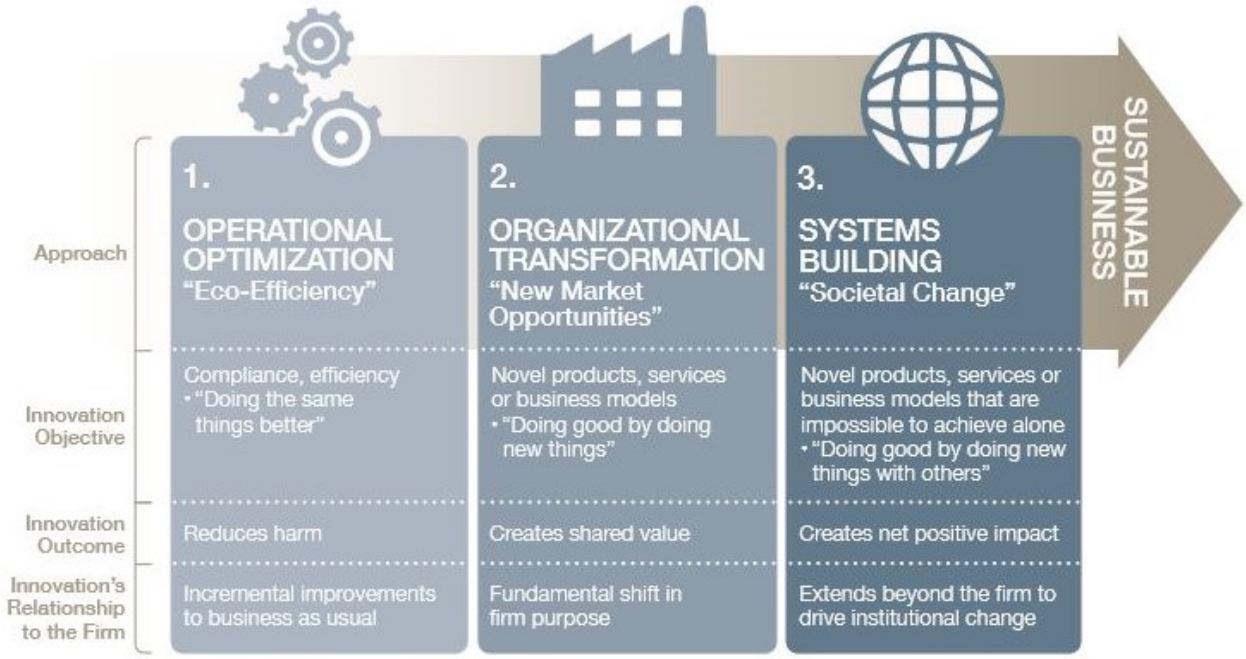

Figure 2.2: The three levels of business innovation (Network for Business Sustainability, 2012)

Operational optimization provides the least benefits whereas system building provides the most. In order to increase chances for success and reach the most beneficial level partners should be carefully selected by a set of criteria such as;

- **Partner relevance**
  - Make sure partners are relevant stakeholders of a specific issue.
- **Partner appropriateness**
  - Put the issue that needs to be addressed at the center - not the company
- **Alternative perspectives**
  - Engage stakeholders as they may provide a broader view of the problem
- **Partner resources and skills**
  - Possible partners should have capabilities and skills that complement each other and are currently outside their own sphere of expertise
- **Partner credibility**
  - Select partners with credibility as doing otherwise might harm the reputation
- **Power balance**
  - Partnerships with large power difference may end up harming each others progress and commitment (Network for Business Sustainability, 2013)

If used by I/S Reno-Nord to help solve the issue they have with the sorted plastic waste it can provide all partners with benefits. I/S Reno-Nord will be able to reach its environmental goals, and private partners

will gain access to an unexploited resource of plastic.

2.9 Summarizing of problem analysis

In the problem analysis various strategies, and agendas from stakeholders ranging from supranational entities, to both public and private associations, and non-profit organizations, were analyzed. The focus of the strategies varied, and so did the proposed ways to tackle the challenges associated with recycling plastic waste. The announcements China made to the World Trade Organization that it would implement a ban on the import of 24 kinds of solid wastes into China which included plastic waste. As mentioned in section 2.2, this ban could lead to a change in the recycled plastic market, according to several actors in the waste management field such as The United Nations Regional Information Centre and Danish Waste Association. This drastic change have forced various waste management actors in Europe to look for alternative solutions to the plastic waste. The attitude towards this shift in discourse varies a lot, some sees it as the beginning of a transition towards circular economy, and others sees it as a boost to the virgin material producers.

As mentioned in section 2.1.6, many of the private associations need to harmonize their expectations and agenda, or the very least not conflict, as that can cause difficulties, and hamper their efforts. However while these stakeholders appears disorganized the EU and the subsequently national and public stakeholders of Denmark have aligned to a great degree. Some of strategies mentioned above is to some extent supported by the new strategy from EU commission. The focus of the commission is very broad and is working on several things to increase the recycling of plastic in the EU. According to the EU Plastic Strategy, the commission wants to take various actions such as introduce a new eco-design directive by using the principle of design for recyclability, use extended producer responsibility and boosting demand for recycled plastic.

The Danish government established an Advisory Board on circular economy to prepare for a future where circular economy is much more included in society. The Advisory Board was looking at the different phases of the value chain of products used by the citizens in their daily lives. The phases ranges from the design of the product, to recycling the product. Many of the advice suggested by the advisory board is close to the strategy for plastic made by the EU. Like the EU the Advisory Board have identified the need for more effective sorting of the waste, which would make the recycling process easier, and increase the recycling rate. The potential public-private partnerships could be a key part in solving the identified issues and overcome the barriers preventing a greater amount of recycling by I/S Reno-Nord.

Chapter 3

Problemformulation

On both supranational and national level, target objectives regarding the recycling rates of plastic from household waste have been made. Various strategies by national actors as well as private actors are being announced. The disruption of the recycled plastic market has increased the need for changes in the current system in order to increase recycling in an environmental beneficial way, that preferably makes a closed loop within Denmark. The barriers and benefits of implementing a public-private partnership with recycling companies in Denmark is unknown and as such will be a priority which leads to the following problem statement and research questions.

3.1 Problem Statement

How can public-private partnerships be useful in optimizing the recycling of household plastic waste?

3.1.1 Research Questions

1. How can a public-private partnership with I/S Reno-Nord be implemented?
2. What are the barriers and benefits of implementing public-private partnership in regards to the recycled plastic of I/S Reno-Nord?

Chapter 4

Methods and theories

A selection of methods and theories have been chosen for collecting and analyzing data. In this chapter they will be elaborated upon, and how it was used in the context of this study.

4.1 Interview

Interview is a qualitative method used to elucidate information through informants (Brinkmann and Tanggard, 2010). For this case study, we've elected to use semi-structured interviews. In the following section the usage of who and how we have used interview will be further elaborated.

4.1.1 Usage of Interviews

Interviews have been used to collect data from the various stakeholders of the current network regarding the plastic waste from I/S Reno-Nord. Furthermore it have also been used to collect data from the stakeholders of the potential network that would exist if the partnerships was to come into effect. Lastly interviews have also been conducted with an expert on plastic waste, and business partnerships. This list includes the following persons interviewed:

- Environmental Manager of Reno-Nord Henrik Kirkegaard
- Environmental Manager of Quantafuel Hanne Riisgaard
- Director of Dansk Affaldsminimering Kim Dalsgaard
- Owner, Business Developer & Marketing Manager Gitte B. Larsen
- Professor Arne Remmen of Aalborg University, Institute of Planning.

This will provide information from experts of the field, and the stakeholders of the selected potential partnerships.

4.2 Policy arrangement

Policy arrangement is an approach, which was developed by Jan Van Tatenhove and Bas Art. They define the approach as “the temporary stabilization of the content and organization of a particular policy domain” (Liefferink, 2006). Originally, policy arrangement was used in the environmental policy field, but is now also used in other fields. According to Duncan Liefferink, the main purpose of the policy arrangement approach is;

> “The overall objective of the policy arrangements approach is to analytically link changes in day to day policy practices to broader, structural changes in contemporary society." - (Liefferink, 2006)

In policy arrangement approach there are four dimensions. These four dimensions are:

- **Actors** - This dimension refers to the coalitions of the actors involved in the policy domain.
- **Power and resources** - This dimension refers to the division of resources between the actors involved, which is leading to differences in power and influence, where power refers to the mobilization and deployment of the available resources, and influence to who determines policy outcomes and how. In policy arrangement power is defined in three different forms, where each form has a relation to one of the other dimensions. These forms of power are:
  - Relational power - Relates to the "Actor" dimension
  - Regulatory power - Relates to the "Rules of the game" dimension
  - Discursive power - Relates to the "Discourse" dimension
- **Rules of the game** - This dimension refers to the formal procedures of decision making and implementation as well as informal rules and ‘routines’ of interaction.
- **Discourses** - This dimension refers to the views and narratives of the actors involved (norms, values, definitions of problems and approaches to solutions) (Liefferink, 2006).

Three of these dimensions are referring to organizational aspects and the last dimension is referring to the substantial aspects of policy (Liefferink, 2006).

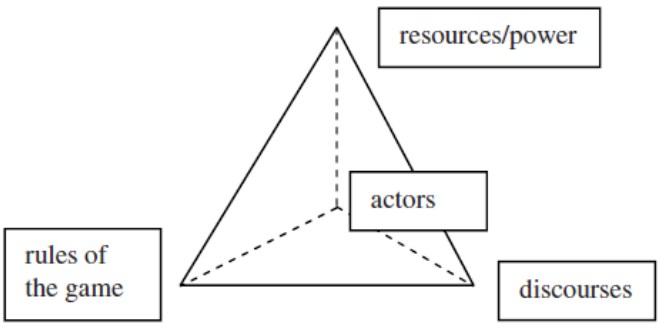

Figure 4.1: This is a model of the policy arrangement approach aligned in a tetrahedron. (Liefferink, 2006)

The four dimensions of the policy arrangement will analyzed as well as the relations between the linkage between the dimensions, and how it can relate to the case of I/S Reno-Nord and the recycling of their

plastic waste. The usage of policy arrangement will further be elaborated in the following subsection.

4.2.1 Usage of policy arrangement

In this study policy arrangement have been used to give an overview and also to analyze how the changes in the way I/S Reno-Nord operate with the plastic waste, and which actors they cooperate with. According to Liefferink changes in one dimension could also have an affect on the other dimensions, and in this case the focus has been to analyze the possible new actors as new partnerships for I/S Reno-Nord (Liefferink, 2006).
In this approach the first two dimensions 'Actors' and 'Power and resources' is being analyzed by using an stakeholder analysis, where the relevant stakeholders are described. Each stakeholder are then analyzed for their attributes which include among others power, where the power is the relations between the actors.
Next up is the 'Rules of the games', where different legislation is being analyzed, and the role and influence it has on the case. Both the legislation on a supranational level as well as national level. The last dimension is the discourse, where the strategies and the actions of the actors the discourse. The four dimensions will be elaborated in chapter 6.

4.3 Stakeholder Analysis

Stakeholder analysis is a qualitative theory used to map the various stakeholders that exist within a network in a specific context. Many different stakeholder theories exist, which uses various definitions of what a stakeholder is and how extensive the network should be mapped. For this report Mitchell's stakeholder theory will be used (Mitchell et al., 1997).

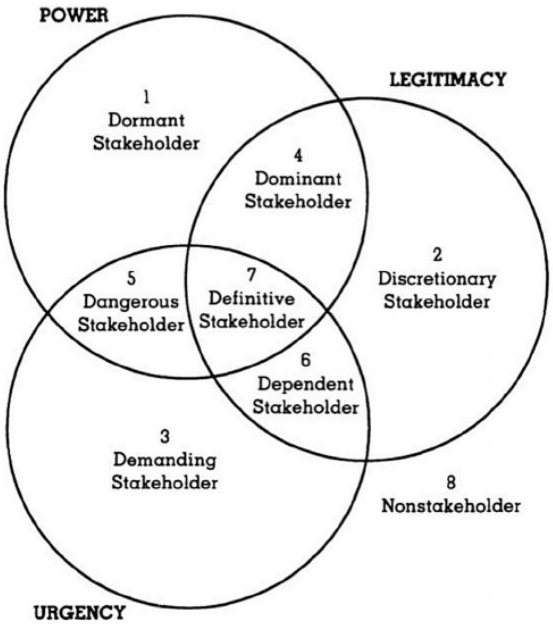

Figure 4.2: Venn-diagram of the types of Stakeholders. (Mitchell et al., 1997)

Mitchell's stakeholder theory assigns the various stakeholders attributes. The stakeholders are given, non, one, two or three different attributes; *'Power, 'Legitimacy' and 'Urgency'*. Then depending on how many, and which attributes, they will be defined as one of the eight different types of stakeholders in the network. An explanation of the different types of stakeholders can be seen in table 4.1 below.

Table 4.1: Explanation of types of stakeholders

Types of Stakeholders	Attributes	Description of Stakeholder
Dormant	Power	Possess the power to impose its will, but not the legitimacy or urgency and thus remains passive
Discretionary	Legitimacy	Possess legitimacy, but no power to influence any decision made, and no urgent claim. Thus they are often ignored by decisionmakers
Demanding	Urgency	Possess urgency, but not the power to influence decisionmakers, and with no claim, they remain a stakeholder decisionmakers only address brief moments of attentions
Dominant	Power & Legitimacy	Stakeholders with power and legitimacy have large amounts of influence on any decisionmaking, but may choose not to act due to lack of urgency
Dangerous	Power & Urgency	Dangerous stakeholders have power and urgency to influence decisionmakers, but lack the legitimacy. For example, by blockade, vandalism, etc.
Dependent	Legitimacy & Urgency	Dependent stakeholders lack the power to make demands to decisionmakers, and thus relies on other stakeholders to exercise their power over decisionmakers. For example, through advocating, awarenss campagins, etc.
Definitive	Power, Legitimacy & Urgency	Possess all three attributes, which makes them extremely powerful. They are capable of influencing decisionmakers and get their demands and claims through
Nonstakeholder	None	Possess none, and thus can influence nothing, and have no desire to influence decisionmaking

Mitchell explains that all stakeholders have varying degrees of salience, depending on how many and which of the attributes the stakeholder has. Furthermore the stakeholder is not "stuck" as that particular type of stakeholder. With work, a stakeholder can acquire more attributes and gain more influence in decisionmaking.
This report have used Mitchell's stakeholder theory and will define stakeholders as the immediate potential network of partnerships with I/S Reno-Nord.

Chapter 5

The Case - Reno-Nord

The case study is the waste management and energy company I/S Reno-Nord. I/S Reno-Nord is a business partnership between the municipalities of Brønderslev, Jammerbugt, Mariagerfjord, Rebild and Aalborg. Their main task is handling household and municipal waste, which includes operating the incineration plant and sorting facility (Reno-Nord). In 2016 Reno-Nord in cooperation with EFACEC Power Solution opened a highly advanced sorting facility in Aalborg. The facility cost 38 million DKK, and is designed to sort metal and plastic waste from households. The facility is capable of sorting 4,3 tons of plastic, and 1,2 tons of metal pr. hour (Reno-Nord, 2016).

> *Translated from Danish:* "It is our hope that we can establish partnerships with local businesses. That way we can not just save resources from being incinerated, but also save transportation costs of the sorted waste. No doubt there is a market for recycled plastic and metal, and Reno-Nord is currently investigating the best market opportunities." - Chairman of the board Daniel Nyboe Andersen (Reno-Nord, 2016)

There is great interest from the board in establishing partnerships with the local business in order to ensure greater recycling in an environmental and economic desirable way.

5.1 Sorting Facility of Reno-Nord

The sorting facility was built in 2016, and the facility was running for the first time in November 2016. The sorting facility screens for four types of plastics. These are described in table 5.1. Likewise the sorting facility also sorts metal into three different fractions, which are aluminum, iron and mixed metal. The aluminum is sorted by an eddy current, the iron is sorted by magnet, and the mixed metal is all the large metal pieces sorted out manually by the employees at the sorting facility. The steps of the sorting process for the waste at the facility is described below here:

1. The plastic and metal waste is delivered to the sorting facility by garbage trucks. The waste is mainly from households in Aalborg, Jammerbugt and Mariagerfjord municipality. Here it is dumped down in a ditch, where a metal conveyor belt transport the waste further into the sorting facility.
2. In the next step in the process, the waste is brought in through a machine called "the bag opener". This machine is a grinder, which purpose is to rip up the waste bags, so the waste can be separated at the facility. This is very essential that it's done properly. If a closed bag go further in the process,

they have to be thrown into incineration waste, because the sorting facility is unable to sort the waste.

3. In the next part of the process the waste is led in to a small room, where wrongly sorted waste is removed from the waste stream manually by four or five workers. These workers have been trained in which items to look for. The workers have specific task depending on where they are in relation to the conveyor belt.
   (a) The first two workers (one on each side of the conveyor belt) is looking for large metal items. This is done because the sorting facility is receiving large amounts of metal items, which have dimensions that are too large for the sorting facility.
   (b) The next two are looking for large plastic foil parts, whose sizes are too large for the facility. Furthermore, they are also looking for electronic waste and other wrongly sorted items, which also are removed and sent to incineration. Example of this could be items made of paper, cardboard, glass or organic waste.
   (c) The last person is mainly looking for wrongly sorted elements, which are sent to incineration, like described before. They are also looking for electronic waste for the same reasons as described before in item b.
4. The next step in the sorting process, is a discfilter, which sorts all the large plastic elements, that are too large for the further process. The elements are instead led by a conveyor belt in to a silo, where it afterwards can be shredded and sent into the system again.
5. Further in the process, is the windshifter, which purpose is to remove plastic foil from the waste stream. The machine is sucking up the plasticfoil.
6. In the next part of the process, iron is removed from the waste stream by a magnet.
7. After this aluminum, cobber and other light metals is removed by an eddy current.
8. When the aluminum, cobber and other light metals is removed, the waste stream is sent to another discfilter, which is removing elements, which dimensions are to small for the further process.
9. In the last step in the sorting process, the waste stream is sent through two NIR scanners, which are identifying the plastic type and afterwards sorting the waste in to the before mentioned three plastic types (plastic foil has already been sorted out in the process), which are described in table 5.1. The remaining waste, is unidentified by the system and ends up in silo. Examples of this could be black plastic (this problem will be elaborated in section 5.1.1) and other unusual types of plastic.(Reno-Nord, 2017)

As mentioned I/S Reno-Nord is sorting four types of plastic at the facility, and the plastic types is described in table 5.1.

Table 5.1: Table of plastic types sorted at Reno-Nord's sorting facility

Plastic type	Example of usage
Polyethylen High density - HDPE	Polyethylen is the most used plastic type. Polyethylen occurs in broad range of variants and applications. HDPE is often seen in products such as for water and drainage pipes, tubs, buckets and toys (Plastindustrien, 2018a).
Polyethylen Low density - LDPE	LDPE is often used for plastic foil, plastic bags and wrapping around cardboard, as it is seen on milk cartons (Plastindustrien, 2018a).
Polypropylen - PP	Polypropylen is one of the most well-known plastic types. Usage of polypropylen is broad and is seen in products such as food packaging, furniture, ropes and instrument panels, bumpers and other components for cars (Plastindustrien, 2018c).
Polyethylene terephthalat - PET	Polyethylen terephthalat is also a well-know plastic type, and the usage of it is seen mostly in packaging. Almost all bottles for beverages is made of PET (Plastindustrien, 2018b).

5.1.1 Challenges at the Sorting Facility

Some of challenges I/S Reno-Nord is facing, regarding the plastic and metal waste, are among others wrongly sorted waste, which are affecting the process of the waste at the facility. Another challenge is when compressing the waste, as metal can be wrapped around the plastic, and make it very difficult to separate in the sorting facility. There are also some challenges related to the identifying process, where the NIR scanner identifies which types of plastic the waste is, and afterwards sorting it. One challenge related to the NIR scanner, are the difficulties in identifying black coloured plastic which results in the black coloured plastic being discarded and later incinerated.

Another problem is that a lot of the plastic waste are products composed of several types of polymer, which in many cases is very difficult or even impossible to separate. For example plastic bottles, as the body of the bottle is one type of polymers, the cap is another type of polymers, and in some cases there can be a plastic foil wrapped around the bottle, which can be a third type of polymers. The NIR scanner identifies only one of the three plastic types, and sorts it into that type waste fraction. This lowers the quality of the recycled plastic. The problem with several polymer types in one product is huge, and have been identified by several actors in the plastic recycling industry, as something that need to change to improve both the quality and quantity of the recycling of plastic. Professor Arne Remmen of Aalborg University say following about the topic;

> *Translated from Danish:* "The big challenge lies in, that everything is allowed in that field, so all kind of trash is in circulation, and there's a lot of whats called mixing abuse - that you have different types of plastic in the same packaging and things like that." - Professor Arne Remmen

However the main issue is that I/S Reno-Nord is unable to sell all the plastic waste after it has been sorted out into the four different plastic types mentioned earlier. Mainly because the market for recycled plastic is very low, and demand is not as big as it could have been (Aalborg Kommune, 2015). A possible solution

would be to engage the stakeholders in order to find partners capable of solving the issue. This would provide benefits for both, see section 2.8

5.2 Possible Partnerships with Reno-Nord

Environmental Manager of I/S Reno-Nord Henrik Kirkegaard was interviewed to map and explore the agenda and future strategies for improving the plastic recycling towards a more circular economy. He finds Public-Private Partnerships a future possibility as he saw possible benefits and reduced economic risks.

> *Translated from Danish:* "Franz *[CEO of Aage Vestergaard Larsen A/S]* have no risk in this when he's guaranteed his amounts *[plastic waste]*, right? So it's about erasing some of the administrative hassle, but also to ensure that it's coherent. Is it perhaps better to keep sorting it? That he keeps washing it? But we cannot be in doubt that we have long term contracts with each other because if he stops washing and receiving it, then I'll have the same problem again, so I'll have the same problem getting rid of it. And then I will have to drive it to Germany which is more expensive. So you can see that partnerships begins to be very logical. And we'll be insanely competitive. We'll have the sorting facility right next to the washing facility. Lots of local haulers will drive that tiny trip for nothing. So compare it with sending it to China, and then we're talking business. Also for us, it makes good sense this here. I can't see anything else than it makes insanely good sense." - Henrik Kirkegard, Environmental Manager of I/S Reno-Nord

Based on the principles of circular economy, the waste hierarchy, the discourse of many of the major actors in waste management, and the strategic environmental waste goals of both the EU, and the Danish government three criteria have been selected for finding possible partnerships with I/S Reno-Nord.

5.2.1 Criteria for Selection

Three criteria was selected in order to maximize the circular economy perspective, and reaching the environmental goals of I/S Reno-Nord;

1. Keeping the plastic waste in the three upper layers of the plastic waste hierarchy, primary, secondary and tertiary, see section 2.4.1. This is done to ensure;
    - The plastic is recycled, even if it's with degradation
    - That it is environmental sensible
    - That the goal of 50 percent recycling in 2022 is reached. See section 2.5
2. Processing the plastic waste within the borders of Denmark due to;
    - Maximize the economic benefits of circular economy
    - Increase social responsibility, through increased employment growth and benefits
    - Stimulate the Danish recycling market of plastic

- Increased and easier supervision of recipients of the waste within the EU environmental requirements

3. Capacity to handle the types and tonnage of waste from I/S Reno-Nord

The following table contains a list of waste management companies in Denmark that recycles or handles plastic waste in some way. The table explains very briefly why these waste management companies have not fulfilled the selected requirements.

Table 5.2: My caption

Company	Description	Reason for Deselection
Marius Pedersen	Collects all types of waste, and sends it abroad for processing	The plastic waste is shipped abroad, and is in some cases used for fuel
Stena Recycling	Collects all types of waste, and sends it abroad places for processing	The plastic waste is shipped abroad, and is in some cases used for fuel
Pap & Plast	Collects plastic and cardboard waste from companies for free	Primarily only collect coathangers
Plastix	Recycles end of use fishing nets	Is focused only on recycling fishing nets
Polyloop	Collects plastic and ships it to a washing facility	The plastic waste is shipped abroad for processing
STRANDETlab	Collects plastic waste on the beach at the Jutlandish west coast. Cleans and recycle the collected waste into plastic granulate	Small, non-profit, driven by volunteers
RC Plast	Collects production waste, and remakes it into plastic granulate and sends it back to production facilities	Only collects and recycles production waste
Letbæk Plast	Receives production waste and artificial turfs and uses it in their own production of products	Only uses recycled plastic granulate from production
Schoeller Plast-Enterprise	Buy-back scheme of own products to remake them. Have recently made a test project with Holbæk Municipality and Aage Vestergaard Larsen A/S of recycling household plastic waste	Their product needs hand sorted plastic waste, and have explicitedly disregarded the plastic waste from automatic sorting facilities, due to the quality.
Fiberline Composites	Recycles fiberglass plastic by sending it to cement producers in Germany	The fiberglass is used as fuel in the cement production

This limits the companies that we've been able to find in Denmark which fulfill all requirements to Aage Vestergaard Larsen A/S, Dansk Affaldsminimering ApS, and Quantafuel A/S. These companies are specialized in different types of recycling, and can subsequently all be partners with I/S Reno-Nord without being in conflict. They are furthermore also companies I/S Reno-Nord have already expressed interest in.

> "No, he *[Franz Cuculiza, CEO of Aage Vestergaard Larsen]* have announced that he wants HDPE, and PP, and PET, where of I assume we'll have success with PE *[HDPE]* and PP, but I'm sure he wouldn't want PET, and then we're back to having to handle the rest another way, and that's where Quantafuel in Skive comes into the picture. If we say that Quantafuel in Skive arrives, then we've handled all the foil. It'll be utilized *[Energy recovery]*, but it's better than nothing." - Henrik Kirkegaard (Translated from Danish)

Combined with the already vested interest from I/S Reno-Nord, particular in the projects and initiatives currently being explored by Quantafuel A/S and Dansk Affaldsminimering ApS, these companies have been selected for further exploration of possible partners in a Public Private Partnership perspective of I/S Reno-Nord.

5.2.2 Aage Vestergaard Larsen A/S

Aage Vestergaard Larsen A/S (AVL) is allegedly northern Europe's largest plastic recycling company, based in Mariager, Nothern Jutland. The company is specialized in regeneration, grinding, fine grinding and compounding of plastic waste. They mostly work with PP, PE, PS and ABS as well as the more technical plastic types such as: PA, POM, PET, PBT (Aage Vestergaard Larsen A/S, 2017).

AVL is currently exploring the possibilities of a test facility, designed to handle dirty plastic waste, including household waste, as a part of preparing it for recycling. However establishing a full scale facility is linked with economical risks, partly due to the value of the plastic waste, but also partly due to the quantities available, see section 5.2.

In relation to the public-private partnership case, there are opportunities for I/S Reno-Nord to increase the quality of their sorted/recycled household plastic waste, that is currently having some issues with the quality which affects the value. By cooperating with AVL, I/S Reno-Nord can increase the quality of the waste, and ensure its used in an environmental sensible manner, and can guarantee a large quantity of plastic waste for the test facility. As AVL makes high quality pure plastic granulates and not mixed granulates, the recycling is considered primary, see section 2.4.1. This is due to there being no degradation. It makes AVL a very desirable partner in an environmental perspective.

5.2.3 Quantafuel A/S

Quantafuel is a Norwegian company specialized in turning plastic waste into fuel, such as synthetic diesel.

> "Quantafuel's core technology is catalysis. Quantafuel's proprietary catalytic systems are tailored to fit different chemical processes converting materials containing low-value carbon into high-quality synthetic fuels." - (Quantafuel, 2017a)

Quantafuel's technology is based upon the Fischer-Tropsch synthesis process. Quantafuel describes the process as a continuous process of converting waste plastic into synthetic low-carbon fuels, through pyrolysis and metal catalysts under high temperatures and in the absence of oxygen (Quantafuel, 2017a).

> "The molecular structure of waste plastic is close to ideal for conversion to synthetic fuel, with C-H (Carbon-Hydrogen) ratio of 1:2, almost identical to the C-H ratio in alkane fuel molecules. The catalytic system helps to ensure that the alkane fuel molecules formed will

> meet the desired specifications. From 1 ton waste plastics the process will yield 700-900 liter fuel dependent on feedstock quality." - (Quantafuel, 2017a)

Furthermore according to Hanne Risgaard from Quantafuel A/S, the diesel will be more environmental friendly during its use as well.

> *Translated from Danish:* "You need to know, that when you're driving with it [Quantafuel A/S synthetic diesel], there will be 50 percent less NOx in it, and there is no sulfur, so it's a much cleaner emission from it" - Hanne Risgaard, Environmental Manager of Quantafuel A/S

Combined with the reduction of CO_2 compared to conventional diesel production, it will be an environmental beneficial method of using the plastic waste.

> *Translated from Danish:* "Now we're saying 90 percent lower CO_2 emission compared to the production of conventional diesel." - Hanne Risgaard, Environmental Manager of Quantafuel A/S

Quantafuel has business cases and developing projects in three countries:

- **Oslo, Norway**

  Quantafuel is currently working on a plant in Nes municipality, just outside Oslo, Norway. Once established it will have the capacity of turning 30 tons of plastic waste a day into 8 million of liters of synthetic diesel.

- **Skive, Denmark**

  Quantafuel is part of the GreenLab industrial park in Skive, Denmark. GreenLab Skive is an innovative project comprised of 17 partners, companies, universities, and public actors. It will be located in a designated energy and resource crossroad. The purpose is to create one of Europe's leading centers for renewable energy. Quantafuels part of this project will be to source plastic waste from local suppliers and produce oil based fuel, such as diesel. Once fully established, the plant will have the capacity of 60 tonnes of plastic waste per day, which will produce more than 15 million litres of fuel a year.

- **Sonora, Mexico**

  Quantafuel's project is in the state of Sonora, Mexico, with a small scale facility capable of testing the conversion of plastic waste into fuel in a real-life setting Quantafuel (2017b).

This makes Quantafuel a possible partner capable of processing the sorted plastic waste from I/S Reno-Nord, that has become more difficult to find buyers for, due to quality, and the current lack of market drivers. However as the recycling method used is a chemical method to turn the plastic into synthetic fuel, it is a tertiary recycling method, see section 2.4.1. This is only considered slightly better than incineration which is being used on large parts of the plastic waste stream.

5.2.4 Dansk Affaldsminimering ApS

Dansk Affaldsminimering ApS (DAM) is a waste management company in Langå, Mid Jutland. They recycle approximately 1200 tonnes of plastic waste from companies a year. In 2017 they build a washing facility designed to wash organic waste off from plastic waste. They envisioned that when running at full

capacity would recycle 5000 tonnes of plastic waste a year, including the waste recycled without the washing facility. Randers municipality have expressed great interest in a partnership, regarding their collected household plastic waste, as it would otherwise be incinerated (Olesen, 2017). Owner Kim Dalsgaard say following about their business model;

> *Translated from Danish:* "In 2011 we started to look at waste that could be found in incineration and landfill. We have made many different things from it. We've made everything from cable granules, plastic from it, that's landfill. We have made bottles, we have made our own molding, and Dansk Affaldsminimering, they simply put, try to gain more value from this plastic. In short, we have tasked ourselves with household plastic that has been collected and built a washing facility for it, in order for these municipalities here to have someone to deliver it to." - Kim Dalsgaard, Director of Dansk Affaldsminimering

The type of recycling being made at DAM is secondary recycling, because in the recycling process there is a degredation of the plastic, and therefore the quality of the plastic is lower, and affects the properties of the material, as it is described in section 2.4.1. This happens because it is not completely the same polymers being recycled. Kim Dalsgaard describe more about how they see themselves as a business, and they want to be specialized in recycling mixed plastic her;

> *Translated from Danish:* "They have some things from their conveyorbelt sector, where we talked that we would like to have some of their things. Because it's waste. This is something that goes straight to incineration from the sorting facility. "..." That's where we start to be great. That's where we'd like to go. There's some who can recycle HDPE canisters. We can do that too, we'd really like to as well, but if we can more than that, then it's better to send these canisters to someone who's really good with canisters. It may be that it's not in Denmark, but maybe in time. It's the same with the PET bottles, there's some out there with some large plants that are really great at it. We'd like to be good at the bit more mixed fraction. It would be much easier to take the HDPE canisters, but we can't just do it. Could we do it, then it would be easy, then we'd have solved the problem. We have this mixed fraction we want to get up and running, and that's what we are trying to design our system to." - Kim Dalsgaard, Director of Dansk Affaldsminimering

The quote shows how DAM see their role in the recycling business, and how they can contribute to recycle some of the unidentified material from the sorting process at I/S Reno-Nord's sorting facility, which right is incinerated. According to both I/S Reno-Nord and DAM there is an considerable amount of plastic in this fraction. Therefore DAM can see some potential in this collaboration between the two companies. According to Kim Dalsgaard this partnership is requiring something from both parties, and it is not just a purchase-sales relationship. He says following about it;

> *Translated from Danish:* "So we have to get started. They [I/S Reno-Nord] also have to collect it all, as it is now. But we also have to return to them and say *'listen, this can't continue in the system. Don't collect it up or remove it away, then it can continue in your process'*" - Kim Dalsgaard, Director of Dansk Affaldsminimering

He also want to contribute to sorting process, and try to improve it by giving feedback to I/S Reno-Nord to get the best possible partnership and create the best possible product.

Chapter 6

Analysis - Policy arrangement

In this chapter we are using the policy arrangement approach to analyze the case and the possible changes happening. This case is analyzed based on the four dimensions of the policy arrangement approach as mentioned in section 4.2. The four dimensions are:

- Actors
- Power and Resources
- Rules of the game
- Discourse

The first two dimensions of the case, "Actors" and "Power and resources" is analyzed in the following section using stakeholder analysis to define which actors are relevant to this case and how the power and resources is distributed between these actors.

6.1 Stakeholder Analysis

The analysis will be done by starting with the *'Actors'* dimension of the tetrahedron using Mitchell's stakeholder theory. First we will designate the relevant actors as stakeholders, and assign them the attributes they possess. Based on data given throughout the report on the stakeholders we can estimate the relevant power and resources at their disposal. Table 6.1 below, shows an overview of the stakeholders and the attributes they possess.

Table 6.1: Given attributes to the stakeholders

Stakeholder	Power	Legitimacy	Urgency	Type of Stakeholder
European Union	**X**	**X**	**X**	Definitive
Danish Government	**X**	**X**	**X**	Definitive
Owner-municipalities of I/S Reno-Nord's sorting facility	**X**	**X**	**X**	Definitive
I/S Reno-Nord	**X**	**X**	**X**	Definitive
Dansk Affaldsminimering		**X**	**X**	Dependent
Aage Vestergaard Larsen		**X**	**X**	Dependent
Quantafuel		**X**	**X**	Dependent
RDB-Plast		**X**	**X**	Dependent
Sortering Facility of I/S Reno-Nord		**X**	**X**	Dependent
Incineration Facility of I/S Reno-Nord		**X**		Discretionary
Government of China	**X**			Dormant
Hauliers				Non-stakeholder

The reason why and why not, the different stakeholders are given the attributes, will be explained in the next subsections.

6.1.1 The Government of China

The government of China have been elected as a stakeholder due to the disruption and power they have over the global plastic waste market. China have closed the market for various solid waste, including plastic. This caused a disruption in the current status quo, which boosted the current discourse of reaching more environmental friendly approaches, to become more relevant than ever.

- **Power**
  - This attribute was assigned to the government of China, as it is capable of influencing the discourse of waste management companies in the EU.
  - We define this as a regulatory power, because the the Chinese government has the power to affect the case by making changes in the legislation regarding importing plastic waste from Europe. As mentioned earlier, this have had an impact on the plastic waste market.
  - The Chinese government also possess discursive power, as their change have had a huge impact on the way plastic waste is being dealt with, because of their plastic waste import ban.
- **No Legitimacy**
  - This attribute was not assigned to China as they have no "risk" or claim on the recycling of plastic waste in the EU or the case of I/S Reno-Nord.
- **No Urgency**

  - They do not have urgency or a pressing need for increased recycling of plastic waste in Denmark or from I/S Reno-Nord.

The given attributes to China means they are a dormant stakeholder. While having the power to influence things they remain passive, and will in this analysis only be given a brief amount of attention.

6.1.2 European Union

The European Union (EU) is a stakeholder as it is the one instituting the directives requiring its member states to reach more than 50 percent recycling of plastic in 2030. This have caused the various national actors to have begun implementing various regulations or strategies in order to reach these targeted goals. The EU is given the following attributes;

- **Power**
  - The EU is capable of forcing its member states, to implement laws, directives, regulations, etc.
  - Have large amounts of resources at their disposal they can fund environmental projects, such as researching eco-design. This can be seen by for example, the Horizon2020 project
  - We define the power of the EU as a regulatory power, because it have the power to change the legislation regarding plastic waste and the recycling of this.
  - The EU's power can also be described as discursive as they are able to make strategies such as the plastic strategy, which affects the discourse, and how focus of recycling of plastic much more present.
- **Legitimacy**
  - Long standing attempts at improving environmental aspects in its member states
  - Their promotion of circular economy
  - Increased chemical restrictions in plastic due to health concerns
  - Their objective goals of increased recycling with the plastic strategy
  - Their promotion of eco-design
  - Their campaign for reduced marine litter, including plastic litter
- **Urgency**
  - Their circular economy strategy focuses on the economic benefits, here among better resource efficiency, and stronger competitiveness of European companies

The EU possess all three attributes which makes them a definitive stakeholder in the network. Much attention are given to the EU by decisionmakers, especially because of their recycling goals which member states needs to achieve by 2030.

6.1.3 The Government of Denmark

The various governments of Denmark throughout the past several years, on both the right and left, have adopted several strategies based upon various EU directives and strategies, including the Circular Plastic Economy by the EU. These strategies requires massive investment and dedication by public institutions as they are even more ambitious than the European Union's goals. This is partly due to a desire to be a frontrunner, and sell the know-how to other member states later on. This means they contain the following attributes;

- **Power**
  - The Danish government is capable of enacting legislation, regulations, fund, or tax various initiatives that can help, increase, or provide solutions to plastic recycling.
  - Can provide incentives for increased recycling on both the private as well as the public sector.
  - The power the Danish government posses is defined as a regulatory power, because it has the power and ability to change legislation regarding plastic waste and the recycling of it.
  - The power of the Government of Denmark can also be seen as discursive as the like The EU, is able to make strategies, which can influence the discourse as they did with the resource strategy, where recycling became more present, and put more focus on the topic.
- **Legitimacy**
  - Denmark have been known for being a frontrunner in environmental initiatives, including recycling. 44 percent of household waste is recycled, but most of it is non plastic (Wanscher, 2017). As such steps are taken to increase recycling of plastic waste which provides legitimacy to this stakeholder.
- **Urgency**
  - The government is bound by EU regulations, laws, and directives, and as such must comply, even though the plastic recycling goals are not binding.
  - It has a vested interest in increased competitiveness of Danish firms.

This stakeholder possess all three attributes which too makes them a definitive stakeholder. They are capable of enforcing their will upon other actors in the network. With the legitimacy and urgency they have enough vested interest to act, and their demands must be addressed by the other actors of the network. As the state, they are enacting strategies and legislation based upon the European strategies and directives, in order to reach target environmental objectives.

6.1.4 Owner-Municipalities of the Sorting Facility

The owner-municipalities of the sorting facility are given objectives, goals and resources from the Danish government. For this case, the municipalities of Jammerbugt, Mariagerfjord, and Aalborg Municipality have invested in I/S Reno-Nord and their sorting facility in order to reach some of the recycling goals set by the resource strategy "Danmark uden affald". The main municipality of this is Aalborg Municipality in which I/S Reno-Nord is located.

- **Power**
  - Municipalities have control over I/S Reno-Nord as it's a partnership company between multiple municipalities
  - They control the public budget in which they can allocate money to I/S Reno-Nord
  - The power the municipalities posses is defined as a regulatory power, due to their ability to enforce their interest with I/S Reno-Nord
- **Legitimacy**
  - They have made several continuous environmental efforts in the waste department. This includes underground containers, and investing in I/S Reno-Nord's sorting facility
- **Urgency**
  - They have urgency as they need to reach objectives passed to them by the Danish state

The attributes they possess makes them a definitive stakeholder. They need to reach goals and targets passed to them by the government, and have the power and legitimacy to do so.

6.1.5 I/S Reno-Nord

I/S Reno-Nord is the basis for this case work, and thus is the starting point of the network. I/S Reno-Nord *"produces"* HDPE, LDPE, PP, PET, and mixed plastic foil, in which they need to find buyers capable of recycling it, see section 5. The analysis is thus made on the basis of who are capable of recycling the types of plastic waste produced at I/S Reno-Nord. The stakeholder I/S Reno-Nord have been divided into three, as the two subgroups, the Incineration Facility, and Sorting Facility, operates independent of each other and have a small conflict of interest regarding the waste.

Figure 6.1 shows a section of the network, and how I/S Reno-Nord can be perceived as three different actors. The Sorting Facility and Incineration Plant are both internal stakeholders of I/S Reno-Nord. This is due to that the plastic waste they are unable to sort, sell, or stockpile are disposed through incineration.

The stakeholder I/S Reno-Nord possess the following attributes;

- **Power**
  - Capable of selecting who to send the plastic waste
  - Are the only waste management company of household waste in the area
  - Have political and financial backing
  - The power I/S Reno-Nord posses is defined as a relational power, because they are in control of the two sub-divisions
  - They have relational power as they control the municipal waste flow, which they can sell to the other potential stakeholders
- **Legitimacy**
  - Is the only receiver of household waste in Aalborg and the area around

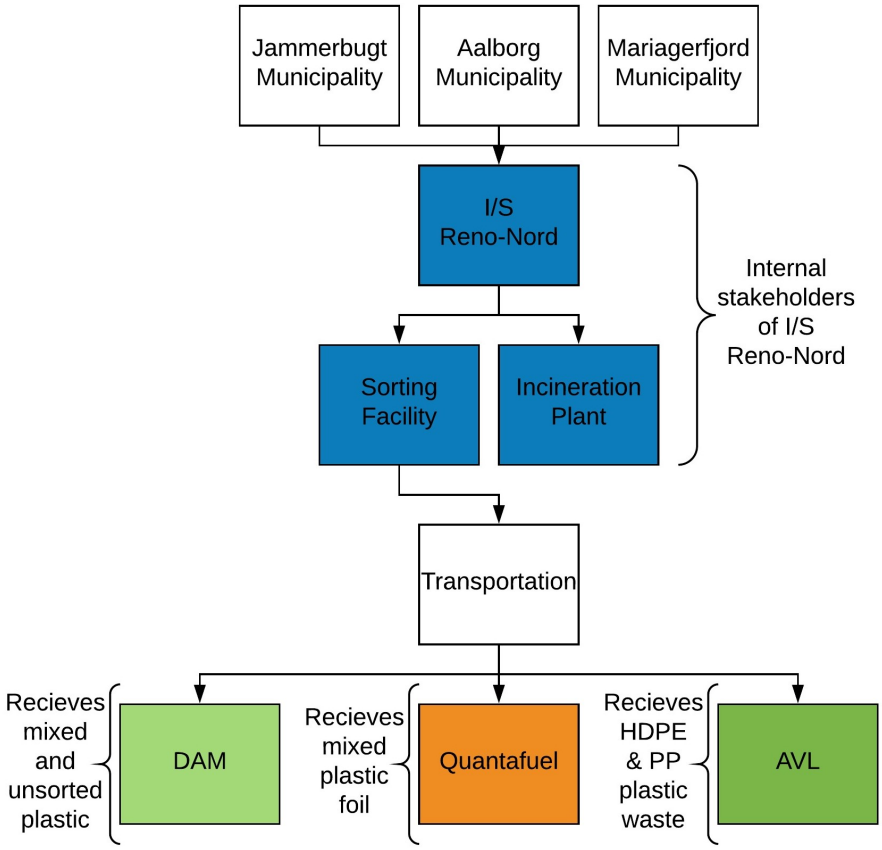

Figure 6.1: Diagram of the waste flow of sorted plastic

  - Handles the plastic waste from households

- **Urgency**
  - Needs to reach the 2030 goals
  - Are currently stockpiling a large part of the sorted plastic waste

Like the stakeholders presented beforehand, I/S Reno-Nord also possess all three attributes which makes them a definitive stakeholder. While I/S Reno-Nord are a definitive stakeholder like the Danish state, they are considerably less influential in the network. They control a large part of the municipal waste flow, and can make their own strategies and decisions, but the goals are set by other stakeholders.

6.1.6 I/S Reno-Nord Sorting Facility

The Sorting Facility is a sub-division of I/S Reno-Nord. They sort the collected plastic waste into four various plastic fractions, and a residual waste fraction, which the machine have been unable to identify or is an uncommon plastic type. Their attributes are;

- **No Power**
  - They do not possess power as they are unable to force their will through. They remain bound by whatever I/S Reno-Nord decides

- **Legitimacy**
  - They have been tasked with sorting the plastic waste
  - They have continually improved the purity of the sorted plastic waste
- **Urgency**
  - Unable to find a buyer for all the waste fractions, and are forced to either stockpile it, or burn it

The Sorting Facility is a dependent stakeholder, as they are unable to carry out their own will, and depends on other stakeholders or managers within the company. They can advocate and promote their interests and ideas, and by getting a stakeholder with power to adopt the same ideas or interest, have a large say in decisionmaking in the network.

6.1.7 I/S Reno-Nord Incineration Facility

The Incineration Facility is a sub-division of I/S Reno-Nord, just like the Sorting Facility is. They incinerate waste in order to generate heat and energy which is consumed by the citizens of the municipality.

The Incineration Facility does not lobby for burning the plastic, however they will in the future require more waste to run the facility at optimal economical cost, than they get in the municipality. Acoording to Environmental manager of I/S Reno-Nord Henrik Kirkegaard it could even be a possibility to import huge amounts of waste to incinerate, because they could lack waste to incinerate in the future. He states following;

> *Translated from Danish:* "... we have to operate with incinerator 3 [Normally Reno-Nord operates with incinerator 4] and for economy reasons Reno-Nord are interested in running fully with incinerator 3 in September and March and with the quantities we have there we have to import hundreds of thousands of tons of waste" [...] "We have a clear interest. I think we are going to import lots of waste here in 2018 and 2019." - Henrik Kirkegaard, Environmental Manager of I/S Reno-Nord

Furthermore the most economic solution to the waste collected by I/S Reno-Nord is incineration.

- **No Power**
  - Like the Sorting Facility, they don't possess power, as they too are under direct management of I/S Reno-Nord
- **Legitimacy**
  - They have legitimacy, as they need large amounts of waste to burn to run the incineration facility at optimal efficiency, and cost
  - The sorted plastic waste, they are unable to stockpile or find a buyer for will have to be incinerated
- **Urgency**
  - They don't possess urgency as whatever solution found will have little to no impact on their processes

The Incineration Facility is a discretionary stakeholder. They can safely be ignored by decisionmakers as they have no power to enforce their claim, nor do they have any urgency to need to.

6.1.8 Aage Vestergaard Larsen A/S

Aage Vestergaard Larsen (AVL) is a large plastic waste management company, specialized in primary plastic recycling, i.e. recycling with no degradation. They are capable of managing the HDPE, PP, and PET plastic waste from I/S Reno-Nord.

- **No Power**
  - AVL does not possess power as they are unable to demand plastic waste from I/S Reno-Nord. Their only way to gain access is to offer the best price and/or service.
- **Legitimacy**
  - They recycle plastic waste with no degradation
  - They have initiated several recycling focused initiatives, such as workshops, partnerships, and research and development projects
  - Have a test washing facility with the possible ability to remove impurities from the household plastic waste
- **Urgency**
  - They possess urgency as they can use the plastic waste from I/S Reno-Nord to produce new granulate in which they can sell

The attributes of AVL makes them a dependent stakeholder. They are dependent on offering the best deal to I/S Reno-Nord as they cannot enforce their claim on the waste in any other way.

6.1.9 Dansk Affaldsminimering ApS

Dansk Affaldsminimering ApS (DAM) is a small waste management company. Their method of recycling includes a degree of degradation, as the polymers are mixed with similar polymers, as the washing facility separates based on the polymers buoyancy in water. The various polymers then group together based on their buoyancy, where some float, others slightly sink, and some drops to the bottom. However some polymers have very similar buoyancy which groups them together when skimming the different layers of water.

DAM have shown interest in the mixed plastic that I/S Reno-Nord's sorting facility cannot identify. With the washing facility DAM will be able to improve the quality of the waste to such a degree that it can be recycled, but still with some degradation. DAM have a buyer for the mixed plastic, that will use it to produce pallets.

- **No Power**
  - DAM does like AVL not possess power as they too can't enforce their claim
- **Legitimacy**

  - Is capable of recycling the plastic waste of I/S Reno-Nord, though with some degradation
  - Have a washing facility that can increase the quality of the plastic waste from I/S Reno-Nord
  - Have experience with handling household plastic waste
- **Urgency**
  - They possess urgency as they can use the plastic waste from I/S Reno-Nord to produce their products with

DAM is a dependent stakeholder, for the same reason AVL is.

6.1.10 Quantafuel A/S

Quantafuel A/S is a Norwegian company that are currently building a facility in Skive, Denmark. They are specialized in turning plastic waste into synthetic diesel. They have shown interest in most of the plastic waste from I/S Reno-Nord, as they are capable of turning it all into synthetic diesel, with little need for fine sorted specific types of plastic waste.

- **No Power**
  - They do not possess power as they can't force I/S Reno-Nord to sell their waste to them
- **Legitimacy**
  - Capable of recycling all plastic waste, however their method of recycling may not be considered actual recycling according to the EU standards
- **Urgency**
  - They need large amounts of plastic waste for their facilities, in which the waste from I/S Reno-Nord is a good candidate

Quantafuel A/S is a dependent stakeholder for the same reasons as AVL and DAM. They are unable to enforce their claim.

6.1.11 RDB-Plast GmbH

RDB-Plast GmbH is the current buyer of some of the high quality plastic waste I/S Reno-Nord is capable of selling. They are a German based recycling company. If I/S Reno-Nord establishes new partnerships with Danish firms, RDB-Plast GmbH stands to lose.

- **No Power**
  - They have no power as they can't enforce their claim, or demand that I/S Reno-Nord keeps the status quo
- **Legitimacy**
  - They have legitimacy as they are a recycling company
  - They are currently handling some of I/S Reno-Nord's plastic waste

- **Urgency**
  - They have urgency as they're currently handling some of the waste, and possibly would like more of it.
  - It is in their interest to keep the status quo

RDB-Plast GmbH is a dependent stakeholder. They can't enforce their claim, but would like to keep the status quo as they risk losing access to I/S Reno-Nord's waste if they make new partnerships with Danish firms.

6.1.12 Hauliers

Hauliers transport the waste from I/S Reno-Nord. The haulier used changes on day to day basis based on supply and demand.

> *Translated from Danish:* "That varies. It depends completely on the arrangements, and where it needs to go. No, there is no fixed agreements, because some of them that transport in Denmark, won't transport to foreign countries, so we can't really use that. There is free procurement." - Henrik Kirkegaard, Environmental Manager of I/S Reno-Nord

- **No Power**
  - They don't possess power as they can't enforce their claim. I/S Reno-Nord selects hauliers on a day to day basis, which means no one have monopoly on transportation for I/S Reno-Nord
- **No Legitimacy**
  - They do not have legitimacy as they are not focused on recycling, but only transportation
- **No Urgency**
  - They have no urgency as any changes made will still require transportation

Hauliers are a non-stakeholder based on their attributes. Whatever changes made will not have any large effect as they still require transportation. However the transportation distance may be shortened considerably.

6.1.13 Interim Conclusion of the Stakeholder Analysis

Through the stakeholder analysis we have mapped the network that would exist if I/S Reno-Nord made a public-private partnership with three different waste management companies, each using a different business model, and method of recycling, see section 2.4.1. The stakeholders in the network have considerable difference of power, but the power between I/S Reno-Nord and the possible partners are within reasonable levels of each other. The EU and the various public institutions governing governing I/S Reno-Nord have both regulatory power, and discursive power. Through their regulatory power they can set the rules of the game, and through discursive power they can push the entire waste management business towards a more environmental conscious future, which will be analyzed more in section 6.3.

I/S Reno-Nord is a 'definitive' stakeholder, and the potential partners are 'dependent' stakeholders. They are dependent on whether I/S Reno-Nord is willing to sell the waste to them, instead of shipping it abroad,

to for example RDB-Plast GmbH as they have done so far. However despite being a dependent stakeholder they don't need the waste from I/S Reno-Nord to maintain their business model, which balances the power difference out to some degree. This is important as, described in section 2.8, large power difference can be detrimental to a partnership.

6.2 Rules of the game

The rules of the game is the legislation on a national as well as supranational level, governing waste management and the associated industry, both public and private. This section is divided into supranational level, and national level.

6.2.1 Rules of the Game On a Supranational Level

On a supranational level the EU have issued directive 2008/98/EC of waste in 2008. In article 4 paragraph 1 it starts with the following;

> "1. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:" - (European Union, 2008)

The waste hierarchy is described in section 2.4 of this report. It is the environmental prioritization of actions when managing waste. The EU directive furthermore says in paragraph 2 that;

> "2. When applying the waste hierarchy referred to in paragraph 1, Member States shall take measures to encourage the options that deliver the best overall environmental outcome." - (European Union, 2008)

Thus all member states works from, or at least ought to work from the basis of the waste hierarchy when making waste management legislation. The impacts are then noticeable on a sub national level where waste management companies applies the waste hierarchy to their own decision making as well. However the directive also defines what recycling is, which is key for one of the selected possible private partners for I/S Reno-Nord. The directive defines recycling as;

> "'recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations;" - (European Union, 2008)

This is a problematic issue, as Quantafuel A/S is using plastic waste to make synthetic diesel, which by article 3 paragraph 17 of the EU directive on waste is not recycling. However Environmental Manager of Quantafuel Hanne Riisgaard argues that it is not fuel;

> *Translated from Danish:* "But as you can see, we have a high quality product. If you take it a step further, a subject you've touched upon yourselves "as fuel" [EU definition of recycling], if you look at the law about car tires, there pyrolysis have been accepted in regards of monetary compensation for things that are recycled, where you can get a black carbon product with a value equivalent to virgin products, then it's recycling, or if you have an oil product with some

> specific requirements, then it's also recycling" - Hanne Risgaard, Environmental Manager of Quantafuel A/S

Despite these arguements from Quantafuel A/S it's doubtful the EU nor the Danish government will see it as recycling and as a possible part of reaching 50 percent recycling by 2022 or 2030.

6.2.2 Rules of the Game on a National Level

On a national level, the rules of the game in Denmark, is the *"Affaldsbekendtgørelsen"* (translated: Waste Order). It's a 130 pages long document which outlines the rules governing the handling of waste in Denmark. Many of the regulations are not relevant for this casework but a selected few, which will be explored further in this sections.

Waste Order §12, part 1; states that municipal waste handling must be done in accordance with the following waste hierarchy; Re-use, recycling, other recovery, disposal (Retsinformation, 2012).

This waste hierarchy stated by the Danish legislation does unlike the EU, not include waste prevention. This causes an issue as the best environmental choice would be waste prevention, but is not given attention due to how public companies are "forced" to make choices.

Waste Order §24, part 1; states that the municipal council must establish arrangements for waste produced by household or companies in the municipality (Retsinformation, 2012).

Waste Order §25 part 1); states the municipal council must make arrangements for collection of household waste (Retsinformation, 2012).

This means the only collector of household waste is a municipality controlled stakeholder.

Competition Law §11 a, part 1; states that aid granted through public funds for certain types of business activities be terminated or repaid, if favouring a specific company over others (Retsinformation, 2018).

This is cause for concern for I/S Reno-Nord as some of their activities as well as future possible partnerships with private actors can be accused of being anti-competition by other companies.

6.2.3 Interim Conclusion of Rules of the Game

The rules on a supranational and national level are aligned in most areas, but the different waste hierarchies in use is detrimental for environmental decisionmaking as waste prevention is given little to no attention by public companies in Denmark. Furthermore Quantafuel's businessmodel is up to debate whether its recycling or other recovery which may cause I/S Reno-Nord to disregard them as a possible partner. The monopoly on household waste leaves I/S Reno-Nord in a strong bargaining position as waste has gone from being *"waste"* to a resource in recent years (Energistyrelsen et al., 2010). However combined with the anti-competition laws it is difficult to use that resource in conjuction with a partnership without being accused of being anti-competition.

6.3 Discourses

The discourse dimension refers to the views and narratives of the actors involved, which could be norms, values, definitions of problems and approaches to solutions, as it is mentioned in section 4.2 (Liefferink, 2006). In this case the focus has been on the strategies from large actors involved in the recycling process of plastics. In the problem analysis, in chapter 2, the strategies of some of the actors were reviewed. One of the most influential actors in the field of recycling, the EU, launched a new plastic strategy in January 2018 as earlier mentioned. The strategy shows how the recycling is a hot topic in toady's society, where especially the plastic waste in the oceans has brought some attention to the topic of plastic recycling.

6.3.1 Design

In the section 6.1 it is also been shown that the EU posses a discursive power, and is able to influence the environmental area as they also have power and legitimacy to create these strategies, which can sway opinions. The focus of the plastic strategy is broad, but the overall target is quite clear; Much more plastic needs to be recycled in the future. The discourse from the EU is widely supported by many actors in the plastic field, which is also shown in problem analysis in chapter 2, and it's further described in section 2.3. The discourse to be more circular and sustainable was strengthen in late 2015, where the EU presented their circular economy package, where a broad range of actions were initiated. The recycling of plastic was a specific topic, and was further elaborated in the EU Plastic Strategy. The discourse started by the EU is supported by the strategies of actors such as the Ellen McArthur Foundation, the Advisory Board for Circular economy in Denmark, The European Recycling Industries' Confederation and the Nordic Council's strategy for recycling, as described in section 2.1.6.

Looking further into the plastic strategy, it shows that a big focus has been put on the design part of the plastic products. As it is now, many of the products in today's market are not designed to be recycled again. This is mainly because the products uses lot of different plastic types, which afterwards makes it very difficult, energy consuming and expensive to dissemble and recycle afterwards. The discourse of better designs of products, is a view, which is backed by a lot actors, see section 2.1. This problem was emphasized as a key issue by professor Arne Remmen of Aalborg University, at the presentation of the plastic academy 'CIRKLA' (Lars Friis Farsøe, 2018).

Both Aage Vestergaard Larsen A/S and Dansk Affaldsminimering ApS also address this problem, and problematize the recycling process, because it's unknown how many different plastic types there are in the waste stream, and how many percentage the plastic is "polluted" with other plastic types. This is a problem, because this will change the properties of the plastic, and makes it more difficult to sell afterwards.

> *Translated from Danish:* "So the challenges of household waste, that, firstly, there are so many different types [of plastic] mixed, that it is extreme." - Gitte B. Larsen, owner of Aage Vestergaard Larsen A/S

The same issue was pointed out by Kim Dalsgaard of Dansk Affaldsminimering ApS.

> *Translated from Danish:* "Then there is multilayer plastic. That is difficult. We would like to appeal that you use the same [material]." - Kim Dalsgaard, Director of Dansk Affaldsminimering ApS

The issue is well known by the recyclers, and shows the need for increased eco-design requirements of plastic products, see 2.1.3.2.

6.3.2 Quality

An issue related to this discourse is about the quality of the product. According to Arne Remmen this has been lacking in the strategies presented by some of the big actors like the EU and the Danish government in their resource strategy "Danmark uden affald". He says following about the topic:

> *Translated from Danish:* "...But if you do not get in touch with designer and the retail business, you'll continue have a lot of trouble, so you can see the bales [with plastic foil] piling up at Reno Nord. The more mess, the more difficult it is to get quality in recycling. That's where I also think the Danish Environmental Protection Agency and the EU come to Short because you only focus on volumes, rather than focusing on quality in recycling. Thus, if there is an economy in recycling, we also have to ensure upfront that there is quality in it. That there is actually something worth saving. Some of that plastic foil, that's the fact that when I'm in the kitchen, it's going in the incineration waste, because there's no need for them to have trouble with it at the sorting plant [at I/S Reno-Nord]." - Professor Arne Remmen

This issue is also identified and is also a part of the EU plastic strategy, where several initiatives are suggested to improve the quality of the recycling. This is further described in subsection 2.3.2. Aage Vestergaard Larsen A/S also emphasized the same issue, because it is complicating the recycling process of the plastic as earlier mentioned. They state the following:

> *Translated from Danish:* "With our [business model], you can recycle again and again, and you can really continue doing it as long as the fraction is clean. But when you have what I usually call a mixing abuse, I know it sounds a bit harsh, but when you do it in that way [mixing of plastic types] it's a one-time only, because the next time it gets into the waste stream then it's impossible to measure what the plastic contains of, and the quality [of the plastic] is just too bad." - Gitte B. Larsen, owner of Aage Vestergaard Larsen A/S

6.3.3 Interim Conclusion of Discourse

The analysis of the discourse in the shows that the lack eco-design in plastic products, where several actors points out this as a huge barrier for more recycling. This can also seen as a barrier cooperation between I/S Reno-Nord and other actor such as Aage Vestergaard Larsen A/S and Dansk Affaldsminimering Aps because these companies requires a ceritain quality of the plastic to recycle. This lead another topic in the discourse in this case, where several actors pinpoint the the focus should be more on the quality of the recycled plastic, and not only the solutions which focuses on the quantitative apects of recycling of plastics. This is also seen as a large problem, and barrier for more recycling. Because it's easier to recycle plastic of a high quality.

Chapter 7

Discussion

The purpose of this chapter is to describe findings and results of the project, and afterwards it will be followed by a discussion of the barriers and challenges of the study to explore where the study could be improved or expanded upon.

7.1 Discussion of theory and methods used

In this section we will discuss some of the different methods and theories used in this report.

7.1.1 Risk of Bias From Interview

Interviews have been used to gather data from the some of the stakeholders, about themselves. This does carry a considerable risk of flawed data, as they attempt to sell themselves as the best possible option. However the information needed to evaluate whether they were a possible partner were not accessible through other sources. In order to minimize self-reported bias, we selected to ask them describe their own business-model, and how it differentiated from the other selected possible partners. This gave us a picture of how they viewed each other, and surprising found that all but Quantafuel A/S did not see each other as actual competitors as they were specialized in different ways. Quantafuel A/S however claimed that Aage Vestergaard Larsen A/S saw Quantafuel A/S as competitors, something we were unable to confirm. Furthermore the claim by Quantafuel A/S that they are recycling is a especially dubious point, and as such they as a possible partner have also been given the lowest priority. However it's still a better solution than incineration, however the current legislation does not take that into account, which is another point that will be discussed more later.

7.1.2 Selection Criteria For Partners

A set of criteria we set up for selecting the stakeholders for a potential partnership with I/S Reno-Nord, but Quantafuel A/S does not fully comply with them, yet are still in consideration for a partnership. The business model of Quantafuel A/S will most likely not be considered recycling by the definition of recycling made by the EU commission, see section 6.2.1. As such they cannot help I/S Reno-Nord reach the 2022 recycling goals, see section 2.5, yet they have still been selected due to their ability to handle

the residual waste that non of the others can. As mentioned before we still consider this a better option than incineration as it's a tertiary recycling method of plastic, see section 2.4.1. According to Hanne Risgaard from Quantafuel A/S this method of producing diesel saves somewhere between 90-98 percent of CO_2 compared to traditional production methods of diesel, see section 5.2.3. As such it will still be an environmental improvement, and have been included in this study.

7.1.3 Stakeholder Theory As a Tool For Finding Actors

We've used Mitchell's stakeholder theory to map the relevant actors and assign them their power and resources. We elected to do that as Mitchell's stakeholder theory provides a definition of power; the stakeholders ability to influence decisionmakers and carry out its own interests. This helped us create an understanding of the power dynamics within the network as a part of evaluating them as partners. This evaluating through the stakeholder analysis included the points in section 2.8.

- Partner appropriateness: The issue of finding buyers of I/S Reno-Nord was put at the center, not I/S Reno-Nord as a company.
- Partner credibility: The attributes 'legitimacy' and 'urgency', combined with exploring their business models, revealed how and why the partners have credibility.
- Power balance: It mapped the power balance in the network, which is an important part as large power differences could be detrimental.

Just mapping the actors in the network, would not have provided the same information as policy arrangement does not provide criteria for partner appropriateness or credibility, and have a very broad view of what constitutes power.

7.2 Innovation through Public-Private Partnership

The changes that would be made if the proposed partnerships were implemented would be operational optimization, see figure 2.2, as it would be doing the same things all the stakeholders currently are, just better. In order to move a step further up the innovation dimension of partnerships to 'Organization transformation', an option would be to have the different partners, not just cooperate with I/S Reno-Nord, but with each other as well. Recycled plastic degrades each time it's recycled, and will need chemical adjectives in order to retain its properties. Another option of ensuring it retains some of its properties is by mixing types of polymers, but that lowers the quality of the plastic. While Aage Vestergaard Larsen A/S only deals with non mixed plastic, it could be an option to send it to Dansk Affaldsminimering ApS once it's of reduced quality. The pallets made of mixed plastic will at some point be unfeasible to recycle as well and at that point the pallets can be send to Quantafuel A/S, and be used for creating synthetic diesel.

Another option could be increased feedback from the partners to I/S Reno-Nord regarding the quality of the waste, and suggestions on how to improve it, something Kim Dalsgaard himself suggested, see section 5.2.4. However at the moment the current discourse isn't ready for this to be implemented yet. As such the best approach will be to take incremental towards a steadily more integrated value chain, with the circular economy perspective in mind.

7.3 Lack of economical perspective

This study have disregarded the economical aspect. The reason for this choice have been the lack of information regarding the prices, as this is a future possibility, and the stakeholders interviewed have been reluctant to speculate in prices of the waste. This means despite the environmental and practical aspects of it is sound, it is unknown whether or not it will be economical feasible or even profitable. Furthermore it's an aspect outside our field of expertise, and is best left to the relevant stakeholders to negotiate and research.

Chapter 8

Conclusion

Based on the findings in the problemanalysis, the following problem statement, and subquestions were made.

8.1 Problem Statement

How can public-private partnerships be useful in optimizing the recycling of household plastic waste?

8.1.1 Research Questions

1. How can a public-private partnership with I/S Reno-Nord be implemented?
2. What are the barriers and benefits of implementing public-private partnership in regards to the recycled plastic of I/S Reno-Nord?

This report have attempted to answer these questions, and based on the interim conclusions made throughout the analysis following the four dimensions of policy arrangement and the discussion, it can be concluded on the basis of the criteria of good partnership that;

- All the partners selected are relevant, as their business model is based on handling plastic waste, in order to produce a product that they can sell.
- All the partners is willing to put the issue of how to recycle the sorted plastic waste of I/S Reno-Nord at the center, as they understand the reasoning to why I/S Reno-Nord is interested in increased recycling.
- The stakeholders are engaged, and will provide their perspective of the issue, which will help create an understanding and might provide new solutions for the waste. However they all cite the need for better designs of products as the recycling process of household waste is at the moment very complicated. I/S Reno-Nord is not powerful enough to encourage producers to make products more orientated towards easier recycling, but stakeholders such as the EU or the Danish state could, and is to some extend already doing. The discourse encourages a greater focus on quality over quantity, which does not necessarily conflict with the strategies, but as the recycling goals are evaluated through quantity and not quality, it is difficult to change the focus to quality. An option would be

to engage more stakeholders, such as the producers, which could help elevate the innovation level from 'operational optimization' to 'organization transformation'.

- The business models, skills and capabilities of all the partners will compliment each other, as they are all specialized in different ways. While there are some overlaps between their competences, and have overlaps in the waste fractions they have expressed interest in, each stakeholder can handle waste the other two cannot.
- All partners but Quantafuel A/S have shown great credibility as a recycling company. However the debatable nature of the business model Quantafuel A/S as recycling, can end up harm the reputation of I/S Reno-Nord. The rules explicitly states that when waste is used for fuel, it's not considered recycling, and the rules Quantafuel A/S would like to fall under is governing car tires, as such any waste send by I/S Reno-Nord to Quantafuel A/S may not be counted towards the recycling goals.
- The power balance between I/S Reno-Nord and the potential partners are within acceptable limits. The EU and the Danish state have considerably more power than the others, but as they are only indirectly involved it will most likely not be an issue, as the discourse encourages the connected value chain.

As such we can conclude that a public-private partnership will be very possible with Aage Vestergaard Larsen A/S, and Dansk Affaldsminimering ApS, as the conditions necessary to facilitate this already exists. A partnership with Quantafuel A/S might prove to be more difficult as the regulations governing recycling may not consider it recycling. As such Quantafuel A/S as a partner should be approached with caution as it may not end up being a long term solution.

A successful partnership with any of the possible partners will provide I/S Reno-Nord with a long term solution to their recycled plastic waste. If done with Aage Vestergaard Larsen A/S or Dansk Affaldsminimering ApS it will be an environmental improvement, that can provide I/S Reno-Nord with feedback on how to further improve their recycling efforts.

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