CLOSING THE LOOP OF PLASTIC FROM MUNICIPAL SOLID WASTE

- ROADMAP TO AN INNOVATIVE RECYCLING SOLUTION

Nanna Becher Jensen
Aalborg University Copenhagen
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Aalborg Universitet København
A.C. Meyers Vænge 15
2450 København SV

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Supervisor: Stig Hirsbak

Group member:

Nanna Becher Jensen

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Resume:
A big waste resource challenge faced today is how to utilise and sustain the valuable resources within plastic from municipal solid waste (MSW). The use of plastic in production has increased twenty-fold the past 50 years and is furthermore expected to double within the next 20 years, which emphasises the need for finding ways and means to manage this dominating troublesome fraction. Today the MSW plastic collected for recycling is exported to treatment facilities in other countries, where the actual recycling percentage is low and far from satisfying. Additionally, knowledge about what the MSW plastic is recycled into is not accessible for the municipalities choosing this option of exportation.

Recognising the necessity of feeding the valuable plastic resources back into the material loop, thus not solely reaching national recycling targets, a radical transition of the current MSW recycling system should be accelerated. In this project it is analysed how Roskilde Municipality can facilitate this transition, based on following research question:

How can Roskilde Municipality facilitate a development towards increased recycling of plastic from municipal solid waste, and what is potentially limiting the possibility of 'closing the loop' of municipal solid waste plastic in Denmark seen from a municipal point of view?

Public procurement of innovation is emphasised as an optimal means for the municipality to initiate the development of a more ambitious recycling solution, as well as to promote an establishment of a Danish market for secondary MSW plastic. In order to develop the essential innovative recycling solution, a process of public private innovation prior to a tender is analysed, assessed, and discussed. In this three-step process, Roskilde Municipality should collaborate with various relevant private actors, experts, and specialists, with the purpose of ensuring an innovative recycling solution where the quality of the processed MSW plastic reaches the requirements of the private actors in the plastic value-chain, thus with the aim of ensuring actual recycling and up-cycling instead of down-cycling and incineration like provided by the only option available today.

Preface

This thesis is carried out as a part of the 4th Semester on the Master Programme Sustainable Cities at Aalborg University Copenhagen in the period from 1st February to 2nd June 2016.

With this thesis I hope to shed light on one of the largest waste resource challenges currently faced globally, and I hope to emphasise the necessity of finding and initiating means for transitioning the current way of recycling plastic from municipal solid waste.

Thank you to the persons who have contributed with their knowledge, insight, and time. Especially thanks to Stig Hirsbak for supervision, commitment, and advice throughout the process of writing this thesis.

Copenhagen, June 2016

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1 Introduction to the project

Addressing the conflicting challenge of global resource scarcity and large amounts of resources in waste being wasted continuously, the EU acknowledge the circular economy as the recipe for decoupling the amounts of waste being produced from the economic growth (EU, 2011). This means that waste needs to be viewed as and treated like valuable resources, which requires challenging changes in the current procedures of managing and treating municipal solid waste (MSW) in Denmark.

This project specifically focuses on the troublesome fraction plastic from MSW, in which a large recycling potential lies (Plastindustrien, 2015). Today the plastic separated for recycling by the households is exported for treatment in other countries where the actual recycling is questionable and the final outcome is uncertain. In order for Denmark to take a step towards transitioning to a circular economy where the MSW plastic resources are recycled and up-cycled to a higher extend than currently, it is emphasised as necessary to close the loop of MSW plastic recycling in Denmark. In order to do so, various actors across the public and private sector need to cooperate and together establish the required value-chain of the MSW plastic in Denmark. This project takes its point of departure in The Municipality of Roskilde who has decided not to include kerbside collection of plastic in their new waste scheme due to the fact that the only currently available recycling option of MSW plastic is exportation. Based on this, the purpose of this project is to study and analyse, what might create the state of lock-in to exportation and how a municipality like Roskilde can facilitate the development of an innovative recycling solution of MSW plastic that, to a higher extend than currently, focus on the actual outcome of the recycling, and not solely on reaching the national recycling target of 50 % by 2022.

This introduction chapter will emphasise the need of a transition towards increased resource efficiency, specifically emphasising MSW plastic as a troublesome fraction with a high recycling potential. The chapter will give an overview of the current tendencies accelerating a circular economy in the EU and Denmark, and additionally provide a brief overview of the municipal challenge of navigating in a possibly locked-in MSW plastic recycling system. As a potential means for un-locking this system and seeking a more sustainable recycling of MSW plastic, public procurement of innovation is emphasised. Finally the focus of the report will be stressed by the research question.

1.1 The need for a resource efficient transition

Today it is globally recognised that a transition towards increased resource efficiency is necessary if the demands of future generations shall be ensured. This requires the limited natural resources of the earth to be utilised in a sustainable manner, where increasing societal prosperity is not dependent on the extraction of these natural resources. As the European society has experienced growth in wealth and wellbeing, the use of resources has intensified to a level where each individual European annually consume 16 tonnes of materials, of which 6 tonnes are wasted (EU, 2011). Specifically in Denmark, the amounts of MSW per capita have in the period from 1995 to 2013 increased by 43 %, which makes Danes frontrunners in generating waste compared to citizens in the member countries in the EU (Eurostat, 2015). This tendency of an increasing generation of waste is a clear example of the result of the take-make-dispose culture that has dominated the European countries since the industrial revolution and currently still is (Ellen MacArthur Foundation, 2013).

The take-make-dispose culture, characterised by a linear model of resource consumption, has thus both led to an increasing waste production as well as an unsustainable overexploitation of natural

resources. If this tendency is not redirected, the EU estimates that more than two planets are needed in order to sustain our current resource use in year 2050 (EU, 2011). Additional planets would probably be needed when considering both the projection of the world population growth to 9.7 billion in 2050 (UN, 2015), as well as adding the prognosis of the size of the global middle class increasing approximately 2.7 times in the period of 2009 to 2030 (OECD, 2010). Hence, it is necessary to pursue a transition towards increased resource efficiency where the linear model of resource consumption is replaced by a circular model where waste is treated as a resource and fed back into the cycle of production.

Especially plastic is a troublesome fraction both regarding contamination of the global environment and recycling possibilities. Knowledge about the plastic plague is not a novelty, but in the beginning of 2016 global public focus was directed towards plastic waste contamination of the global environment when The Ellen MacArthur Foundation published the report "The New Plastic Economy" (Ellen MacArthur Foundation, 2016). The report reveals that there are over 150 million tonnes of plastic contaminating the oceans today, and if this tendency carries on, the ocean will consists of more plastic than fish in 2050 (Ellen MacArthur Foundation, 2016). Plastic can thus be characterised as today's footprint on the earth (Information, 2016). The plastic contamination of the oceans and nature, reflects a rising demand among consumers both in terms of the before mentioned take-make-dispose culture, but also in terms of a rising use of plastic in production and for packaging (Information, 2016a). The use of plastic in production has increased twenty-fold the past 50 years and is expected to double in the next 20 years (Ellen MacArthur Foundation, 2016). This prediction emphasises the necessity of a transition towards increased resource efficiency, and that the solution to the plastic problem requires a circular thinking where the valuable resources in plastic are recycled and treated as a resource while not compromising with the global environment.

Recognising the need for a change in utilising the resources available in plastic, the following section will examine how the EU and Denmark seeks to accelerate the required transition towards a circular economy.

1.2 Towards a circular economy in the EU and Denmark

Transitioning from a linear economy towards a fully circular economy is a complex task that is not done overnight. It necessitates changes in various aspects of the product value-chain; design of products, production processes, consumption patterns and consumer behaviour, new ways of utilising the waste resources, and new company business models and markets for secondary raw materials that ensure the resources to be up-cycled and not down-cycled (EU, 2015). Thus, transitioning to a circular economy requires long-term strategies and collaboration between all governmental levels, private businesses, and citizens across the entire value-chain of products (EU, 2015). In December 2015 the EU Commission adopted a new and improved circular economy package consisting of an action plan and four legislative proposals on waste. The action plan aims at tackling all stages of a product value-chain, thus not only focusing on handling of waste, but providing a comprehensive framework for establishing a path towards 'closing the loop' (EU, 2015a).

Generally, the EU sets the overall legislative framework of waste management for the member states to follow. Through targets, plans, programmes, and policies the EU determine the direction, prioritisation, and pace of managing the resources from waste in Europe. In relation to this, and as a way to become a European recycling society, the Waste Framework Directive sets the target of

minimum 50 % recycling of MSW by 2020, focusing on the fractions glass, paper, plastic, and metal (EU, 2008). Furthermore, the before mentioned circular economy package proposes to boost the recycling of MSW by setting the target of 65 % recycling in 2030 (EU, 2015b). In relation to this, the Commission proposes a new way of calculating recycling percentages, which additionally emphasises the political agenda for transitioning towards a resource efficient Europe. The calculation of recycled fractions should be based on the waste entering the final recycling process where there is no need for additional sorting in order to be processed into a new product (EU, 2015b), thus calculated based on the output of the sorting. Contrary the current method for calculating recycling percentage is based on the total amounts of collected materials overall (EU, 2008), thus based on the input of the waste.

In Denmark the EU requirement of 50 % recycling of MSW has been implemented in the Danish Resource Strategy introduced in 2013 and the recycling percentage should be reached by year 2022. The fractions included in the national recycling target are similar to the fractions from the Waste Framework Directive; glass, paper, plastic, and metal, and additionally the fractions cardboard, wood, and organic waste are included (Regeringen, 2013). The latest published national recycling percentage of these seven MSW fractions was 28 % in 2013 (MST, 2015), which shows that the amounts of recycled MSW waste need to almost double within the next 6 years.

As mentioned in the previous section, the use of plastic for packaging is increasing, and currently representing more than ¼ of the total volume of plastic being used (Ellen MacArthur Foundation, 2016). Thus plastic for packaging is being the largest single category (Information, 2016a). The EU recycling requirement on plastic packaging is currently 22,5 % by 2008 (EU, 1994), which is similar to the current legislative requirement in Denmark (Miljø- og Fødevareministeriet, 2015). A new recycling target has finally been proposed by the EU as a part of the circular economy package, which is a requirement of minimum 55 % recycling of plastic packaging before 2025 (EU, 2015c). This requirement will challenge Denmark where currently only 34 % of all plastic packaging waste is recycled and 64 % is utilised in incineration plants. The largest recycling potential lies specifically in plastic packaging waste from Danish households, where only 10 % is recycled (Plastindustrien, 2015).

Finding ways towards exploiting this recycling potential is a challenging task that is up to the individual Danish municipalities to solve. Additionally, this challenge is further emphasised considering the EU proposal for a new calculation method for recycling percentages, where only the waste entering the final recycling processes can be considered recycled (EU, 2015b). This new calculation method will presumably lead to lower recycling percentages in Danish municipalities thus the challenge of the task is emphasised even more. The municipal challenge of individually reaching the national recycling targets in a complex waste system is examined in the following section.

1.3 The municipal challenge of navigating in a possibly locked-in waste system

Due to the decentralised structure of the Danish planning system, it is up to the individual municipalities to reach the national recycling targets by planning, implementing, and monitoring the recycling of the MSW. The municipalities are thus facing a large task both in relation to reaching the current recycling targets for the overall MSW, as well as reaching the recycling targets for MSW plastic proposed by the circular economy package, hence finding ways towards exploiting the large potential that lies within this fraction.

The waste system and sector can be characterised and understood as a complex socio-technical system constituted by and involving various interdependent actors of both human and non-human character (Uyarra & Gee, 2013; Corvellec et al, 3013). This web of coalitions between multiple actors, including various infrastructural investments and legislative frames, can have the effect of getting in the way of innovative recycling solutions to emerge. Thus the system can be locked and can prevent an emergence of alternative solutions, which is required in order to redirect towards increased sustainability in waste management (Corvellec et al, 2013). *"Difficulties to escape from a lock-in present challenges for city governance authorities (…) city governance authorities are also facing increasing demands to develop the city toward more sustainability. And such demands often require confronting existing sustainability lock-ins"* (Corvellec et al, 2013).

As mentioned previously, the national recycling targets presented in the Resource Strategy has forced Danish municipalities to plan and establish collection and treatment solutions for MSW plastic in order to reach the target of 50 % recycling within 2022. Since the 1980'ies Danish households have been separating their waste for recycling, which means that there have been established markets for the recyclables, but when it comes to recyclable MSW plastic, a market does still not exist in the optimal way. Currently the MSW plastic sorted for recycling is via municipal waste companies exported to treatment facilities in e.g. Germany or Sweden, but the problem and the fact is that the actual amounts of plastic being recycled are questionable and the recycling percentage is thus very uncertain (Jørgensen, Affaldskontoret, 5.04.2016). The current waste system dominated by exportation of MSW plastic generally lacks transparency. This means that the municipalities cannot be sure about the actual recycling percentage of the plastic when it is exported. Even though the treatment facility promises a certain recycling percentage, it is simply a question of economics; if the prices are low on recycled materials and it is cheaper to incinerate the plastic, this will happen and the municipalities will have no knowledge about this (MSW plastic seminar 7.04.2016, Danish waste company). This is contrasting to the EU vision of a circular economy where the valuable resources in waste should be fed back into the production cycle. Thus, the problem for the municipalities is not necessarily to reach the national recycling targets on the plastic, but rather to find a good, satisfying, and transparent recycling option where the resources in the plastic are actually fed back into the cycle, substituting natural resources, and contributing with economic growth and local jobs. Therefore the focus should be on actually recycling and up-cycling the plastic where the materials are used for equal or higher value purposes rather than the plastic being down-cycled into products with lower value or incinerated, which is currently the case with exportation. Considering that the only currently possible option available is exportation where the transparency of what happens to the plastic is non existing, it can be difficult for a municipality to ensure recycling and up-cycling instead of down-cycling and incineration. Therefore the goal must be to create a closed loop of plastic recycling in Denmark where the plastic is either recycled into similar products or up-cycled into new products that extends the lifetime of the plastic.

In order to redirect this tendency of exporting MSW plastic for down-cycling purposes, it is necessary that the Danish municipalities facilitate and seek alternative and innovative options of treatment instead of choosing the solution of exportation. This is a challenge in many aspects, both because the municipalities need to reach the recycling targets within 6 years, and also because many municipalities are challenged due to size and resources. Additionally, the current waste system constituted by a web of interwoven actors and aspects might limit this redirection, which might force the municipalities to choose the currently available solution of exporting the MSW plastic because there currently is no Danish recycling solution available. Therefore the following section emphasises

public procurement as a potential means for an ambitious municipality to facilitate the development of an innovative recycling solution of MSW plastic where the resources are being fed back into the cycle.

1.4 Public Procurement of innovation as a potential key for un-locking the system

When public authorities are procuring work, goods, or services, they have to put the procurement out to tender. As a way for municipalities to facilitate the development of alternative innovative options of recycling MSW plastic, public procurement is recognised as a means for accelerating an earlier appearance of an innovative solution on the market and thus functioning as a potential key for un-locking the existing system of exportation.

In 2007 a political agreement resulted in the Danish waste sector being re-organised into more liberalisation of company recyclable waste (which will be presented and discussed in chapter 5) with the initial political aim of encouraging the private actors on the market to develop and establish innovative recycling initiatives. The Danish Energy Agency recently published an evaluation of this political agreement, which showed that the market emergence of new innovative recycling solutions has not yet occurred (Energistyrelsen, 2016). For this reason the potential within public procurement of innovation is in this project emphasised as a means towards accelerating the development of innovative recycling solutions that was initially intended with the political agreement in 2007. Public procuring of innovative solutions is a way for public authorities to boost the evolvement of a particularly new market (EU, 2015d). Through public procurement of innovation it is possible for a municipality to set out specific demands for the recycling of MSW plastic that focus on both environmental and resource aspects as well as economic balance. Contrary, if the recycling solution should emerge by private economic actors on the market as intended, the focus would most likely be on creating economic profit rather than on the environmental aspects and circulating the plastic resources for actual recycling and up-cycling purposes.

Seeking to understand and test how public procurement can function as a stepping-stone for creating increased innovation and growth, the project Cleantech TIPP (Cleantech Testbed for Innovative Public Procurement) has been initiated (Gate 21, 2016). The project led by Gate21 gathers municipalities, utility companies, companies, lawyers, universities and business organisations[1] and specifically focuses on establishing a dialogue with the actors on the market via a proces of public-private innovation prior to a tender as a way to facilitate more innovative public procurement (Gate 21, 2016). Therefore, public procurement of innovation and especially public-private innovation is recognised as a means for accelerating an innovative recycling solution of MSW plastic to be developed, thus it can be described as a potential key for un-locking the current system of exportation. Additionally public procurement of innovation is recognised as a way to ensure a recycling solution that considers both environmental, resource, and economic aspects.

1.5 Project focus

The necessity of accelerating a transition towards increased resource efficiency is acknowledged, and the EU is focused on directing policy action towards decoupling the economic growth from the amounts of waste being produced in the member states (EU, 2011). As a means for accelerating increased recycling of the valuable resources in waste, the new EU circular economy action plan

[1] Municipalities: København, Malmö, Frederiksberg, Helsingborg, Høje.Taastrup, Fredensborg, Allerød, Albertslund. Private partners: Teknologisk Institut, DHI, Processio. Other partners: Hållbar Utveckling Skåne, Systainable Business Hub, Höje Å Vattenråd, Syvsav, Concito, Dansk Symbiose Center, Lunds Universitet, Aalborg Universitet Kbh, NSE, DTU, Rønne & Lundgren (Gate 21, 2016).

focuses on closing the loop of recycling by incorporating all stages of a product lifecycle, thus seeking to establish a system involving all actors in the value-chain (EU, 2015). As a response to the still increasing amounts of plastics being used in production, and plastic contamination of the global environment, the circular economy action plan emphasise increased plastic recycling as being essential for the transition to a circular economy (EU, 2015). Furthermore, the EU is both setting the target of 65 % recycling of MSW by 2030 (EU, 2015b), 55 % recycling of plastic packaging by 2025 (EU, 2015c), while also focusing on establishing a new method of calculating recycling percentages based on actual inputs for recycling rather than total collected amounts (EU, 2015b), which all added together will leave the Danish Municipalities in a even more challenging position than the current of reaching the national recycling target of 50 % MSW by 2022.

Recognising that a large recycling potential lies within plastic from MSW (Plastindustrien, 2015), the centre of attention in this project is closing the loop of MSW plastic recycling in Denmark. Roskilde Municipality is used as a concrete case and point of departure for the analyses. In order to reach the national requirement of 50 % recycling of MSW, the municipality is currently planning how to implement a new waste separation scheme where the fractions glass, paper, metal, organic waste, and residual waste are separated and kerbside collected. The fraction plastic is thus not included in the new separation scheme, due to the fact that Roskilde Municipality do not want the plastic to be exported to treatment facilities in other countries where the actual recycling percentage is low and unsatisfying (Sejersen & Fallov, Roskilde Kommune, 15.04.2016). As a way to reach the national recycling targets and to follow the national goal of minimising waste incineration, Roskilde Municipality want to collect plastic from the households within year 2022 (Sejersen & Fallov, Roskilde Kommune, 15.04.2016). This means the municipality needs to find out how to ensure a satisfying treatment solution that enable the recycling target to be met without compromising with their vision of becoming the leading resource cycle municipality in Denmark (Sejersen & Fallov, Roskilde Kommune, 2015).

The focus of the project is emphasised by the following research question:

How can Roskilde Municipality facilitate a development towards increased recycling of plastic from municipal solid waste, and what is potentially limiting the possibility of 'closing the loop' of municipal solid waste plastic in Denmark seen from a municipal point of view?

The waste system and waste business in Denmark is a complex socio-technical system, consisting of multiple actors with various interests in the MSW plastic - some presumably limiting the possibility for a municipality to facilitate a transition towards closing the loop of plastic recycling in Denmark. Additionally, the waste sector itself; the institutional structure, the legislative framework, and market conditions similarly might limit the transition or make it difficult for a municipality to navigate within. From this point of departure, and based on understandings of complex systems from theories about lock-in and actor-network, the focus of the analysis is firstly to map and analyse the current waste system in Denmark with the purpose of investigating what actors or aspects, both human and non-human, might be limiting the possibilities for a municipal facilitated establishment of a Danish recycling option for MSW plastic. In order to establish a closed loop where the resources are fed back into the cycle, it is naturally necessary to consider all stages in the plastic value-chain by ensuring sorting, processing, and eventually that the plastic is sold for recycling or up-cycling purposes. This naturally requires involvement of economic actors that can add value to the plastic in the different stages of the value-chain, which is the second focus in the analysis. As a potential means for facilitating

a transition in the current way of exporting MSW plastic for recycling towards establishing a Danish recycling solution, the possibility of creating a market dialogue and cooperation between relevant actors in the plastic value-chain before the collection and treatment is put out to tender is considered and analysed. This means that the process of public-private innovation prior to a tender is emphasised as a means for Roskilde Municipality to find and facilitate an innovative recycling solution where all the stages in the value-chain are considered and incorporated, thus functioning as an potential key for un-locking the current system of exporting the MSW plastic. Additionally it is considered and discussed how other actors than Roskilde Municipality could accelerate the transition by implementing various elements and actions. The purpose of this project is thus to shed light on the complex challenge that an ambitious Danish municipality face when seeking to feed the valuable resources within MSW plastic back into the cycle, and additionally the purpose is to analyse and discuss how a municipality can facilitate the establishment an innovative recycling solution in Denmark.

1.6 Structure of the report

The first chapter has described and explained the overall point of departure, and the final focus of the project has been stressed by the research question. In the following chapter the two theoretical approaches applied in the project are described. Hereafter it is presented how the two theories together form and provide the theoretical frame of understanding used in the analysis, when the third chapter presents the methodology of conducting the analysis. In this chapter the design of the research is described and it is explained how the empirical data have been collected. The fourth chapter presents the case of Roskilde Municipality as a point of departure for the analysis, followed by a description of the current system and procedures of recycling MSW plastic. Hereafter the fifth chapter of the analysis maps, analyses, and discusses various actors and aspects within the current system that might constraint the municipal possibilities of closing the loop of MSW plastic recycling in Denmark. Thus it is analysed what might contribute to creating a state of lock-in to the current system of exportation. Following this, the sixth chapter analyses and discusses how a municipality like Roskilde can actually facilitate an establishment of a solution for MSW plastic to be recycled and up-cycled. Public procurement of innovation is recognised as a way to accelerate the necessary transition and specifically the focus is on analysing and discussing the possibilities and advantages of establishing a process of public-private innovation prior to the actual tendering of the MSW plastic. Hereafter it is assessed and discussed how other actors than Roskilde Municipality could initiate actions that contributes to the transition of the current system. Finally in chapter seven the conclusions to the project are presented.

2 Theoretical approach

Based on the introduction of the problem area emphasising the current tendencies of reaching sustainability and acknowledging the view on circular economy as the recipe for increased resource efficiency of waste, a facilitation and support of a transition towards closing the loop of MSW plastic recycling in Denmark is recognised as inevitable. The waste system can be described as a complex socio-technical system, which is depended on and involves multiple actors that in collaboration constitute the waste system we know today.

In order to analyse and assess how this system transition can be accelerated and might come about, two theoretical approaches are applied as an overall frame of understanding – techno-institutional lock-in and actor-networks theory (ANT).

"… Lock-in occurs through combined interactions among technological systems and governing institutions" (Unruh, 2000, p 817) and provides a *"theoretical and practical relevance of understanding urban infrastructure lock-in for the planning and governance of cities towards sustainability"* (Corvellec et al, 2013).

"ANT seems ideally suited to understand a world in which technological systems and environmental change are major preoccupations. With its emphasis on the lack of any boundary between society and technology (…) it has the potential to deliver a theory appropriate for contemporary planning practice for sustainability" (Rydin, 2012, p 24).

The combination of these two theoretical approaches generate and function as an overall framework for understanding, analysing, and interpreting the collected empiricism. Thus, they are applied as a 'pair of theoretical glasses' though which the current waste system is viewed and understood, and additionally as a way to understand how currently embedded systems can be changed.

Firstly, the theoretical understanding of how systems can be in a state of a techno-institutional lock-in is presented, and how this state can limit the up-take of innovative and more sustainable solutions. Hereafter the theory of actor-network is presented, providing the overall understandings of how systems are made up by networks consisting of various human and non-human actors. The following chapter 3 of methodology will describe and assess the combination of the techno-institutional lock-in and the ANT and it is emphasised how the theories in collaboration will form the applied framework for the project.

2.1 Techno-institutional lock-in

Understandings of technological and institutional system lock-in has been evaluated and viewed upon by various scientific writers, resulting in multiple terms and various interrelated approaches. The theoretical approach applied in this project is used to provide an overall understanding of how existing systems might be locked-in due to technological and institutional actors and aspects influencing and making up the system, thus preventing or limiting the possibilities of new innovative solutions to break though and be a part of the existing system.

"Today's solutions are constrained by yesterday's choices, even if these choices have lost their relevance and even if new alternatives have emerged that are more efficient and effective than the solutions that currently dominate" (Corvellec et al, 2013, p. 33).

Technological solutions of today that once were sustainable and innovative, can be embedded to a point where it dominates further technological development to stay in the same trajectories, thus limiting the adoption of new innovative alternative solutions that might be necessary in order to transition to a system that lives up to the current and future challenges of sustainability. This embeddedness of technologies is not only caused and created by the technological system itself, but also by the reinforcement added from the institutional framework (Foxon, 2007). Therefore, institutional and technological systems constantly undergo processes of co-evolution, meaning *"... modern technological systems are deeply embedded in institutional structures, (...) factors leading to institutional lock-in can interact with and reinforce the drivers of technological lock-in"* (Foxon, 2007, p 144).

Hence, the theoretical understandings of lock-in is a way to describe the current state of a socio-technical system, where stability and inter-relatedness between the technological and institutional settings on one side can create stability, predictability, and reliability in the system, but on the other side it can create a system lock-in strongly discouraging radical change (Unruh, 2002; Foxon, 2007). Adding to this, actors benefitting from the technological settings and institutional framework of the current system, can similarly contribute to the lock-in:

"Actors, such as those with large investments in current market-leading technologies, who benefit from the current institutional framework (including formal rules and public policies) will act to try to maintain that framework, thus contributing to the lock-in of the current technological system" (Foxon, 2007, p 145).

In order for decision-makers to support and redirect towards sustainability with deployment of innovative alternative solutions, it is necessary to understand and gain knowledge about what/whom might contribute to the techno-institutional lock-in and in what way (Unruh, 2002; Corvellec et al, 2013), making it possible:

."*... To overcome a lock-in, policy makers and city managers have to reorient an array of interrelated factors"* (Corvellec et al, 2013, p 38).

The described theoretical understanding of how socio-technical systems can co-evolve into a techno-institutional lock-in leaving ambitious policy-makers with a complex challenge, is applied to the project with the aim of providing a frame for describing the current waste system and how specific actors and aspects within might limit the possibilities for a municipality like Roskilde to facilitate a transition. Considering this municipal challenge of facilitating the loop of MSW plastic to be closed in Denmark, the knowledge of the state of techno-institutional lock-in in the current waste system and furthermore what actors and aspects create this embeddedness, is recognised as valuable and necessary for ambitious decision-makers. Hence, the theoretical understandings of techno-institutional lock-in create an overall framework in this project, together with the perspectives in actor-networks provided by the following ANT.

2.2 Actor network theory

In line with the theoretical understandings of techno-institutional lock-in, the theory of actor-network is suitable for studying complex socio-technical systems with the purpose of understanding how they are made and what they are made off (Callon, 2001). The ANT provides a way of viewing upon and understanding the society as consisting of various complex actor-networks (Dankert, 2012). In this

project the following perspectives of actor-networks are applied in order to map and analyse relevant actors necessary in relation to closing the loop of MSW plastic recycling.

First of all, the ANT describes actors as being both human and non-human with no analytical distinction. This means that actors can both be persons, institutions, concepts, policies, objects etc. as long as they are a part of constituting the studied actor-network. To give an example related to the theme of the project; when understanding the waste system and waste business as a network, it does not make sense to distinguish between human and non-human actors. The complex waste system consists of various technological constellations e.g. an incineration plant, which affect the outcome of the network just as much as the regulations in the Danish Waste Announcement.

The notion of actor-network is the main focus of the ANT. The actors are defined by mutual actions and connections, which together establishes the actor-network. This means that the network is not determined and defined by the specific actors, but rather defined by the various actions performed by these actors, which thus continuously make up the actor-network. Similarly this also means that the specific networks do not exist if the specific actions and connections between the actors were not there, and that actor-networks are constructed, reconstructed, and kept alive through the interaction and connection between the various actors (Dankert, 2012). This interaction or 'work' that is necessary in order construct, reconstruct, or to keep the actor-network alive is called translation (Elgaard, 2003). This means that the processes of translation are the actions of continuously cooperation and interaction between actors, by which the actors reinforce and strengthen their collaboration and get further stabilised into the actor-networks. In this project, the notion of translation processes are used in order to emphasise which actions the municipality need to focus on when seeking to establish the coherent new actor-network that is required in order to facilitate the development towards increased MSW plastic recycling.

3 Methodology

This chapter describes the methods of conducting the analysis and thus the methods by which the research question is sought answered. Firstly, the design of the research is presented with the purpose of describing the overall thoughts of structuring and doing the analysis. Secondly, the collection of the empiricism is described, and hereafter a discussion and assessment of the reliability and validity of the research will finalise the methodology chapter.

3.1 The design of the research

The research has been designed with the purpose of studying the current problem of sustaining the valuable resources in MSW plastic waste, and with the aim of finding potential means for an ambitious municipality to accelerate and facilitate the necessary transition towards increased recycling of MSW plastic both in terms of quantity and quality.

Due to the fact that the topic and focus of this project is a currently unsolved global problem in which various different opinions and views exist, the method of researching can be characterised as exploratory. This means that the research has the purpose of investigating a phenomenon or a field where no actual solution has yet occurred, and has the aim of not necessarily emphasising conclusive evidence and one final solution to the problem (Andersen, 2013; Yin, 2009). Doing an exploratory research has been inevitable when working with this project theme. When the problem initially was emphasised it was clear that this was a topic that required an investigation and analysis of various persons, opinions, and statements across and outside the waste sector in order to identify the final project focus. The exploratory research method can be characterised by investigating in a way that is not stringent and not determined to go in a specific direction (Andersen, 2013). In this project the process of collecting the empirical data and the process of gaining knowledge about the problem and theme of the project, can be characterised as open and flexible. Thus this research has been step-by-step, where the final focus of the research has been modified and sculptured by the seminars attended in the beginning of the thesis writing and by the various interviews conducted. This means that the project has evolved continuously through the process, concurrently with the knowledge I have gained.

The theories of actor-network and techno-institutional lock-in are applied to form an overall framework for the analyses by providing a way of understanding complex systems as actor-networks and how these can be changed and locked-in due to continuous reinforcements between human and non-human actors that make up these networks (chapter 2). The theoretical understandings of techno-institutional lock-in and perspectives from ANT are combined. This is possible due to the fact that the two approaches generally are much alike and possess a similar understanding of socio-technical systems as made of various elements. Both approaches understand complex systems as a combination of various human and non-human actors that influence and affect each other, and similarly agree that this can create a state where systems can be locked-in or stabilised, which can influence the capability of redirecting the system. Thus, describing socio-technical systems as being interrelated and embedded in a way that potentially can cause a techno-institutional lock-in, can be related to the ANT perspectives of how networks and connections between actors can create a stabile actor-network. Thus, the combination of the theoretical understandings of techno-institutional lock-in and the ANT provides an overall theoretical frame of understanding for the analysis in this project. The strength of the combination lies within how the two approaches supplement each other and provide a theoretical frame of how the current system and the actors and aspects within, might cause barriers that prevent the necessary change towards resource efficiency. Thus combined, the two

approaches provide an understanding of socio-technical systems as networks consisting of various human and non-human actors, and how a technology can be locked-in a network due to the connections and relations between the techno-institutional actors and aspects. In order to un-lock and reorient the system it is necessary for policy-makers to gain knowledge about which actors and aspects, and in what way the system is locked, with the purpose of redirecting the current actor-network and establishing a new actor-network enabling transition towards the needed resource efficiency. The notion of translation processes adds value by emphasising and indicating which actions and connections between the various human and non-human actors that are crucial for the municipality to focus on in order to establish a new actor-network that facilitates increased MSW plastic recycling. Thus, in this project the two theoretical approaches for understanding systems and how they are constructed and reconstructed by interrelated cooperation between various human and non-human actors are together applied as an overall frame of understanding.

Furthermore, the two theories are used to structure the analysis, while not determining the direction of the analysis and assessment. The first part of the analysis (chapter 5) especially applied the theoretical understandings of techno-institutional lock-in, thus the state of the current system of exporting recyclable MSW plastic was analysed and the barriers for a municipality to choose a different recycling option was investigated. The theoretical understandings of actor-networks as constituted by various human and non-human actors, was used as a way to map the actors that in collaboration create the state of lock-in. Based on this knowledge of the current actor-network, the second part of the analysis (chapter 6) uses the theoretical understandings of actor-networks to analyse how Roskilde Municipality potentially can un-lock the system by facilitating a change in the current actor-network towards establishing a new actor-network that supports actual recycling and up-cycling instead of down-cycling and incineration as today. This way the applied theories both contributed to the overall understanding of the problem as well as guided the structure of the analysis without determining it. In many projects theories are used as stringent guides for structuring the process of the analysis as well as dominating the argumentation for emphasising the best or right solution to a given problem. Due to the novelty of the focus in this project, it has not been possible or suitable to apply theory that specifically emphasises a specific direction for targeting the problem focus. Therefore the research was designed and constructed to fit and shed light on the complexity of finding ways to transition the current waste system, and the answer to the research question has been sought through the use of an exploratory, flexible, and open methodology. The following sections will present and describe the methodology for generating the empirical data used in the project.

3.2 Empirical data collection

This section describes and assesses the methodology for collecting the empiricism, and how the methods have contributed to the analyses. Firstly the methodological consideration of literature review is presented and it is described how it has been used in the project. Hereafter, the methodological considerations of doing interviews are described, followed by a presentation of the various interviews. Finally the reliability and validity of the research is described and argued for.

3.2.1 Literature review

The introduction chapter (chapter 1) was primarily based on reviews of current relevant literature. A review of literature can be defined as a way to provide the knowledge needed in order to intensively investigate and explore a certain topic (Cronin et al, 2007). This means that the initial step in the process of writing this project was to investigate the problem by reading a variety of relevant

literature that consisted of relevant documents, including EU directives, programmes and plans, resource objectives from Denmark and the EU, Danish legislation, governmental and municipal strategies and plans, reports, scientific papers, articles etc. The review of literature has thus contributed with necessary knowledge about the problem area and knowledge about the various opinions on how to solve the problem of ensuring more recycling of MSW plastic resources. Furthermore the literature review provided knowledge about the complexity of this project focus, which led to the recognition that the analyses should include various aspects and actors within and outside the waste sector.

3.2.2 Conducted interviews

Besides the literature reviews, the main method for collecting empirical data was conducting various qualitative interviews with relevant persons within and outside the waste sector (table 1). Qualitative methods are mainly interested in 'seeing the world through the eyes of those being studied' and 'developing a strong contextual understanding, so as to be able to explain what is going on and unravelling complicated events' (Georg, 2011). Considering the complexity of the MSW plastic waste system and the necessary transition, the use of the qualitative method was relevant in this project. The development and innovation in the waste sector highly depends on the various opinions, political and business interests, and priorities, which means it has been necessary to use the qualitative method as a tool for investigating and understanding how the various relevant interviewees view upon the transition and the troublesome fraction MSW plastic.

Both personal and phone interviews were conducted, of which transcriptions can be found on the USB stick attached to the back of the report. Similar to all of the interviews, an interview guide was prepared in advance and the actual interview was held in a semi-structured way. This way of interviewing was chosen because the purpose of the interviews were both to collect empirical data for the analyses as well as a way to gather knowledge and insights to the next step in the process - in relation to the before described exploratory research design.

The first interview was held with the private waste consultant Henning Jørgensen. This interviewee was chosen as an initial source for getting increased and specific knowledge about the problems in relation to MSW plastic as well as knowledge about the relevant actors in the system. Hereafter an interview was held with the two lawyers Anders Birkelund and Johan Weihe. These two specifically work with procurement law and the purpose of the interview was to gain knowledge about the new Danish Public Procurement Act that came into force in January 2016, and the new possibilities of innovation within. Then an interview was held with the two municipal planners in Roskilde Municipality, Annette Sejersen and Jacob Fallov, with the purpose of understanding their view and assessment of the MSW plastic as well gaining knowledge about the political interests and ambitions within the city council. Hereafter a phone interview was conducted with Jens Christian Olsen who is the project leader on the new sorting plant in Aalborg Municipality. The purpose of this phone interview was to know about their vision, facts about the plant, and what the output of the MSW plastic would be when the plant is build and in operation. The same day an interview was held with the head of administration and development in Kara/Noveren, Marianne Roed. The main purpose of this interview was to gain knowledge about the waste company's interests in the treatment of the MSW plastic and which direction the development is envisioned, and additionally to understand how they imagine their role within this development. A phone interview were held with lawyer Majse Jarlov, which specifically was about the process of public-private innovation (chapter 6) and how this process can function as a means for a municipality to facilitate a development of an innovative

recycling solution for MSW plastic where the output is actual recycling and up-cycling. Majse Jarlov's model of public-private innovation (figure 1) was presented in the Cleantech TIPP project, thus this specific model has been emphasised as a good and qualified means for the partners in the project to develop an innovative tender that accelerate the development of cleantech solutions. Finally a phone interview was held with Camilla Raagaard Ernst, who is a project leader in Gate 21 and specifically work with the Cleantect TIPP project. The purpose of this interview was to gain knowledge about how to facilitate a process of public-private innovation, which is the centre of attention in chapter 6.

Table 1 Interviewed persons and dates of the interviews

Name	Function	Organisation	Date of interview
Henning Jørgensen	Private waste consultant	Affaldskontoret	05/04/16
Anders Birkelund & Johan Weihe	Lawyers	Bech-Bruun	11/04/16
Annette Sejersen & Jacob Fallov	Waste planners	Roskilde Municipality	15/04/16
Jens Christian Olsen	Project leader	RenoNord	21/04/16
Marianne Roed	Head of administration and development	Kara/Noveren	21/04/16
Majse Jarlov	Lawyer	Rønne & Lundgren	29/04/16
Camilla Raagaard Ernst	Project leader	Gate 21	29.05.2016

3.2.3 Attended seminars

Through the process of writing this thesis I have attended three seminars (table 2) about MSW plastic and circular economy that have contributed to the knowledge generation as well as resulted in empirical data that have been used in the analysis. Programs for the seminars can be found on the USB stick attached to the back of the report. The first seminar was about the circular economy package and various opinions on how Denmark should seek to transition towards a circular economy. This seminar gave a good initial overview of the challenges of implementing actions that initiate circular economy as well as knowledge about the various opinions of how the circular economy package seek to solve these problems. The second seminar was about the recently ended project initiated by the utility company FORS A/S, where it was tested if the plastic from households actually can be recycled and used as a substitute for virgin plastic. The seminar included presentations of the results, possibilities, and barriers, thus the seminar contributed with knowledge about the possibilities with secondary plastic as well as knowledge about the concerns and difficulties for the actors in the plastic value-chain. The third seminar was about the challenge of recycling the MSW plastic and how to deal with the fraction in a more sustainable manner. The seminar included various presentations across the waste sector and gave insights to the current challenge and various opinions among relevant actors. Especially this seminar contributed with great knowledge about the municipal challenges, the interests and roles of the waste companies, and the worries and difficulties for the plastic processing companies when it comes to recycling the MSW plastic. In this seminar I had the possibility to talk with multiple municipal waste planners across Denmark, Local Government Denmark (KL), Ministry of Environment, waste companies, and a plastic processing company. Due to the fact that this seminar was off the record, it was not possible to record the various presentations and individual conversations, but it was possible to quote the participants directly as long as no names were cited.

Table 2 Attended seminars and dates

Name	Held by	Date of seminar
Cirkulær økonomi for kommuner of forsyninger	Horten law firm	01/02/16
Muligheder og udfordringer ved genanvendelse af husholdningsplast	FORS A/S	23/02/16
Affaldsmøde omkring husholdningsplast	Affaldskontoret	07/04/16

3.2.4 Reliability and validity

When doing a project it is necessary to explain and argue for the reliability and validity of the study, which can be described as the criteria for determining the quality of a research design (Yin, 2009). The reliability of a research emphasises the possibility for different researchers to get the same results and empirical data by using the same methods of collection. Therefore in order for a project to gain reliability it should be documented and described thoroughly how the empirical data has been collected and how the analysis has been made (Yin, 2009; Bryman, 2008). The reliability of this project have thus been sought obtained through this methodology chapter as well as the transcriptions of the conducted personal and phone interviews, which can be found on the USB stick attached to the back of the report. The validity of a research can be described as the credibility and that what was initially intended investigated, is actually what is investigated (Yin, 2009; Bryman, 2008). This means that there should be connection between the research question and the final results of the project, and that the analyses are based on thorough empirical inquiry and not solely from one source (Yin, 2009). In this project the validity of the research have been sought through the multiple interviews, attended seminars, and the studying of resent projects and reports. Additionally the validity is sought through the connectivity between the introduction and project focus, the analysis, and finally the conclusion of the project, which means that the output of this project is in accordance with the problem initially emphasised.

4 Roskilde Municipality as a point of departure

Roskilde Municipality is chosen as a case for understanding the municipal challenge of navigating in the Danish waste system, which can be characterised with a high level of complexity and multiple actors, aspects, and interests involved. Therefore the current stage of waste management and the faced challenges and considerations regarding MSW plastic recycling in Roskilde Municipality will function as a point of departure for the analysis, which will be described in this chapter.

In 2013 the recycling percentage of the 61.000 tonnes collected MSW was 21. The remaining 79 % was utilised for heat and electricity in the incineration plant Roskilde Forbrændingsanlæg. This leaves Roskilde Municipality with a challenging task of reaching the national recycling targets within the time limit, and it is estimated that at least 10.000 tonnes of waste should be moved from incineration to recycling each year in order to reach the 50 % recycling before 2022 (Roskilde Kommune, 2015).

As a way to reach the national recycling target and as a way to reach the municipal goal of becoming a leading municipality of resource circularity, Roskilde is right now in the process of preparing a new waste separation scheme to be implemented and accordingly preparing documents for tendering the collection. Currently only paper and residual waste are kerbside collected, but with the adoption of the waste and resource plan in September 2015 by the city council, it is decided that the waste scheme also include kerbside collection of carton, glass, metal, and organic waste (Roskilde Kommune, 2015). In order to prepare for rolling out the new waste scheme, a 6 months pilot project is carried out in 2016 where the new waste separation solutions are tested before the waste scheme is finally rolled out to the rest of the municipality's approximately 86.000 inhabitants (Danmarks Statistik, 2016) from May 2017 (Roskilde Kommune, 2016).

As mentioned in the introduction and as the reason for choosing Roskilde Municipality as a point of departure, the new waste scheme does not include kerbside collection of plastic due to the fact that the municipality is not satisfied with the current available treatment option of exportation. Therefore collection of MSW plastic is postponed to year 2022 the latest:

"Fordi de erfaringer vi har hentet sammenholdt med det som vores politikere har sagt - at vi skal lave en ordning, der er ambitiøst og fornuftigt - jamen så vil vi ikke anbefale en udsortering af plasten. Vi vil ikke bede borgerne om at sortere noget, der bagefter bliver sammen, og hvor vi ikke kan garantere, at vi ikke i perioder ville ende med noget, der kunne ende i en ovn et eller andet sted" (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

The MSW waste in Roskilde is collected, treated, and sold by the waste company Kara/Noveren (K/N). K/N is owned by 9 municipalities, which are Roskilde, Kalundborg, Køge, Holbæk, Lejre, Odsherred, Solrød Strand, Greve, and Stevns, of which Roskilde Municipality owns the biggest share of approximately 26 % (K/N, 2015). The incineration plant is a combined heat and power plant and is located in Roskilde. The incineration plant consists of two boilers of which one was invested in in 2013 (K/N, 2016). When Roskilde Municipality were deciding if the MSW plastic should be a part of the new collection scheme, they both consulted other Danish municipalities for experience as well as consulted K/N. What finally made Roskilde Municipality decide not to kerbside collect plastic from households was a report made for K/N last year (K/N, 2015a). K/N hired a consultancy company in Denmark to do

a report where plastic batches from K/N were followed to a treatment facility in Germany and the sorting procedures and recycling percentages were mapped:

"Resultaterne var temmelig nedslående (…) Vi var nede på, at 80 % blev brændt, og det sagde de åbent" (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

The results thus showed that the currently available solution of exporting plastic for sorting and recycling is far from optimal. The Danish Waste Announcement emphasises that it is up to the Danish municipalities to assure a satisfying treatment and recycling for the recyclables (MST, 2012), and 80 % incineration can definitely not be characterised as being satisfying.

Another aspect that is important to include when describing the case of Roskilde Municipality, is the political aspect. In order for decisions regarding the new waste scheme and waste management to be implemented, the waste planners in the municipality presents a recommendation for decision to the climate and environment committee and hereafter it will finally be processed by the politicians in the city council. When the municipality were in the process of deciding whether or not to include plastic in the collection scheme, the political climate and environment committee firstly wanted to include the plastic, but the waste planners convinced them that the right decision was to postpone the collection until a better recycling option is available (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

In the following section, the current procedures and system of recycling MSW plastic is explained and discussed with the purpose of describing the problem that Roskilde Municipality is facing when seeking to facilitate a recycling solution in Denmark, as well as emphasising the need for a change.

4.1 The current system of plastic from municipal solid waste

As mentioned several times, MSW plastic is a troublesome fraction for recycling due to many different types of plastic and various combinations of these types used for packaging and products. In order to find out how Roskilde Municipality can facilitate closing the loop of MSW plastic recycling, it is necessary to understand the current system. Therefore this section explains the system of exportation and the coherent plastic material flow, with the purpose of understanding the necessity of closing the loop of the MSW plastic value-chain nationally. In the following the plastic material flow will be described.

Firstly the plastic is sorted by the households and placed in separate bins or cubes. This naturally varies from municipality to municipality due to their specific choice in collection. Hereafter a carrier company collects the fraction and transports the plastic to a transfer station often owned by the waste company. The plastic is pressed into bales and transported and sold to sorting plants most often in Germany or Sweden. Hereafter the fate of the plastic is no longer in the hands of the waste company, and the municipality must rely on the recycling percentages agreed on in the contracts. The before mentioned report made for K/N showed that when the plastic bales arrived at the facility in Germany, it would be visually inspected and separated based on the quality. Only the best qualities will stay in Europe (approximately 20 %), and the rest will be exported to Asia where the fate of the plastic is uncertain, but most likely incinerated (K/N, 2015).

"Det var begrænset hvor meget man overhovedet kunne få at vide om hvad der var sket, idet mange sagde, at det var forretningshemmeligheder - og det gælder også transportører, som ikke er interesseret i

at fortælle hvad der sker. Og det kom nok også lidt bag på K/N, at de ikke skulle mere end 1 led ud før der var hermetisk lukket. Men der hvor man kunne få noget information, var det jo sørgeligt" (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

The lack of visibility and transparency between the various stages and actors in the plastic value-chain makes it difficult for a municipality to get certainty and assurance about what happens to the plastic when exported. This information is necessary for the municipalities when seeking to redirect towards a model of circular economy and towards treating plastic waste as resources, thus not just with the purpose of reaching national recycling targets. Currently 49 Danish municipalities kerbside collect plastic from households and the plastic is mostly exported to either Germany or Sweden (Jørgensen, Affaldskontoret, 5.04.2016). Compared to the knowledge of 80 % being incinerated when exported it is quite thought provoking that half of the Danish municipalities have chosen to collect the plastic for the purpose of recycling. Furthermore it should be recognised that energy utilising plastic in incineration is considered recycling in Germany (K/N, 2015a). Adding together, this emphasises the need for a change and the need for a Danish sorting solution to be established. Furthermore it is necessary to ensure cooperation and visibility between the market actors in the plastic value-chain with the purpose of making sure the plastic is finally sold for recycling and up-cycling purposes, thus making it possible for the municipalities to know what the plastic has been used for as well as making it possible for the municipalities to provide this information to the citisens that separate their waste.

In order to exploit the potential of recycling MSW plastic and additionally to follow the European goal of transitioning to a circular economy and resource efficiency, the current flow of plastic materials need to change in order to close the loop of the plastic value-chain in Denmark. Figure 1 illustrates the stages in the current value-chain for MSW plastic collected in Denmark and exported for recycling in treatment facilities in Germany or Sweden. Additionally it illustrates the stages to add in the value-chain in Denmark in order to create a closed loop with visibility and transparency in the system. The figure illustrates the MSW plastic separated for recycling and thus not the plastic in the residual waste, which is incinerated for heat and power purposes.

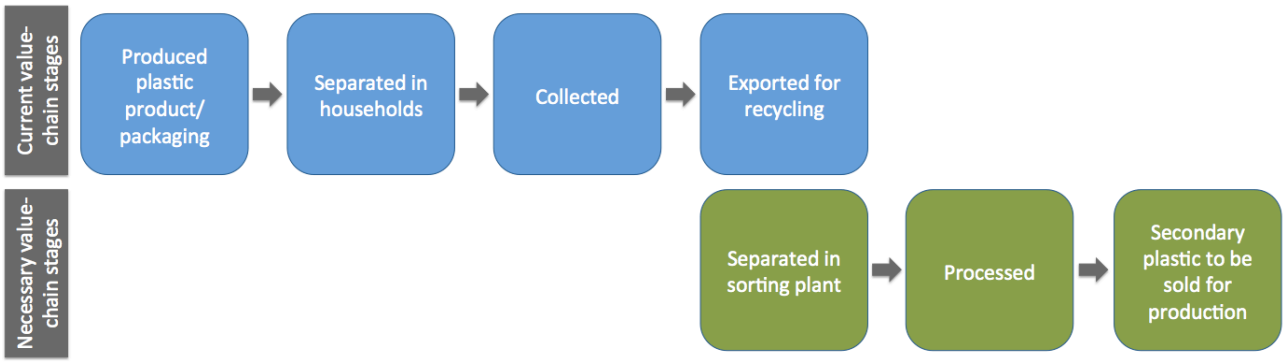

Figure 1: Stages in the current MSW plastic value-chain and stages necessary to add in order to close the loop nationally

In order to do so, it especially requires cooperation between the relevant actors within the three latter stages in the value-chain, which is illustrated with the colour green. Municipal facilitation of this cooperation is the centre of attention in this project. Firstly the stage between the collection of the MSW plastic and the processing companies is inevitable in order to avoid exportation of the MSW plastic:

"Vi vil ikke have den husholdningsplast som Vestforbrænding samler ind hos borgerne. Det er simpelthen et for uensartet produkt, der består af alt for mange typer plast (…) Vi vil gerne have plasten, så længe den er sorteret i en god kvalitet, som vi kan afsætte til vores plastkunder. Det er jo meget enkelt – hvis vi laver et dårligt plastgranulat kan det ikke blive afsat til en fornuftig pris, som jo hænger sammen med om plasten reelt bliver genanvendt til nye produkter (…) Det vil altså sige, at der mangler et dansk mellemled mellem leverandørerne og plast genanvendelsesvirksomhederne hvis husholdningsplast skal kunne bruges (MSW plastic seminar, 7.04,2016, AVL).

This missing link is first of all a plastic sorting plant. As mentioned previously, there are no current sorting solution for MSW plastic in Denmark, but this is soon about to change. Aalborg Municipality have planned to build and operate a sorting plant together with their waste company RenoNord and the municipalities of Jammerbugt and Mariagerfjord. The sorting plant will separate MSW plastic and metal, and the new plant is currently being build and is expected to be operating from October this year (RenoNord, 2016). The three municipalities Aalborg, Jammerbugt, and Mariagerfjord are cooperating on financing the sorting plant for the price of 38 million Danish kroner, and additionally the project has received funding from the Danish Environmental Protection Agency. The new sorting plant, which will be located next to the incineration plant in Aalborg Municipality, is expected to create 5 local jobs (RenoNord, 2016). In relation to the stages, illustrated in figure 1, that needs to be included in the value-chain of the plastic, the second stage of processing and thus eventually the third stage of selling the secondary plastic for production is not currently included in Aalborg:

"Vi kommer til at sortere plasten og så bliver den solgt på markedet. På sigt vil vi gerne have at plasten bliver afsat lokalt, men det er ikke muligt lige nu" (MSW plastic seminar, 7.04.2016, RenoNord).

This means that after the MSW plastic has been separated in the sorting plant, it will be exported and sold directly on the market instead of being further processed into a secondary plastic product that is ready to be sold and substitute virgin plastic in new production in Denmark. When the MSW plastic is just exported after the separation, it means that the visibility and transparency in the system and the knowledge of what happens with the plastic in the end is still not available for the municipality. Thus the planned model in Aalborg Municipality will in the end be very similar to the current available solution of exporting the MSW plastic when considering the knowledge of what happens to the plastic in the end. Naturally the waste company in Aalborg will be able to sell the plastic for higher prices than currently when the plastic has only been separated in the households, thus the plastic will presumably have an increased chance of being recycled into satisfying purposes. But considering the necessity of transitioning towards increased resource efficiency and treating waste as valuable resources by recycling and up-cycling instead of down-cycling and incineration, it is necessary to establish an entire plastic value-chain in Denmark and thus create collaboration between the actors that in cooperation can add value to the plastic in the different stages. As mentioned earlier established Danish processing companies do not want to buy the kerbside collected MSW plastic from the waste companies (MSW plastic seminar, 7.04.2016, AVL). Therefore in order to close the loop in Denmark, it is necessary to additionally establish a warm water washing plant after the plastic have been separated on a sorting plant where the food scraps, oil, and grease on the plastic can be washed off:

"Der er ikke nogen i Danmark, der kan vaske det på en ordentlig måde endnu. Vi har haft det med i overvejelserne, om vi skulle lade et varmtvandsvaskeanlæg være en del af vores anlæg, men vores sorteringsanlæg er et sorteringsanlæg og ikke et oparbejdningsanlæg. Og derfor har vi taget

beslutningen og sagt, at lige nu er det ikke aktuelt. Også fordi det er en stor ekstra investering" (Olsen, RenoNord, 21.04.2016).

As seen in the flagship project initiated by the Holbæk Municipality where MSW plastic were collected, processed, and finally used for production of new plastic products, it is indeed possible to recycle and process the MSW plastic into new high quality products (FORS A/S, 23.02.2016). But in order for the results of the project to function in reality where the MSW plastic is attractive and useful for the market actors in the stage of processing the separated plastic, it is inevitable to establish a solution where the plastic is washed with warm water:

"AVL er lige nu meget interesseret i det der kommer fra genbrugspladserne. Grunden til det er, at det som udgangspunkt ikke er søbet ind i madaffald, olie og fedt osv. Og der har de nemt ved at vaske og genanvende det. Men lige så snart der er fedtet madaffald eller olie på, så kan de simpelthen ikke vaske det af med koldt vand. Derfor er de ikke interesserede i husholdningsplasten. AVL har vaskeanlæg til koldt vand og det kan vi godt klare at levere plast til. Men det er kun det fra genbrugspladserne. For husholdningsplasten, der kan vi simpelthen ikke sige, at der er nogen af de enkelte plasttyper som vi kan garantere er fri for fedt og madrester osv." (Olsen, RenoNord, 21.04.2016).

Focusing on the goal of facilitating actual recycling where the resources are used for good purposes rather than down-cycled, it is thus necessary to include an extra stage in the Danish value-chain as illustrated in Figure 2.

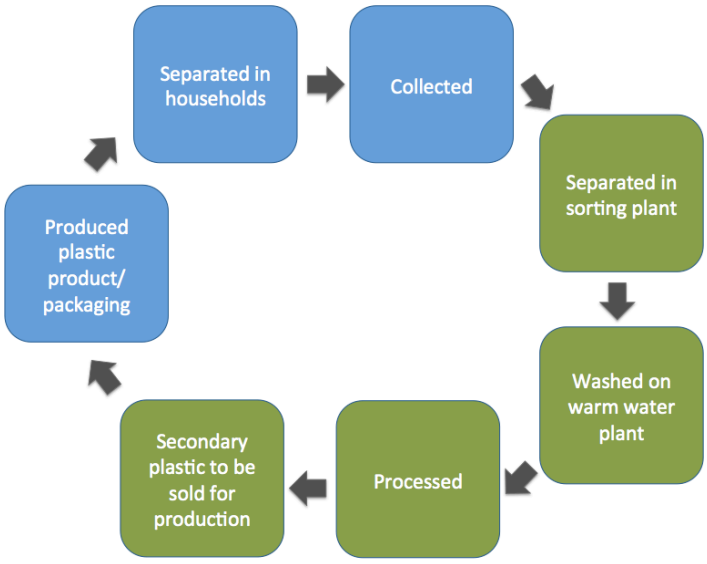

Figure 2: Stages to include in the Danish value-chain in order to close the loop of recycling

The initiative from Aalborg Municipality is inspiring to Roskilde Municipality, and they visualise a similar solution on Zealand:

"Vi har jo tilkendegivet, at vi forventer at skifte den eksisterende papirbeholder ud med en dobbeltbeholder til papir og plast. Så vi tror jo på, at det kommer. Men ift. hvad der skal til for, at vi vælger det til, det er jo formeneligt, at vi kan se, at Aalborg kommer i gang – de åbner dørene 1. november. Hvis vi kan se, at der kommer noget fornuftigt ud af det, så vil jeg tro, at man måske også laver et form for samarbejde på Sjælland hvor man kan aflevere plasten" (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

But the question is if the initiative of building a sorting plant in Aalborg Municipality is ambitious enough to meet the necessary transition towards a more circular economy. The sorted plastic will be sold and the residual plastic will be incinerated locally, which is positive.

"Der gør vi jo så det her, at vi har taget de her forurenede emner fra, og vi brænder det så lokalt. Det gør at vores miljøregnskab i genanvendelsen af plasten forhåbentligt kommer til at se bedre ud, fordi når det plast vi eksporterer har den renhed som vi håber på, så er der ikke nogen god grund til at skulle køre det hen på det nærmeste forbrændingsanlæg og forbrænde det" (Olsen, RenoNord, 21.04.2016).

But the fact that the plastic is still exported for processing and sale in other countries means that the municipality or Denmark would not benefit from the potential jobs that could be created and business potential for private companies, as well as the visibility of what happens to the plastic remains uncertain. Naturally building a sorting plant in Denmark is a step in the right direction, but still it should be recognised that the ideal solution where the plastic resources are circulated nationally, is not yet in place.

This chapter has described the case of Roskilde Municipality, thus defined the point of departure for the following analysis. It is obvious that the problem of recycling MSW plastic is a challenge that involves many aspects of technological, institutional, and political character. The waste system presumably consists of various barriers and interests that can constraint the municipal room to manoeuvre and make it difficult for a municipality to navigate within the system and choose an alternative recycling option. These potential constraints will be mapped and analysed in the following chapter, with the purpose of understanding what might affect the current system to be in a state of lock-in to exportation of the MSW plastic.

5 Mapping of constraining actors and aspects in the waste system

In this chapter the theoretical understanding of systems as actor-networks is used as a basis to acknowledge that systems consists of various interwoven human and non-human actors and aspects. Together these actors form networks that might cause systems to be in a state of lock-in where innovative and alternative solutions are unable to emerge and substitute existing solutions (chapter 2).

Therefore, the purpose of this chapter is to map and analyse the constraints in the current waste system, with the aim of getting an understanding and knowledge about what actors or aspects might challenge and form barriers for a municipality like Roskilde when seeking alternative recycling options for MSW plastic. In other words, the aim is to examine if the current actor-network might create a state of techno-institutional lock-in that constraints the development and uptake of new innovative solutions. This knowledge can be used as a point of departure in chapter 6 and provide an understanding of what actors or aspects in the current system might limit the municipal possibilities for facilitating an emergence of a new actor-network. Thus, which actors to 'be aware of' and navigate within when seeking to break the techno-institutional lock-in and establish a new actor-network in Denmark that facilitates increased recycling of MSW plastic.

The constraining technological and institutional actors and aspects mapped in this chapter are:

- 5.1 Market exposure of company recyclable waste
- 5.2 A question of volume
- 5.3 Municipal responsibility of reaching recycling targets
- 5.4 Lack of long-term strategies on a governmental level
- 5.5 The role and interests of waste companies

5.1 Market exposure of company recyclable waste

The first institutional actor to analyse is the current legislative rules of market exposure of company recyclable waste. This legislative rule is a potential constraint for municipalities when seeking to facilitate an establishment of a new actor-network that promotes and ensures a Danish MSW plastic recycling. In 2007 a political agreement regarding the organisation of the Danish waste sector was made, which to a higher extend than previously focused on liberalisation. One of the central points of the agreement was to establish market exposure of recyclable company waste instead of the municipalities being in charge of waste from both companies and households. This meant that the municipalities no longer were responsible for deciding where the company recyclables should be treated and they should no longer establish waste schemes for collection. The companies were now able to single-handedly choose where to treat their recyclable waste. The purpose and intention of liberalising the company recyclables was to encourage and facilitate competition on the market leading to the emergence of innovative recycling initiatives from private market actors (Regeringen 2007; Regeringen, 2007a).

A recently published report by the Danish Energy Agency evaluates the political actions and effects of the re-organisation of the Danish waste sector (Energistyrelsen, 2016). The report emphasises that the initial purpose and expectations of liberalising company waste has not yet been met: *"Markedsudsættelsen af det kildesorterede genanvendelige erhvervsaffald har ganske vist ført til muligheder i valget af indsamlings- og behandlingsløsninger, men der har endnu ikke været betydelige*

effekter på hverken priser, økonomisk vækst eller genanvendelse som følge af markedsudsættelsen" (Energistyrelsen, 2016, p 164) *... "og har følgelig heller ikke skabt de nødvendige forudsætninger for øget privat innovation"* (Energistyrelsen, 2016, p19).

Additionally, the initial expected outcome of the market exposure of recyclable company waste is questioned:

"Rapporten viser, at der nok ikke er sket den store forandring, men i virkeligheden tror jeg der er sket en forringelse af mulighederne for at lave nogle innovative løsninger" (Jørgensen, Affaldskontoret, 5.04.2016).

When the political agreement was implemented in the Danish Waste Announcement and came into force in 2010, it was no longer legal for municipalities to collect and treat recyclable company waste together with recyclables from households (MST, 2009). As a way to reach the national recycling targets and to facilitate an innovative development of recycling the resources in waste, Vejle Municipality planned in the years after the Danish Resource Strategy, to establish a waste sorting plant. In order to live up to the new legislative restrictions for public and private recyclables to be treated together on municipal recycling plants, the planned model was to separate the sorting of the recyclables. The intention was to treat the MSW during the daytime, and afterwards treat the company recyclables in the evening. Various lawyers approved this model of public-private partnership and therefore Vejle Municipality put the establishment of the sorting plant out to tender. In the end Kammeradvokaten turned down the tender and categorised it to be against the law. The final decision from Kammeradvokaten was that municipalities are not allowed to own, operate, or participate in partnerships about waste sorting plants if the plant will be treating recyclable company waste (Kammeradvokaten, 2014). The market exposure of company waste can thus be considered as a large constraint for municipalities to facilitate alternative solutions for recycling the waste:

"Det er en stor barriere, at kommunerne ikke længere må varetage det genanvendelige virksomhedsaffald. Det ødelagde interesser fra kommunal side om at bygge nogle anlæg hvor de kunne tage det privates genanvendelige affald" (Jørgensen, Affaldskontoret, 5.04.2016).

"At kommunerne ikke må behandle genanvendeligt erhvervsaffald på deres anlæg, har helt sikkert været en hæmsko for at nye løsninger er kommet. Det er jo ikke længere økonomisk attraktivt for kommunerne at investere i anlæg fordi plastmængderne i husholdningsaffaldet er simpelthen for små" (MSW plastic seminar, 7.04.2016, municipal waste planner).

"Det er egentligt en skam fordi kommunerne ville kunne lave sorteringsanlæg med udgangspunkt i både miljømæssige fordele og balance i økonomien, hvorimod erhvervet nok holder sig fra det fordi der ikke er økonomi i husholdningsplasten – i hvert fald ikke hvis formålet er at tjene penge på det (MSW plastic seminar, 7.04.2016, municipal waste planner)".

This indicates that the legislative rules of market exposure of company recyclables can be acknowledged as an institutional barrier for municipalities. In relation to the theoretical approach applied in this project, the legislative restrictions can be recognised as an actor creating a barrier for a municipality to facilitate a recycling solution of MSW plastic and additionally it can be recognised as an actor contributing to the lock-in to the current system of exportation.

5.2 A question of volume

Another aspect that might constrain the municipal room to manoeuvre is the MSW plastic itself and the volume necessary in order to make a Danish sorting and washing plant feasible. This technological aspect is closely related to the previous constraint of legislative rules about market exposure of company waste:

"Teknologien er der, men det er et spørgsmål om volumen - om der er affald nok til, at et anlæg kan løbe rundt. Plastmængderne er nok for små til, at det giver mening for en enkelt kommune" (Jørgensen, Affaldskontoret, 5.04.2016).

Thus in most cases the question of volume might make it difficult for an individual municipality to single-handedly establish a technological solution. Adding to this, the challenge of volume is even more constraining because of the market exposure of recyclables from companies. As mentioned previously, MSW plastic consists of various types of plastic and in order to be attractive for processing companies and eventually be sold for new production, the plastic needs to be sorted into specific clean product types. Therefore the volume of the plastic is necessitated to be of a certain size for it to be feasible for either a municipality or for private companies to invest in a sorting plant, if the plastic is put out to tender.

In this relation, the case of the Danish company DKRaastoffer can be mentioned as an example of the importance of volume when investing in a plastic sorting plant. The private company went bankrupt in 2014 only two years after the company had started to optically sort plastic and afterwards process it into granulate. DKRaastoffer invested 50 million Danish Kroners in the plant and had to treat 24.000 tonnes annually for the business to be cost-effective (Horsens Folkeblad, 2014), but even though the company received the plastic from approximately half of the recycling stations in Denmark (Kolding Kommune, 2014), they simply did not receive the expected and adequate volume in order to keep the business healthy (Horsens Folkeblad, 2014).

The sorting plant for metal and plastic in Aalborg Municipality is planned to have a capacity of 4,6 tonnes/hour and approximately 14.000 tonnes/year (Olsen, RenoNord, 21.04.2016). When the sorting begins in October this year, it will receive plastic and metal from 137.000 households in three municipalities, which means that only half of the capacity in the plant will be exploited. It is possible for RenoNord to receive and sort plastic from 250.000 households (DAKOFA, 2016), and the plan is that other municipalities in the Northern Jutland eventually will participate and deliver their plastic and metal to the plant:

"Da vi startede med at lave projektet med MST, var alle kommuner i Nordjylland inviteret med til at deltage i et samarbejde om mængder og muligheder for at lave noget centralsortering (…) Så ja, vi forventer selvfølgelig også, at der er nogle der vil benytte sig af det for det vil da klart gøre det mere økonomisk fordelagtigt, hvis vi kan komme til at behandle større mængder" (Olsen, RenoNord, 21.04.2016).

If the sorting plant in Aalborg were not able to sort the metal, the project would not be feasible:

"Det er reelt metallen, der giver mest økonomi til projektet (…) Det ville nok ikke give mening for os at lave et sorteringsanlæg, der kun sorterede plast. Så skal man op i langt større mængder før det giver mening økonomisk" (MSW plastic seminar, 7.04.2016, RenoNord).

Therefore, the fact that it is necessary to have a certain volume of the plastic for a sorting plant to be feasible can be a barrier for a municipality seeking to single-handedly facilitate an alternative solution.

5.3 Municipal responsibility of reaching recycling targets

Closely related to the constraint of the amounts of plastic available in the MSW, is the institutional constraint of the municipal responsibility of reaching recycling targets. It has been mentioned in the introduction chapter, that the Danish decentralised planning structure leaves decision-making and planning of how to reach the national recycling targets up to the individual municipalities. Considering that all Danish municipalities in 2013 had to find means and ways to reach the 50 % recycling before 2022, combined with the described issue of volume, some might question why the municipalities were not pointed towards cooperation:

"Den kommunale ret til selvbestemmelse skaber lidt et problem fordi vi har samme mål, men frihed til løsningen. Alle har jo blikket rettet mod at nå målene i sin egen kommune, så man glemmer nok at se på hvilke fordele der kunne være ved at arbejde sammen med naboerne" (MSW plastic seminar, 7.04.2016, municipal waste planner).

"Tankevækkende, at der sidder 98 kommuner og arbejder med at finde den samme model. Tænk på alle de ressourcer, der bliver brugt på det" (MSW plastic seminar, 7.04.2016, municipal waste planner).

This municipal responsibility of individually reaching recycling targets is probably not constraining the large municipalities to be ambitious and facilitate alternative recycling solutions as currently seen in Aalborg Municipality, but it might be a barrier for smaller municipalities with fewer resources available. Therefore the municipalities presumably are more likely to simply choose the currently available solution recommended by their waste companies, which is exporting the MSW plastic for recycling in other countries. This is the case of 49 Danish municipalities (Jørgensen, Affaldskontoret, 5.04.2016), which in the end does not comply with the aim of increased resource circularity.

Adding to this, the challenge of choosing and facilitating an alternative solution is presumably even larger considering that 49 municipalities out of 98 have already adopted a waste scheme where plastic is kerbside collected. Recognising that municipalities probably need to cooperate in order to reach the necessary volume of plastic, it is constraining that half of the municipalities have initiated individual solutions. These municipalities have already invested money, signed contracts with carrier companies, delivered new bins for collection, and involved the citizens in the sorting and collection, which inevitably will make it even more difficult to shift towards alternative solutions that requires cooperation and possibly similar sorting and collection methods among municipalities. A solution for this could be that when the Resource Strategy was published in 2013 and the municipalities had to reach the 50 % recycling targets, the cooperation between municipalities and facilitation of an alternative solution could have been provoked from the national level:

"Jeg har da tænkt flere gange, at det bedste ville være en løsning hvor man fra vores side tog hånd om sagen. Tro mig vi har været der. Som fagfolk kunne vi rigtig godt tænke os den der 'stalinistiske

tankegang', hvor vi som statslig myndighed sætter nogle streger på kortet og dikterer et samarbejde og hvordan og hvorledes det skal foregå. Men det ville jo skabe et ramaskrig for det strider jo mod kommunernes lokale ansvar og selvbestemmelse. Selvstyre er jo religion i Danmark. Men jeg er sikker på, at det i mange tilfælde ville være langt bedre for miljøet og for genanvendelsen af plasten (MSW plastic seminar, 7.04.2016, MST).

In line with this, there are different municipal opinions about governmental interference. Roskilde Municipality definitely do not agree that this is a task for the government to solve and they are certain that the individual municipalities can handle the challenge of recycling MSW plastic single-handedly (Sejersen & Fallov, Roskilde Kommune, 15.04.2016). Contrary, a waste planner from a smaller municipality thinks that it is a task that is too large for a single municipality to handle:

"Regeringen burde beslutte, at der skal laves et sorteringsanlæg og hvor og hvordan, fremfor at lægge den ud til kommunerne. Det er lidt en joke at tro, at vi kan klare det hele" (MSW plastic seminar, 7.04.2016, municipal waste planner).

The municipal responsibility of reaching the recycling targets is thus recognised as an institutional constraint that in some cases might limit the possibilities of municipal cooperation on establishing new innovative solutions instead of just choosing the current solution of exportation. Additionally it is presumably a bigger challenge for small municipalities with fewer resources than for larger municipalities.

5.4 Lack of long-term strategies on a governmental level

Another potential institutional constraint for a municipality to choose and facilitate an alternative and more innovative solution is the lack of long-term goals and clear strategies from the government:

"Det vigtigste er, at vi får en langsigtet strategi og målsætning for, hvor vi skal hen og nogle klare rammevilkår. Hvis de politiske mål er for kortsigtede, bliver resultatet desværre oftest derefter. Det gælder ikke kun på området for forbrændingssektoren, der aktuelt er til debat, men også for hvordan vi kan etablere og udvikle offentlige-private samarbejder. For meget usikkerhed sætter tingene i stå, og det hæmmer investeringslysten" (Dansk Affaldsforening, 2014, Madsen, J.C. Vejle Kommune).

If there is no clear governmental strategy including long-term goals on the recycling of MSW plastic, the municipalities might see it as a potential risk to invest and facilitate alternative solutions or initiate collaboration with private companies - simply because it is uncertain whether or not the recycling targets or restrictions might change in the future, and possibly affect and neglect the municipal investments already made:

"Jeg har prøvet at skyde det op et par gange, at man skal have styr på den langsigtede strategi fra regeringens side, altså fra central hold, mere end man skal lægge det ud til kommunerne, hvor de så skal lave en langsigtet strategi, men samtidig er bundet op af at skulle følge eventuelle ændringer fra regeringens side" (MSW plastic seminar, 7.04.2016, municipal waste planner).

Another political constraint to be mentioned is the fact that the initiatives proposed by the municipal waste planners are eventually decided by the existing political city council. This is naturally the way the Danish system is organised, but it might be an institutional constraint if the politicians in the council visualise another direction or are less ambitious than the municipal planners seek to be. As

mentioned previously the climate and environment committee in Roskilde Municipality initially wanted to include MSW plastic in the new waste separation scheme, but in the end the waste planners succeeded in persuading them into accepting the collection of plastic to be postponed (Sejersen & Fallov, Roskilde Kommune, 15.04.2016). In some cases this might mean that the waste planners in the municipalities can be forced to plan and manage a decision that they might not believe in and contrary it might in some cases be difficult for ambitious municipal waste planners to persuade the city council into new and innovative decisions and actions. Naturally that is just the case of politics – there are always multiple factors and interests affecting the output of the decisions, but from an ambitious municipal point of view, this can constraint the possibilities of redirecting towards a more innovative solution that focuses on the actual circularity of the resources in the plastic and focuses on choosing another path than exportation.

5.5 The role and interest of waste companies

Another actor that might constraint and create a barrier for the municipal development of increased recycling of MSW plastic, and thus contribute to the creation of a system lock-in, is the municipal waste company. Waste companies profit from handling the waste for the municipalities, which means that they presumably have interests that could affect their actions and the advice they give their owner municipalities.

The first aspect to point out is ensuring that the MSW plastic is exported to a sorting plant and a documented market that meets the municipal requirements for recycling. As mentioned several times the procedure after the plastic is collected should be visible and transparent for the municipalities, in order to make sure that the plastic is actually recycled and fed back into the cycle, thus not just treated like today where the actual recycling percentage is very low. In the case of Roskilde Municipality, a barrier towards transparency and an aspect that influences the municipal room to manoeuvre in the last stages of the value-chain, is the statutes in K/N:

"Indsamling og aflevering af plast er en grundydelse i vores vedtægter så dvs. at vores ejer-kommuner skal aflevere deres plast til os, og så skal vi så finde ud af at afsætte det bedst muligt" (Roed, K/N, 21.04.2016).

This means that if the owner municipalities choose to collect the MSW plastic, they have to deliver it to K/N. Hereafter K/N in principle can sell the plastic as they wish, as long as the plastic is sold as good as possible. Then the question is how the waste companies would define the best option:

"Og hvorfor mener vi så systemet er godt nok som det er nu? Jamen det er fordi når plasten bliver udsorteret så bliver det til en råvare, og om det så bliver til et kloakdæksel eller noget andet, det kan man selvfølgelig godt have en holdning til. Men det er der jo heller ikke i forbindelse med andre fraktioner, eks. med træ er det jo fint nok, at det bliver til spånplader. Så det vi siger er bare, at så længe det bliver sorteret og på den måde bliver til en råvare, som kan bruges til noget andet, så har vi det ganske fint med det" (MSW plastic seminar, 7.04.2016, Danish waste company).

This shows that the view on recycling in waste companies is not necessarily on actual recycling and up-cycling of the MSW plastic, which is necessary in order to create a sustainable recycling of the valuable resources in the plastic. This is therefore a very constraining aspect for an ambitious municipality, when considering that the waste companies might have another vision of the best

recycling or treatment option. Additionally, the definition of the best solution is presumably highly influenced by the price on the plastic, which means that the MSW plastic might sometimes get sold to treatment facilities that do not necessarily assure high recycling rates and where the plastic is actually fed back into the cycle. Adding to this, the recycling rate promised to the waste companies by the treatment facilities might not live up to an ambitious municipality's assumption of actual recycling:

"Vi blev lovet 85 % genanvendelse på et anlæg i Tyskland. Vi fandt så senere ud af, at forbrænding er ligeså godt som genanvendelse i deres optik (…) Forretningen er styret meget af økonomien på markedet, så når økonomien i at genanvende plasten er bedre i forbrændingen, så trykker de lige på en knap og kører plasten ind i forbrændingsanlægget i stedet" (MSW plastic seminar, 7.04.2016, Danish waste company).

Adding to this, if Roskilde Municipality wanted to deliver their MSW plastic for treatment at a privately owned sorting plant in Denmark, the restrictions in the K/N statutes would be a problem:

"Pga. vedtægterne kan man formelt set kun hvis vi har en aftale med anlægget. Så skal kommunerne aflevere til os, og så er det så os der beslutter om det er det anlæg eller et andet vi vil aflevere til. Så vi har frihed til at afsætte hvor vi vil. Og det er klart, at hvis alle vores ejer-kommuner henvender sig til os og foreslår at vi afleverer plasten til det anlæg, så ville vi jo nok vælge at gøre det og lytte til kommunerne. Men rent formelt kan vi vælge at afsætte det lige nøjagtigt hvor det passer os, så længe det bliver genanvendt fornuftigt – om det så er Tyskland, Sverige, Polen eller Jylland" (Roed, K/N, 21.04.2016).

This means that if the municipality should have any chance of influencing whom the plastic is sold to, all the nine municipalities in the area of K/N should cooperate and collectively push K/N to choose the option the municipalities want. Presumably this collaboration could be done, but considering the various mentioned constraining aspects, it could be difficult. For example if the other owner municipalities had already invested and chosen to collect the plastic in a certain way. This might be different to the collection method required by the private Danish sorting plant, which presumably could mean that not all the owner municipalities would benefit from or be willing to collaborate. Another example that could constraint the possibilities of the required cooperation could be if the political city councils in the owner municipalities did not approve or accept to deliver the plastic to a specific plant, which might sometimes not be the economically optimal price. The waste company statutes can thus be considered as an institutional barrier for the individual municipality to be proactive and choose a better recycling solution than the currently available exportation to questionable sorting plants.

Another aspect to point out is the interest of the waste companies in the waste incineration. In K/N 95% of the turnover comes from incineration of waste (K/N, 2015), which presumably could mean that the waste company is highly interested in directing large amounts of the MSW plastic to the incineration plant because the market prices are not necessarily always optimal. This assumption is turned down by K/N:

"Det er klart, at vi har et forbrændingsanlæg hvor vi selvfølgelig gerne vil have noget affald ind, men vi vil kun have det affald ind som ikke kan genanvendes eller ikke giver mening at genanvende af den ene eller anden årsag. Mange andre kraftværker har for meget kapacitet og det har vi også, men vi fylder op med affald som vi importerer fra England og Irland" (Roed, K/N, 21.04.2016).

Thus K/N is not interested in incinerating waste that could be recycled, because they will just import the waste. But at the same time it also indicates that K/N naturally has a high interest in utilising the full capacity of the incineration plant. At some point the countries from which K/N import the waste, will probably establish a national treatment solution, which means that the amounts of waste available for import might decrease. At the same time the Danish amounts of waste for incineration will decrease as well, due to the increasing recycling targets and that the citizens presumably will be better at separating their waste. This would mean that K/N would not have enough waste to utilise the capacity in the incineration plant. This assumption might have the effect that K/N would advice the owner municipalities to postpone or not collect MSW plastic, simply because the economy of incineration at their own incineration plant might be better than exporting for recycling:

"Hvis man tager omkostninger og transporten med, så ville det være både bedre og billigere at brænde det i Danmark fremfor at køre det til Sydtyskland eller Polen. Så er det udelukkende fordi genanvendelsesprocenterne skal nås" (Roed, K/N, 21.04.2016).

Compared to the knowledge of 80 % incineration and 20 % questionable recycling when exporting the plastic to treatment facilities in Germany (Sejersen & Fallov, Roskilde Kommune, 15.04.2016), it is not necessarily a bad decision to currently choose incineration in Denmark until a Danish solution have emerged. But it is questionable to what extend the waste company's interests of incineration should be affecting the municipal decisions on recycling.

5.6 Sum-up on constraints creating a state of lock-in in the current actor-network

According to the applied theoretical approaches complex systems can be in a state of lock-in due to continuously interrelated reinforcements between the technological and institutional human and non-human actors that make up systems or actor-networks. When an actor-network is in a state of techno-institutional lock-in there are various constraints that together form a barrier for making radical changes. A radical change is necessary in order to redirect the current way of exporting MSW plastic for recycling towards establishing a Danish actor-network that includes the various stages in the plastic value-chain and cooperation between the various relevant actors within. In order for municipal waste planners and decision-makers to overcome a lock-in, it is important to gain knowledge about which technological and institutional human and non-human actors and aspects might constraint the possibility of establishing a new actor-network due to their embeddedness in the current actor-network. This knowledge is necessary for understanding which interrelated actors and aspects to reorient or make up for in order to establish a new actor-network. Therefore this chapter have mapped and described potential constraints that can have an effect on the municipal possibilities for redirecting towards facilitation of an alternative recycling solution for MSW plastic instead of just choosing exportation like 49 municipalities have done. Figure 3 illustrates the identified aspects and actors that together contribute to the creation of a techno-institutional lock-in to the only currently available recycling solution of exportation. These various identified aspects and actors can constraint and complicate the municipal possibilities of facilitating a transition towards a required Danish solution for MSW plastic where the resources in the plastic can be used as a substitute for virgin plastic in production.

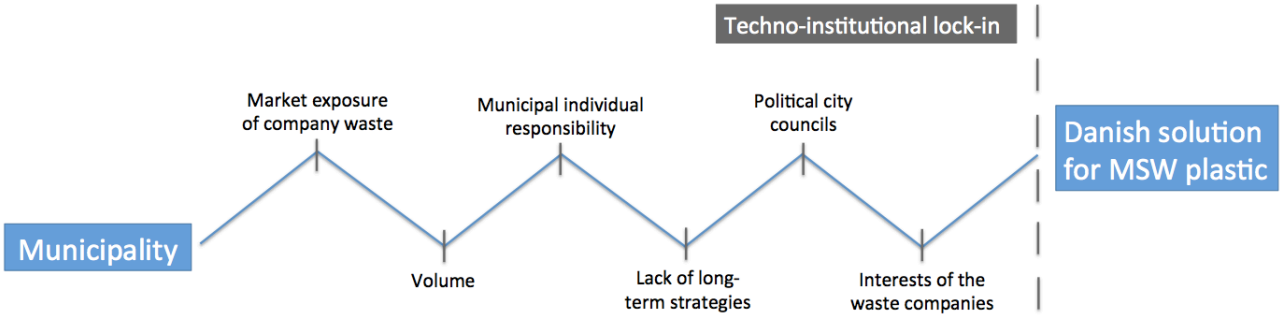

Figure 3: Technological and institutional actors and aspects contributing to a lock-in to the current MSW recycling procedure of exportation

The identified aspects of market exposure of company recyclables and the municipal responsibility of reaching recycling targets have a constraining effect on the possibility of assuring the right volume necessary to make investments in a plastic sorting plant feasible and attractive. The municipal responsibility of reaching recycling targets has resulted in various differentiating kerbside collection methods, which presumably additionally limit the interests in changing the method of collection in order to create a similar fraction and the necessary volume. Furthermore the necessary transition is constrained due to political aspects and interests in the waste sector. The lack of long-term strategies from the governmental level is troubling because it can constraint the initiative for investing in a sorting and washing plant when it is uncertain what recycling targets or further restraints might be implemented from the governmental level. Adding to this, even if municipal waste planners are willing to initiate and facilitate a development, it might not be possible if the municipal city council is not accepting the recommendations or seek another direction than the municipal waste planners recommend. This can be characterised as a potential constraint for ambitious waste planners because the politicians in the municipal city council are essential for a change to be facilitated. Another constraining actor is the municipal waste company, especially if the owner municipalities are necessitated to deliver their MWS plastic for recycling to the waste companies due to the restrictions in the statutes. This means that the waste companies are responsible for handling the recyclables, thus that they are allowed to sell the recyclables to recycling and treatment facilities of their choice. The municipality have no certainty of the recycling procedure and whom the plastic is sold to, and therefore if the plastic is finally recycled for satisfying purposes and not just down-cycled or incinerated because the prices are low. In relation to the waste company, the incineration plant can be a technologically constraining actor. It is in the interest of the waste company to utilise the capacity in the plant, which might lead to the consultants in the waste company advising the municipalities to not collect all recyclables. For example if the municipality decides to kerbside collect plastic, the waste company might advice them to only include the hard plastic and not the soft. This way they get a higher price for the plastic when exported and additionally the soft plastic resources goes to the residual waste and then finally gets incinerated.

Based on the theoretical approaches applied in this project, the system can be characterised as being in a state of techno-institutional lock-in that can constraint the municipal room to manoeuvre. The current actor-network can thus be defined as locked-in to the current solution of exportation due to the various constraining actors and aspects mapped in this chapter. As explained in the beginning, the purpose of identifying the possible constraints is to get an overview of what might limit the municipal room to manoeuvre and contribute to the creation of a system lock-in that supports the municipalities in choosing the currently available solution of exportation. The identification of the constraints can then function as a point of departure for investigating and analysing how to then facilitate the

establishment of a Danish recycling option. The next chapter of the analysis will thus focus on how Roskilde Municipality can facilitate this transition towards creating a new network of actors necessary for establishing a Danish sorting and washing solution that focuses on national resource circularity instead of exportation.

6 Roadmap to an innovative recycling solution

Referring to the applied theoretical understandings of systems as complex actor-networks, the purpose of this chapter is to analyse how a new actor-network can be established while recognising the previously mapped constraining actors and aspects causing lock-in to the only currently available option of exportation. Municipal facilitation and establishment of a satisfying Danish solution for recycling MSW plastic that ensures a sustainable recycling and up-cycling is a challenging task that requires inclusion of and cooperation between various actors within and outside the waste sector. In order to utilise the valuable resources in the MSW plastic and prevent down-cycling and incineration, and contribute to reduce CO_2 emissions, it is necessary to find new ways of facilitating increased recycling and up-cycling and not just let the important decisions of treatment options up to waste companies and carrier companies as today. The overall goal should be to seek a more sustainable and resource efficient handling of waste as a resource, and therefore it is necessary that the municipalities get more influence on the recycling process in order to make sure that the collected materials are recycled in consideration to both environmental and economic aspects. The previous chapter 5 mapped constraining actors and aspects that can limit a municipality to choose a different recycling option than the currently available exportation. The current system of exportation was explained and described as being in a state of techno-institutional lock-in, which according to the theory (chapter 2) can limit the possibilities of an alternative innovative solution to be developed and established. According to the circular economy action plan, recycling of plastic is essential when transitioning to a circular economy (EU, 2015). Therefore, the purpose of this chapter is to analyse how the current system potentially can be un-locked, thus how Roskilde Municipality can accelerate and facilitate the required transition towards increased recycling and circularity of the valuable resources in the plastic from MSW while ensuring visibility and transparency through the stages in the plastic value-chain. The main goal of establishing a new Danish recycling solution is to ensure actual recycling and up-cycling of the MSW plastic instead of down-cycling and incineration, which naturally can be done in other countries. But by seeking to establish the actor-network and the plastic value-chain in Denmark, it is possible to create jobs and economic growth nationally instead of exporting the valuable resources and thus create jobs in other countries (MST, 2015a; Ellen MacArthur Foundation, 2015a). Additionally the chapter

As emphasised multiple times, there is currently no functioning market for MSW plastic or a coherent MSW plastic value-chain in Denmark where the collection of plastic from the households leads to the final stage where the plastic resources are fed back into the cycle by plastic producers or up-cycled for other purposes. Therefore it is acknowledged in this project that Roskilde Municipality has two options: to be reactive or to be proactive. Either the municipality keep incinerating their MSW plastic until a Danish recycling solution has emerged, or the municipality is proactive and on the contrary seek to facilitate and accelerate a transition. Acknowledging that Roskilde Municipality has an ambitious goal of becoming the leading municipality of resource circularity, it is analysed how the municipality can reach their goal by proactively engaging in the transition of the waste system and not just reactively await the solution to emerge by other forces.

As mentioned in the introduction the Cleantech TIPP project led by Gate21 gathers municipalities, utility companies, companies, lawyers, universities and business organisations on testing how public procurement can function as a stepping stone for creating increased innovation and growth.

Specifically the project focuses on establishing market dialogue and public-private innovation prior to a tender as a way to facilitate more innovative tenders (Gate 21, 2016):

"Grunden til vi synes det er en god ide at lave OPI (public-private innovation), det er fordi når offentlig og private mødes, så sker der mange gange nogle rigtig gode ting i det rum fordi det offentlige repræsenterer et behov og nogle problematikker, som de ikke selv kan løse. De har heller ikke selv værktøjerne til at kunne løse det, men de har en ide om hvad de i hvert fald ikke vil have og hvad der i hvert fald ikke fungerer (…) Og det særlige er så når de møder de forskellige markedsaktører og hvis man får skabt et rum hvor man kan lytte til hinanden og få plads til problematikkerne uden der går salg i den (…) de har jo mulighed for at gå ind og få en rigtig god kilde til inspiration, der kan lede til viden om hvor skal vi udvikle os videre hen, og samtidig kan både markedet og de offentlige være i stand til at lave en benchmarking mod hinanden, hvor man kan få afstemt om man som kommune forventer noget helt tosset af markedet og tror de, at det er noget helt andet der skal til udviklingsmæssigt, hvad de kan se ift. konkurrenter på markedet osv." (Raagaard Ernst, Gate 21, 29.05.2016).

Based on this, the possibilities that lies within a process of public-private innovation before the collection and treatment of the MSW plastic is put out to tender, is emphasised as a possible means for the municipality to be proactive, and is therefore the focus of this analysis. As previously described, the political agreement on reorganising the Danish waste sector towards liberalisation of company recyclables with the aim of boosting the market creation of innovative recycle options, has not yet happened (Energistyrelsen, 2016). In order to accelerate the development of innovative recycling solutions, the public authorities can demand and purchase innovative solutions: *"Public procurement of innovation can articulate and increase demand for innovations, and improve conditions for the uptake of innovations in order to spur innovation and their diffusion into the marketplace, triggering and accelerating the production and diffusion of innovation throughout the innovation chain"* (EU, 2013, p 3). This way the public authorities can facilitate innovative alternatives to be developed while at the same time assure specific environmental demands for the solution to be met. Furthermore it is recognised that other actors or authority levels can accelerate and support the transition further by implementing various means in the MSW plastic recycling system, which additionally is assessed and discussed after the municipal facilitation of a process of public-private innovation has been analysed.

As mentioned in the theory chapter, actor-networks are constituted by various human and non-human actors, which are defined by mutual actions and connections. Therefore, in order to establish a new actor-network in Denmark, it is recognised as inevitable to both redirect the actions of current actors as well as create cooperation and connections between the various relevant actors in the value-chain. Therefore, it is necessary to focus on the processes of translation, which is defined as the 'work' that construct and reconstruct the actor-networks by continuous cooperation and interaction between the actors (Elgaard, 2003). In this chapter the term translation will be used to emphasise which actions Roskilde Municipality should specifically focus on when seeking to establish a new actor-network, which is inevitable when seeking to facilitate the development towards increased plastic recycling and establishing a coherent new actor-network. In other words, this means that the notion of a translation process is used as an indicator that emphasises where the municipality should specifically focus on creating actions that initiate cooperation between the various human and non-human actors, since establishing good processes of translation are crucial for the outcome of the new actor-network.

Firstly is it presented how Denmark has implemented the overall juridical frame of public procurement (Erhvervs- og Vækstministeriet 2015a; EU, 2014a), followed by a presentation and

description of a public-private innovation process prior to a tender and how such a developing process can accelerate innovative solutions to emerge from a municipal point of view. Hereafter the chapter is firstly divided into the three steps within a public-private innovation process where it is analysed and assessed how Roskilde Municipality through this process potentially can facilitate the emergence of a Danish recycling solution for MSW plastic. Hereafter it is discussed and assessed that establishing a new actor-network potentially could be promoted by implementing other potential means to promote the establishment of a market for secondary MSW plastic, which should be facilitated by other actors or from another level than the municipal. The chapter is finalised by a sum-up before the conclusion of the project is presented in chapter 7.

6.1 Public-private innovation prior to a tender

As mentioned earlier, when public authorities are procuring work, goods, or services, they have to put the procurement out to tender. Public procurement is emphasised as an ideal possibility for the public authorities to demand innovative solutions (EU, 2015d) and thus an ideal way to accelerate the development of an innovative MSW plastic recycling solution.

The overall purpose of tendering public procurement is to ensure the most optimal use of public financial means and create an equal playing field for businesses operating within Denmark and across Europe (EU, 2016; Konkurrence- og Forbrugerstyrelsen, 2016). The EU sets the overall rules on public procurement in Europe via the Public Procurement Directives adopted in 2014. By April 2016, the EU member states had to implement the EU directives into national law (EU, 2016a). Therefore, in January 2016 the EU Public Procurement Directives were implemented directly in Denmark when the new Danish Public Procurement Act came into force, thus providing the first Danish law setting up a national framework for public procurement (Erhvervs- og Vækstministeriet, 2015a). The Public Procurement Act, to a larger extend than previously, make it possible for the contracting entity to focus on environmental aspects and externalities, and the option of using flexible tendering procedures is more accessible. Other then that, the options with the new law are not significant different than before it came into force (Birkelund & Weihe, Bech-Bruun, 11.04.2016). The Public Procurement Act provides a new flexible tendering procedure called innovation partnerships. The new tendering procedure is introduced as a completely new innovative option for when the contracting entity is not procuring standard off-the-shelf solutions or items (Erhvervs- og Vækstministeriet, 2015), as if Roskilde Municipality in some constellation were to procure a sorting and washing plant for MSW plastic. This new tendering procedure initially seems obvious for the municipality to use when seeking an innovative solution, but it is questioned if the intentions with the new Public Procurement Act and the possible outcome of the tendering process is any different from what could have been achieved previously:

"Det er gammel vin på nye flasker et meget langt stykke hen ad vejen (…) Forskellen ligger i at leverandøren på et tidligt tidspunkt bindes kontraktuelt til at levere en løsning, som ordregiver så kan indkøbe uden at lave et nyt udbud (…) Spørgsmålet er om ikke man havde kunne benytte de gamle fleksible løsninger, som langt hen ad vejen er de samme, allerede efter de gamle regler. Det tror jeg nok godt man kunne. Så på den måde får vi ikke noget nyt i form af en ny fleksibel udbudsprocedure" (Birkelund & Weihe, Bech-Bruun, 11.04.2016).

Additionally, the complexity of the new tendering procedure is emphasised as being too complicated for municipalities to initiate:

"Innovationspartnerskab har vi haft i 4 måneder og der er ingen tvivl om når man læser i udbudsloven, så er det meget svært at forstå hvad det går ud på. Og det kan man også allerede se nu med de juridiske fremstillinger der har været, det er meget forskelligt hvordan juridiske folk der beskæftiger sig med udbudsret hvordan de ser udbudsformen. Så jeg tror den er svær at gå til (…) jeg tror simpelthen ikke kommunerne kan finde ud af det fordi det er komplekst" (Jarlov, Rønne & Lundgren, 29.04.2016).

When assessing and analysing how a municipality like Roskilde might facilitate the development of a new innovative recycling option, the focus in this project is therefore directed towards the possibilities within public-private innovation before the actual tendering process and the actual procurement. This is due to the recognition that closing the loop of MSW plastic recycling in Denmark requires both an establishment of a new actor-network with extensive cooperation between the various actors in the plastic value-chain as well as an innovative sorting and washing plant that can deliver the quality required by the market actors. By doing a public-private innovation process before the collection and treatment is put out to tender, Roskilde Municipality has the possibility of collaborating and sharing knowledge with a range of relevant private actors on the market as well as knowledge institutions and other relevant specialists. This way the innovative specifications for the tendering documents are formed through a process of collaboration between the public authority and private relevant actors on the market that could add value to the plastic, thus being a part of the plastic value-chain. The purpose of the public-private innovation process prior to the tender is to bring the relevant actors together and thus in collaboration find the criteria for an innovative MSW plastic recycling solution in Denmark that is beneficial for the market as well as matching the recycling and up-cycling expectations of the municipality.

In order to analyse how Roskilde Municipality can facilitate actions that seek to establish a new actor-network around MSW plastic recycling, it is necessary to understand the process of doing a public-private innovation prior to a tender. Provided by lawyer Majse Jarlov (Jarlov, Rønne & Lundgren, 29.04.2016) and used in the Cleantech TIPP project, figure 4 illustrates the various steps to undergo when doing a public-private innovation process that should lead to the actual tendering process. The figure illustrates a combination of public-private innovation and a tender of the new innovation partnerships, which would not be carried out in reality (Jarlov, Rønne & Lundgren, 29.04.2016), but the figure gives a good overview of the entire process.

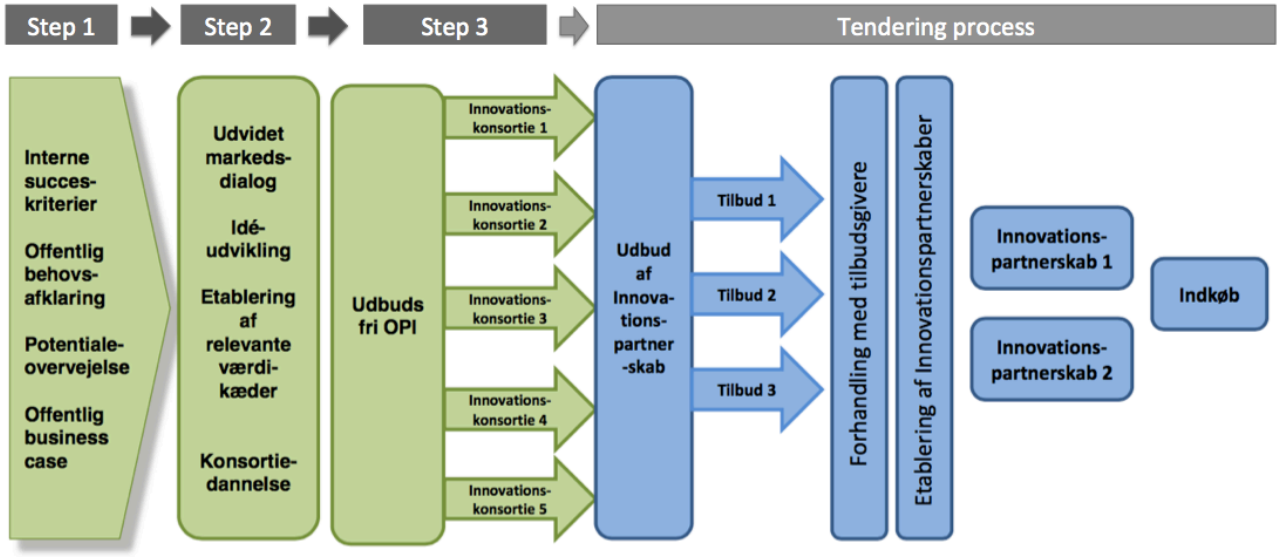

Figure 4: The three steps in the public-private innovation process leading to the process of tendering. The figure illustrates a combination of both public-private innovation and afterwards a tender of innovation partnerships, which in reality would not make sense to combine. The figure is reproduced (Jarlov, Rønne & Lundgren, 29.04.2016)

Figure 5 illustrates the three steps that are the centre of attention in this chapter and are analysed in relation to Roskilde Municipality. The three steps function as a process model for doing public-private innovation, thus the sections in this chapter are structured according to the three steps illustrated in figure 5. The steps are briefly presented in the following in order to give an overview of the steps in the process.

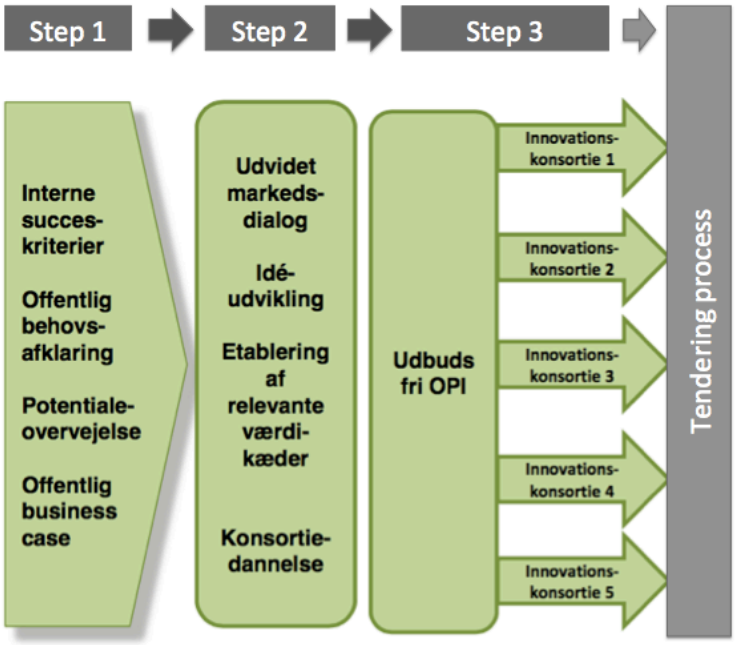

Figure 5: The three steps in the process of public-private innovation prior to a tender. The figure is reproduced (Jarlov, Rønne & Lundgren, 29.04.2016)

The first step in the process of public-private innovation is where the public authority internally determines what demand the new innovative solution should be able to cover. The purpose of this first step is thus to define the current problem and to determine the success criteria for the solution. In this step an internal marked dialogue is established with the purpose of gathering experts that together

with the municipality can help determine and specify the public demand. This first step is therefore the point of departure and preparation for the next step (Rønne & Lundgren, 2016).

The second step is the external market dialogue where the relevant private actors across the value-chain are brought together with the purpose of developing ideas and examining how a public-private innovation process can lead to an innovative solution to be found. Additionally it is determined whether or not the solution is already available at the market, which is essential in order to do this process (Rønne & Lundgren, 2016).

The third step is the tender-less public-private innovation where the private actors decide to form innovation consortiums and cooperate with the municipality on developing and testing new innovative solutions. In this step there are signed contracts with the relevant different innovation consortiums, which binds them to cooperate with the public authority on the innovative developing process. The reason why there is no need for a tendering process is in this step is because the private actor/supplier is not bound to deliver certain work, goods, or service, but only bound to cooperate on the development (Jarlov, Rønne & Lundgren, 29.04.2016; Rønne & Lundgren, n.d.). Hereafter; when the innovative solution has been developed, the success criteria of the public authority has been reached, the specifications for the tender documents are defined, and the public authority wants to procure the solution, the procurement finally should be put out to tender.

These three steps of doing a public-private innovation process will in the following be assessed, analysed, and discussed individually with Roskilde Municipality as a point of departure. Thus, it is analysed how the municipality could accelerate and facilitate a development of a closed loop of MSW plastic recycling in Denmark by initiating a process of public-private innovation.

The steps described and analysed in the following:

- Step 1: Determining the public demand and the criteria for the innovation
- Step 2: Market dialogue
- Step 3: Establishment of tender-less innovation consortiums

6.1.1 Step 1: Determining the public demand and criteria for the innovation

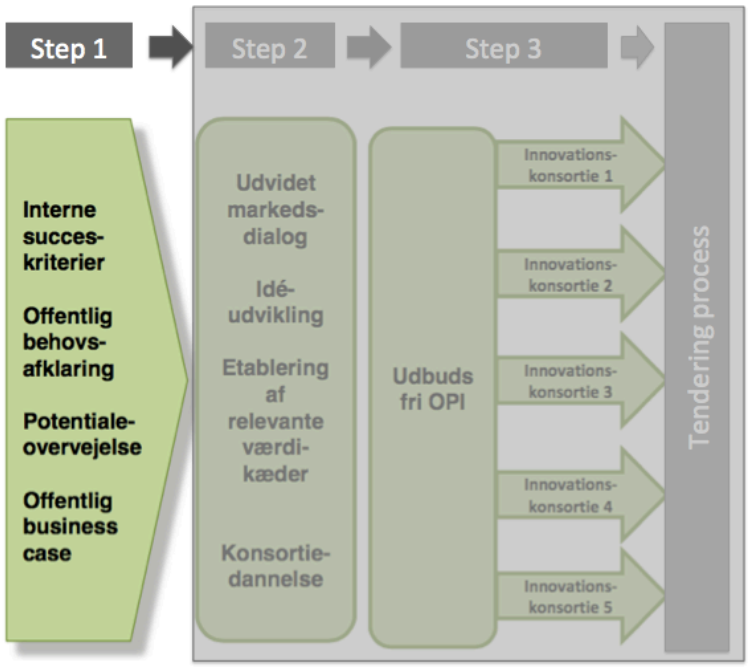

Figure 6 Focusing on the first step of doing a public-private innovation

The first step for Roskilde Municipality is to identify which public demand the new innovative solution should meet, thus determine the success criteria for the new actor-network. This step is in the Cleantech TIPP project called the internal market dialogue, which means that this is the step where the municipality spends time and resources on figuring out what exact demand the innovative solution should cover. This first step is essential for laying the groundwork for the public-private innovation process and it is necessary to allocate time and resources for this first step:

"Mange gange giver man heller ikke nok tid ift. problematikkerne. Og det er det vi prøver at bringe ind i den interne markedsdialogen. Man går meget tit i løsningsmode – hvorfor er det, at det ikke fungerer – man glemmer nogen gange at køre et par runder rundt om problematikken og behovet" (Raagaard Ernst, Gate 21, 29.05.2016).

This first step sets the point of departure for initiating an external market dialogue in the second step, and therefore it is important that the municipality has worked thoroughly with the public demand and expectations during the internal market dialogue:

"Hvis man kan argumentere for det, og man kan tænke videre over det man kan kalde en business case light inden man møder markedet, hvor man siger 'lad os lige prøve at tænke over det her – hvor omkostningstungt er det lige pt. med den nuværende løsning, hvad koster det ikke at gøre noget, hvad kunne man forestille sig det vil koste hvis vi kører ud af det her innovationsspor, som handler om den her type prototype osv.' Hvis man øver sig lidt inden kommunemæssigt, så har man også større chance for at kunne gå ud og få interesseret nogle private aktører, som så har lyst til at lege videre med bolden og lyst til at gå ind og regne på nogle forskellige scenarier for løsninger" (Raagaard Ernst, Gate 21, 29.05.2016).

Based on this recognition, the following sections will focus on the first step of the public-private innovation process and emphasise specific aspects that Roskilde Municipality should include and reflect upon before initiating the second step of the external market dialogue with private actors.

Decide the vision

The first crucial aspect to consider is to set an internal goal and vision of the level of recycling that the innovative solution should be able to fulfil. Roskilde Municipality has already initiated the process of visioning a more ambitious treatment solution than the currently available, by choosing to postpone the collection of MSW plastic (Roskilde Kommune, 2015):

"Muligvis skal der være nogle, der samler noget ind før der kommer en løsning. Det var i hvert fald den diskussion vi havde da vi skulle beslutte os om plast skulle med i ordningen – kommer løsningen først når der er et udbud af plastikken på markedet. Og der kan man jo sige, hvor langt tid skal vi vente? Hvor langt tid skal man køre det ned til en cementovn i Tyskland før nogen gør noget. Og hvis vi har gjort det tilstrækkeligt længe, tror vi så på, at der er nogen der reagerer? Det har vi ikke nogen grund til at tro" (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

Thus, Roskilde Municipality is already in a position where they have dealt with the previously mentioned constraint of just choosing the currently available option of exportation. Hereafter the municipality need to consider and decide on the outcome of the treatment. In the case of Aalborg Municipality building the first MSW plastic and metal sorting plant in Denmark, they have chosen only to build a sorting plant. This naturally means that the separated plastic will be sold for higher prices than if only separated in the households and kerbside collected, but inevitably it still means that the separated plastic will be exported because the processing companies in Denmark are not interested in the plastic (Olsen, RenoNord, 21.04.2016). The sorted plastic will presumably be sold for purposes that include a higher recycling share than what is currently possible with the option of exportation. But aiming at an ambitious solution where there is transparency and cooperation in the flow of the plastic value-chain and where the MSW plastic is sold for actual recycling and up-cycling and where local jobs are created as well as economic growth, it is emphasised in this project that the municipality should include a warm water washing plant. Naturally this will necessitate a larger investment, but if the goal is to facilitate an actual recycling solution of MSW plastic in Denmark, it is necessary to facilitate washing of the plastic so the food scraps, grease, and oil are removed (Olsen, RenoNord, 21.04.2016).

Gather large volume

The second aspect to consider is the volume of the MSW plastic. As described in the previous chapter, it can be a constraint for a single municipality that the plastic need to have a certain volume in order for a sorting plant to be feasible. It is recognised that Roskilde Municipality cannot single-handedly establish a sorting plant, and they need to cooperate with other municipalities in order to reach the necessary volume for a sorting and washing plant to be feasible. Therefore Roskilde Municipality needs to initiate and establish collaboration with other municipalities. In this relation, collaboration between the municipalities in the area of the waste company K/N would be an obvious place to start:

"Potentialet for Roskilde Kommune er for lille - der er simpelthen ikke volumen nok. Jeg synes K/N er et oplagt sted at starte. Kan man ved at samle mængderne i det i forvejen etablerede samarbejde sikre, at man når en volumen, hvor det kan svare sig" (Jørgensen, Affaldskontoret, 5.04.2016).

As the largest municipality of the owner municipalities in K/N, Roskilde Municipality could initiate the collaboration:

"Så skulle man (Roskilde Kommune) gå foran og smide nogle penge i og satse på at de andre kommer med. Det handler om det gode samarbejde og i Roskilde har man jo flere ressourcer end mange af de andre kommuner, så de tager jo ofte gerne imod hjælp. De mindre kommuner har ikke ressourcer til at kunne udvikle og finde nye muligheder, så Roskilde kunne forsøge at skabe et samarbejde" (Roed, K/N, 21.04.2016).

Therefore, in the first step of the public-private innovation process, it is necessary for Roskilde Municipality to investigate the possibilities of collaborating with other municipalities in order to gather a large volume. In this relation it would naturally make sense to initiate cooperation with the other eight municipalities in the area of K/N. Additionally none of these municipalities collect MSW plastic in their waste scheme (Roed, K/N, 21.04.2016). If the volume of the MSW plastic should be increased even more than what can be collected in the area of K/N, the cooperation could be expanded to additionally include and consist of other municipalities or other waste companies:

"Hvis man skal se rent rentabelt på det, så tror jeg alle affaldsselskaber på Sjælland hver især er for små til at lave noget alene – ARC og Vestforbrænding kunne måske godt selv, men vi andre bliver nødt til at snakke sammen med nogle af de store eller med hinanden, hvis det skal give mening" (Roed, K/N, 21.04.2016).

It could thus for example be collaboration between K/N and the waste company AffaldPlus due to the geographical location of the municipalities. In this relation it can be questioned if a cooperation between two waste companies might be difficult due to the individual investments in incineration plants:

"Det er måske også det er der problematisk, fordi de (affaldsselskaberne) vil gerne lave noget (en løsning for plasten), men de så jo gerne at det lå ved siden af deres egen ovn, fordi hvis man laver et plastsorteringsanlæg, så ved vi jo at 20-30% vil ryge fra og så er det jo en god idé at have anlægget placeret ved siden af sit forbrændingsanlæg så man har noget foder til anlægget. Hvis man har plastsorteringsanlægget liggende hos det andet affaldsselskab, så ender en del af kommunens eget affald i andres hænder" (Jørgensen, Affaldskontoret, 5.04.2016).

The question of interests in the incineration plants might be a potential barrier for cooperation between waste companies is not emphasised by K/N:

"Selvfølgelig ville alle affaldsselskaberne som udgangspunkt gerne have plasten hen til deres anlæg. Men for det første skulle anlægget jo bygges i umiddelbar nærhed af et forbrændingsanlæg, så det transportmæssigt og miljømæssigt giver mening. Så vil man helt sikkert kunne lave en afregningsordning med at man afleverer til et vis antal kr. pr. ton, og så ift. restmængden får en rabat eller noget ift. det kraftvarmeværk, som så overtager restmængden. Det tænker jeg sagtens kunne løses" (Roed, K/N, 21.04.2016).

Considering the necessity that Roskilde Municipality gathers the required volume of MSW plastic in order to ensure that investing in a sorting and washing plant would be feasible, it is necessary to focus

on establishing collaboration between other municipalities. In relation to the theoretical understandings of how actor-networks are created, it is thus necessary for Roskilde Municipality to especially pay attention towards creating good processes of translation that can lead to the municipalities agreeing and cooperating on finding a new and more ambitious solution for recycling of MSW plastic.

Establish a steering committee and gather a group of experts

In order for the municipality to internally discuss the public demand and identify success criteria for the innovation it is necessary to take expert advice. This can be done by establishing a group of experts and specialist who have knowledge, insights and interest in contributing with formation of the requirements for the innovation:

"Hvis man er interesseret i innovation i affaldssektoren, så ville man lave en temagruppe, hvor man inviterer fagfolk ind. Der skal sidde nogen, der kender noget til det. Det er meget vigtigt, at der sidder nogle kompetente folk, der ved hvorfor det er svært at lave et udbud inden for det her område, hvorfor er det svært at skrive udbudsmaterialet, hvorfor kan vi ikke sætte minimumskrav osv. – hele den problematisering det kan kun blive bearbejdet hvis der sidder nogen, der ved noget om det. Så det er ligesom første krav. Og næste step det er så at få dem til at mødes over flere omgange og flere workshops og arbejde med materialet ud fra en skabelon (…) Så mødes i faggrupper og få kortlagt problematikker, potentialer, behovsafklaringer osv." (Raagaard Ernst, Gate 21, 29.05.2016).

These knowledgeable experts could be a variety of relevant persons:

"Man kunne sagtens bede universiteter og andre kloge om at være med. Hvis de har en interesse i, at der kommer en løsning på det område, så ville de jo også have en interesse i at bidrage med den viden de har" (Jarlov, Rønne & Lundgren, 29.04.2016).

Thus, this group of experts are invited to contribute to the internal market dialogue and lay the groundwork for the second step of the external market dialogue. During these meetings with the group of experts it is necessary to make sure that the discussions and considered aspects are documented thoroughly. In order to control the entire process of public-private innovation, it is necessary to establish a steering committee that can ensure that the juridical factors and rules are followed:

"Når det så er klart og man laver en dokumentation – rent juridisk er det vigtigt, at man også går ud og offentliggør hvad man er i gang med ift. udbud osv. – så der forskellige juridiske steps som man skal sikre sig samtidigt, dvs. man skal opbygge en form for styrgruppe, projektgruppe eller følgegruppe, som netop kan holde styr på hvad det er for nogle proces-steps vi er i gang med nu og er der noget juridisk vi skal have højde for" (Raagaard Ernst, Gate 21, 29.05.2016).

Therefore, it is necessary for the municipality to establish a steering committee that consists of various relevant actors who constantly can make sure that the process and the steps within the public-private innovation is moving in the right direction (Jarlov, Rønne & Lundgren, 29.04.2016).

Discuss the model of operation of the sorting and warm water washing plant

A third aspect to consider before the external market dialogue is initiated is the model of operation of the sorting and washing plant. If the municipalities in the area of K/N have decided to cooperate on collecting the MSW plastic for treatment, the model of operation should be discussed and finally decided during the market dialogue in the second step of the public-private innovation process. There are two obvious possibilities: either the sorting and washing plant are build by a private actor and operated by K/N similar to the model of the sorting plant in Aalborg Municipality, or a private actor both build and operate the sorting and washing plant. These two models of operation have different obvious aspects that should be considered. The first mentioned model where the sorting and washing plant are build by a private actor and operated by K/N entail that gathering the required volume of MSW plastic, is more difficult due to previously mentioned institutional constraint that municipalities are not allowed to treat company recyclable waste. Contrary, if a private actor own and operate the sorting and washing plant it is then possible to treat both recyclable plastic from households and companies, which inevitably makes it possible for the plant to receive and treat a larger volume. This would therefore mean that the collaboration between the municipalities in the area of K/N might be able to gather enough volume. As mentioned in the previous chapter 5, an important constraining aspect is the restrictions in the statutes of K/N, saying that if the MSW plastic is collected in the owner municipalities, they are obligated to deliver the plastic to K/N whom then is in charge of the treatment. If a private actor then operates the sorting and washing plant, it is not certain that K/N would deliver the MSW plastic for sorting and washing at this specific plant. Contrary if the plant is operated by K/N, the MSW plastic would naturally be sorted and washed at this specific plant because the owner municipalities had invested in this. Thus, if the sorting and washing plant is operated by K/N the visibility and transparency of what happens to the plastic presumably is more accessible and controllable for the municipality, but on the other hand it might be more feasible to let a private actor operate and own the plant because it would be possible to treat the company recyclable plastic together with the household recyclable plastic. This aspect should naturally be discussed in the second step of the public-private innovation process as well, because it naturally also depends on which model of operation the private actors are interested in, but it is recommendable for the cooperating municipalities to discuss this internally before the external market dialogue is initiated.

Sum-up on the first step of the public-private innovation process

The first step in the process of doing public-private innovation is where Roskilde Municipality form the basis for facilitating a new innovative solution to be developed. Therefore it is the step where Roskilde Municipality internally decides the vision of what demand the new innovative solution should be able to cover, which is essential in order to lay the groundwork for initiating the process of cooperation with private actors on the market:

"Hvis man kan argumentere for det, og man kan tænke videre over det man kan kalde en business case light inden man møder markedet hvor man siger lad os lige prøve at tænke over det her – hvor omkostningstungt er det lige pt. med den nuværende løsning, hvad koster det ikke at gøre noget, hvad kunne man forestille sig det vil koste hvis vi kører ud af det her innovationsspor som handler om den her type prototype osv. Hvis man øver sig lidt inden kommunemæssigt, så har man også større chance for at kunne gå ud og få interesseret nogle private aktører, som så har lyst til at lege videre med bolden og lyst til at gå ind og regne på nogle forskellige scenarier for løsninger" (Raagaard Ernst, Gate 21, 29.05.2016).

Recognising the need for a more ambitious solution that adds value to the MSW plastic, it is emphasised that Roskilde Municipality should demand an innovative solution that is able to make the plastic desirable for the next actor in the plastic value-chain. This means that the solution should be able to sort and warm water rinse the MSW plastic so it reaches a higher quality than currently possible. A steering committee should be established, who serves the purpose of making sure the entire process of public-private innovation lives up to the juridical requirements for a tendering process as well as continuously reviewing and documenting the initiatives in the process. Together with this steering committee, the municipality should gather a group of experts and facilitate multiple meetings and workshops with the purpose of specifying the public demand, potentials for the MSW plastic, and what innovation should be developed. This means that the internal market dialogue is the process where the group of experts contribute with their knowledge and insights to the issue and help the municipality on identifying the problem and thus specifying the demand for the innovation.

Furthermore in the first step of the public-private innovation process, the municipality should initiate cooperation with other municipalities in order to gather as much MSW plastic as possible. An obvious place to start is by initiating cooperation with the other eight owner municipalities in the area of K/N. Adding to this the municipality should seek to include other municipalities or waste companies in southern Zealand as well, due to the recognition that it will be more interesting for economic actors to participate in the process of public-private innovation if the volume of the MSW plastic is as large as possible. After the cooperation has been initiated, it is necessary to discuss the model of operation.

Considering the theoretical understandings of how an actor-network is constructed by processes of translation, Roskilde Municipality should in this first step specifically focus on the translation processes in relation to the other eight owner municipalities in the area of K/N. This means that the actions of facilitating and creating cooperation and mutual understandings between the municipalities are essential in order to form a good basis for the new actor-network and for the next step in the public-private innovation process – the market dialogue.

6.1.2 Step 2: Market dialogue

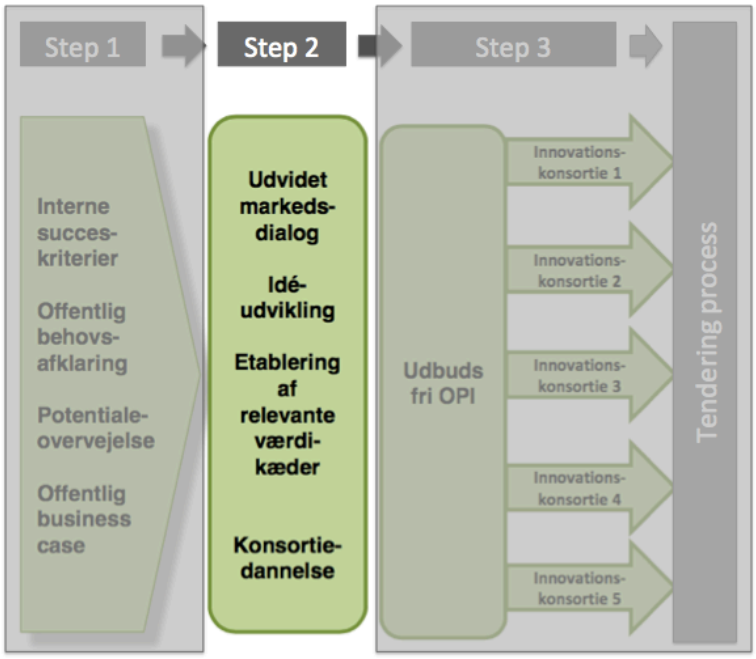

Figure 7: Focusing on the second step of doing a public-private innovation

The second step in the process of public-private innovation is for Roskilde Municipality to establish an external market dialogue with relevant private market actors across the plastic value-chain, with the purpose of discussing potential innovative solutions that could cover the municipal demand:

"Den måde hvorpå man kunne starte det op, er ved at have en markedsdialog, hvor man starter meget åbent ift. hvad det er for nogle overvejelser man som ordregiver har med henblik på at prøve at komme lidt nærmere en løsning, og også med henblik på at få markedet modnet til at nogle forskellige aktører i værdi-kæden - som måske ikke er vant til at tænke i samarbejde - finder sammen" (Jarlov, Rønne & Lundgren, 29.04.2016).

The market dialogue is characterised as an informal dialogue and knowledge sharing where there is no individual feedback to the potential bidders/suppliers of the solution (Jarlov, Rønne & Lundgren, 29.04.2016).

"Og det er jo det det hele handler om – man har et behov og før vi kan købe en ydelse ind som dækker det behov, så skal vi kunne beskrive vores behov, og det kan vi ikke lige nu fordi det hele er så diffust. Så vi skal have nogle input til hvilken retning tror vi, vi skal gå. Så man starter meget bredt med markedsdialogen og der kan man jo sagtens have gjort sig en masse overvejelser om hvordan man tror tingene ser ud, det kan også være man bare starter sindssygt åbent og siger vi vil bare gerne have alle jeres uforbeholdne input" (Jarlov, Rønne & Lundgren, 29.04.2016).

The following sections will emphasise and reflect on specific aspects that Roskilde Municipality should include in the second step of the process of public-private innovation, before the third step of forming innovation consortiums is initiated.

Setting the scene for the market dialogue

The first thing for Roskilde Municipality to do in the second step of the public-private innovation process is to facilitate an external market dialogue between various potential private actors. This can be done in different ways:

"Det kan man gøre på forskellige måder. Hvis ordregiver kører en markedsdialog, hvor man selv ved hvem markedet er, kan man selv pege på de aktører som man tror er interessante og som man tror vil have gavn af at samarbejde, men man kan også gøre det åbent. Jo mere diffus ens opgaveløsning er, jo mere oplagt vil det måske være, at man spørger mere åbent" (Jarlov, Rønne & Lundgren, 29.04.2016).

For Roskilde Municipality, it would presumably be appropriate to combine the methods of gathering actors, thus to both specifically invite potential actors as well as announce the market dialogue publicly. This is due the fact that in order to close the loop of MSW plastic recycling in Denmark, it requires both a development of an innovative treatment solution as well as internal collaboration between the actors in the plastic value-chain after the plastic has been sorted and washed. It is therefore necessary to gather various actors both in order to discuss and determine the requirements for the potential innovative solution, as well as to determine which quality the plastic should reach in order to ensure that the next actor in the value-chain is interested in receiving it. The aim is thus to establish an open dialogue where the innovative solution and criteria for closing the loop of MSW is found in collaboration. This means that after the first step of the internal market dialogue, Roskilde Municipality should establish an external market dialogue via various meetings and workshops. Considering the necessity of creating cooperation between the various actors in the plastic value-chain and developing an innovative recycling solution, it is important to include as many aspects and as much knowledge as possible. Therefore both relevant private actors in the market dialogue as well as other interested companies, organisations or institutions, e.g. knowledge institutions like universities, who have an interest in accelerating resource efficiency and sustainability, should be included. In this second step of the public-private innovation process, the established steering committee will continuously participate in the meetings with the market actors and make sure the dialogues are documented and that the overall juridical framework is followed.

Furthermore, it is necessary to emphasise, that a municipal facilitation of this second step of the process of public-private innovation requires extensive work, competences, resources, and time in order to establish the meetings with the market and make sure that the right private actors participate:

"Det er enormt svært at invitere 100 mennesker til en konference. De skal virkelig have vækket en appetit på hvad det kan være og det kræver, at man laver noget kommunikativt arbejde og at man får vækket interessen, og når de så kommer så skal man samtidig sørge for, at der står nogle klar til ligesom at fange dem og spire deres interesse til at gå videre (…) Og meget af det er noget basalt arbejde, men markedet føler ofte ikke, at det er seriøst nok, hvis de ikke har en kontaktperson, som de bare kan ringe og rådføre sig hos. Så igen, det er enormt tidstungt" (Raagaard Ernst, Gate 21, 29.05.2016).

After the first meeting with the market, it is especially essential that Roskilde Municipality allocate time and resources for taking care of the potential innovation partners:

"Så igen det vil kræve konstant pleje fra kommunens side, for når du først åbner op for sluserne for noget aktivitet for markedet, så skal man også bare have nogen, der sidder og fanger den. Og når den fanger, så skal den jo kortlægges. Det handler enormt meget om projekt styring og ledelse og finde ud af alle de små hurdles der kommer på vejen" (Raagaard Ernst, Gate 21, 29.05.2016).

Therefore it is necessary to initially acknowledge that the second step of external market dialogue requires continuous cooperation between the municipality and those market actors that potentially could be interested in initiating a process of innovation.

Set the model of operation of the sorting and warm water washing plant

When the market dialogue is established it is necessary to discuss the model of operation with the potential suppliers of the washing and sorting plant. Even though this was emphasised in the first step as well, it is naturally necessary to examine how the suppliers of the innovative solution imagine the model of operation after the sorting and washing plant has been build. As explained previously, there are two models of operating the plant – either it is build by the supplier and operated by the waste company K/N, or the plant is both build and operated by the private supplier.

In this relation, the first aspect to consider is if the private actors would at all be interested in investing and operating the sorting and washing plant. The second aspect to consider is whether or not a privately operated plant might make it difficult for the municipalities to ensure transparency in the system with the aim of securing the resources in the MSW plastic:

"Selv hvis det er i Danmark, og hvis det er et anlæg, der gerne vil snyde, så kan det jo godt gøre det. Det kommer an på priserne. Hvis det er for dyrt lige nu, så vil de hellere udsortere det til forbrænding fordi det sammenlagt er billigere end sortering og genanvendelse" (MSW plastic seminar, 7.04.2016, KL).

The question is if a privately owned plant might in periods choose a less environmental treatment option, if the prices on the sorted and washed plastic are too low. In this relation it is additionally necessary to emphasise the constraint within the statutes of K/N. As previously mentioned, if the MSW plastic is kerbside collected in the owner municipalities, they are obligated to deliver the plastic to K/N and hereafter it is up to K/N to decide where to deliver the recyclables (Roed, K/N, 21.04.2016). This means that K/N might not always deliver the MSW plastic for the specific sorting and washing plant if the prices for treatment at other plants are more feasible (Roed, K/N, 21.04.2016). From an economically point of view this might be reasonable, but considering Roskilde Municipality's goal of becoming the leading municipality of resource circularity, this option and the risk within, is not optimal. The overall aim is to facilitate an innovative solution and facilitate actual recycling of the MSW plastic for up-cycling purposes, and therefore it is recommended that the municipality should be ensured full visibility of what happens to the waste.

Ensuring cooperation between the actors in the value-chain

Besides developing an innovative solution for sorting and washing the MSW plastic, the most important outcome of the market dialogue is to establish cooperation between the relevant actors in the value-chain of plastic. This is recognised due to the fact, that if there is no cooperation and mutual understandings and agreements of the necessary quality of the plastic, it will most likely not be purchased by the next actor in the plastic value-chain, which then would lead to exportation and down-cycling like today. Thus, if there is not established cooperation between the actors in the plastic

value-chain, the necessary new actor-network for recycling MSW plastic will not be established, which then will be a barrier for closing the loop in Denmark. In relation to the theoretical understandings, it is thus important for Roskilde Municipality to focus on establishing translation processes that support and promote the cooperation between the various relevant actors across the plastic value-chain.

Therefore, the first aspect in this relation is to facilitate a dialogue about the specific quality of the MSW plastic. Considering that there currently is no Danish recycling of kerbside collected MSW plastic, this should obviously be discussed during the market dialogue. Firstly, the knowledge is inevitable for developing specific requirements that the innovative solution should be able to meet. Secondly, knowledge about specific quality requirements in the various stages though the plastic value-chain is necessary for the individual actors to know, thus what specific level of quality should be reached in order for the MSW plastic to be purchased by the next actor in the plastic value-chain.

The second aspect for Roskilde Municipality to consider in the market dialogue is how to actually ensure a resilient and transparent system where the MSW plastic continuously will be recycled and up-cycled as it moves through the established stages in the plastic value-chain:

"Det bliver svært at håndhæve output kravene når plasten bliver sendt mellem forskellige anlæg. De forskellige operatører er ikke forpligtede til at behandle plastikken på nogen bestemt måde, når først de har den i deres hænder " (MSW plastic seminar, 7.04.2016, MST).

Adding to this, it should be considered how to ensure a stabile and resilient system within the value-chain where the MSW plastic is not treated or exported for other purposes if e.g. the demand and market prices on secondary plastic are low:

"Olie priserne er én ting, og samtidig så er der det årligt tilbagevendende problem i denne periode, at kineserne holder et forholdsvist langt kinesisk nytår. Og når de holder nytår, så holder alle undtagen dagligvarebutikker lukket. Det betyder så, at efterspørgslen på sorteret plast den falder, og så falder prisen. Det er jo verdensmarkedspriser" (Olsen, RenoNord, 21.04.2016).

Thus, various external aspects could affect the necessary stability and resilience in the system. A way for Roskilde Municipality to ensure collaboration between the actors in the value-chain, could be to set up a contract:

"Hvis du vil have at aktørerne skal samarbejde, så bliver der nødt til at være en eller anden kontraktuel forpligtelse, og hvis du laver et udbud, så i stedet for at udbyde et sorteringsanlæg og udbyde en modtageydelse på oparbejdningsanlæg separat, så ville man kunne udbyde det samlet. Så bliver aktørerne jo tvunget ind. Så kan det være den ene skal være underleverandør til den anden, men på den måde tvinger du i hvert fald parterne til at samarbejde (…) Det sker rigtig ofte, at man udbyder opgaven samlet selvom man godt ved at markedet faktisk er delt op, hvor der er nogen, der gør det ene, og nogen der gør det andet" (Jarlov, Rønne & Lundgren, 29.04.2016).

Naturally this can potentially have the risk that no private actors are willing to bid on the assignment, but this is exactly what the market dialogue prior to the tender should seek to prevent:

"Man (ordregiver) siger, at nu laver man en opgave hvor man godt ved, at det går på tværs af den måde markedet ser sig selv på og hinanden på. Så for at hindre, at man ikke får nogle tilbud ind, jamen så

starter man med at massere markedet så de relevante aktører er med på hvad der ligger i opgaven, så de ikke bliver skræmt når de ser udbuddet – så ved de på forhånd, at opgaven vil blive udbudt som en samlet ydelse og så må de så internt organisere sig på en måde som de kan håndtere – og hvem er underleverandør til hvem eller vil man gå sammen i et konsortium eller hvordan vil man gøre det" (Jarlov, Rønne & Lundgren, 29.04.2016).

"Man skal se behandlingen i en sammenhæng gennem hele forløbet (…) Så har man hele forløbet samlet og så kan aktørerne ikke skubbe ansvaret fra det ene led til næste led og sige 'jamen det er også fordi entreprenøren eller vognmændene er elendige til at hente tingene, det er derfor plasten eller glasset går i stykker'. Hvis det er samme person eller partnerskab, der har ansvaret gennem hele leddet så får man nogle andre ting og opnår bedre resultater" (Jørgensen, Affaldskontoret, 5.04.2016).

Thus by setting up a contract Roskilde Municipality has the possibility of ensuring collaboration between the various actors in the MSW plastic value-chain, which is essential in order to assure the plastic resources to be actually recycled or up-cycled in Denmark.

Sum-up on the second step of the public-private innovation process

The second step in the process of doing public-private innovation is where Roskilde Municipality facilitate a market dialogue with the purpose of gathering relevant private actors, that potentially could be a part of developing the innovative recycling solution. Meetings and workshops should be included in this second step, including various relevant actors both across the plastic value-chain in Denmark and potential developers and suppliers of the solution, as well as including relevant persons from knowledge institutions.

By creating a market dialogue that consists of various relevant actors within and outside the waste sector and by bringing together as much knowledge as ambitiousness as possible, the best foundation for the development of the innovative solutions is established. After the first step of the public-private innovation, it is necessary for Roskilde Municipality to emphasise their vision and their demand for an innovative solution that prepares the MSW plastic for the next stages in the plastic value-chain. This means that the point of departure for the market dialogue is the public demand and specific needs identified in the previous step.

During the market dialogue, it is necessary to support a discussion and a settlement of the level of quality the plastic should reach after the sorting and warm water washing. This way the municipality additionally receive knowledge about the requirements from the private actors, and is thus able to initiate actions to gain more volume of the MSW plastic, if necessary. The model of operation should be determined in collaboration between the potential private partners and Roskilde Municipality and the multiple other municipalities. Furthermore, it should be discussed and settled which quality the plastic producing companies require for the processing companies to reach. Thus, the dialogue, cooperation, and visibility across the potential MSW plastic value-chain should be set, and adding to this, the municipality should emphasise the necessity of ensuring the MSW plastic to be fed back into the loop by actual recycling or up-cycling. Finally it is necessary to recognise that the process of public-private innovation requires extensive work and competences in the municipality. Initiating a market dialogue with the relevant private actors is difficult and especially the process of continuously cooperating with the actors in the third step of the public-private innovation process requires extensive municipal resources.

Again, considering the theoretical understandings of how an actor-network is constructed by processes of translation, Roskilde Municipality should in this second step focus on the translation processes between the actors in the plastic value-chain. This should be done by establishing dialogues and discussions about how to solve the problem of recycling MSW plastic in collaboration, thus seeking to create common understandings of the required quality. This means that the action of facilitating cooperation between the various actors in the value-chain is essential to form the basis of the new actor-network where the MSW plastic is recycled and up-cycled in Denmark, and additionally to form the basis for the third step of the public-private innovation process – establishing innovation consortiums.

6.1.3 Step 3: Establishment of innovation consortiums via tender-less contracts

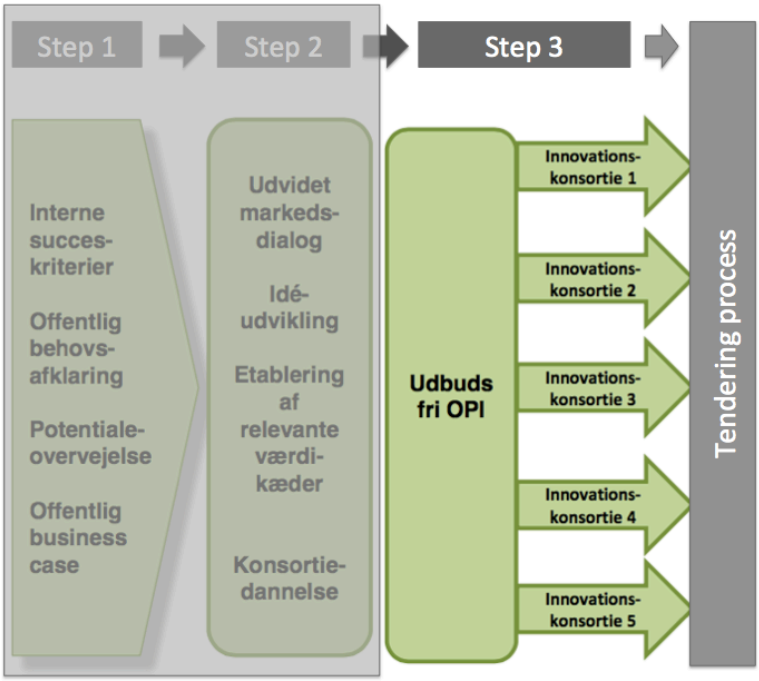

Figure 8: Focusing on the third step of doing public-private innovation

After both the internal and external market dialogue, the private market actors form innovation consortiums with the purpose of actually developing and testing the innovation by continuously getting feedback from the municipality. This is the third and last step of the public-private innovation process before the innovation is put out to tender. After the market dialogue, the private actors know which demands the innovative solution should meet and they can form innovative consortiums that consists of relevant actors across the stages in the plastic value-chain that need to cooperate in order to develop the demanded innovation:

"Efter markedsdialogen, tegner der sig eks. 3 konstellationer, som vi som kommune godt kunne tænke os at arbejde videre med. Så kunne man vælge at sige, nu overgår vi til et mere formaliseret samarbejde, hvor vi indgår en samarbejdskontrakt med de her 3 konsortier. Vi ved stadig ikke hvad vi skal købe, men vi vil gerne holde dem kontraktuelt op på, at de forpligter sig til at indgå i et samarbejde omkring et eller andet fælles udviklingsmål. Så det er ikke en leveranceaftale, fordi der er ikke nogen leveringsforpligtelse, men de forpligter sig til at indgå et samarbejde" (Jarlov, Rønne & Lundgren, 29.04.2016).

This means that since there is no commitment for delivering a certain work, good, or service, there is no need for putting the contract out to tender. Therefore the three described steps can together be characterised as a tender-less public-private innovation, which means that there is no obligation for the economic actor or supplier to deliver a certain innovative solution, but rather an obligation for cooperating with the public authority on developing an innovative solution that lives up to the public demands:

"Der er ikke nogle misligholdelsesbeføjelser ift. det produkt han ender ud med at levere fordi det han leverer det er, at han gerne vil indgå i et samarbejde. Og så må man se hvad det samarbejde fører til via leverandørens bidrag og myndighedens bidrag, men der er ikke en resultatforpligtelse som der ville være i en normal leverancekontrakt (Jarlov, Rønne & Lundgren, 29.04.2016).

Thus in the third step of the public-private innovation the actors in the market dialogue form innovation consortiums that seek to live up to the requirements and demands from the municipality. Therefore, if Roskilde Municipality demanded an innovative solution that could ensure the MSW plastic to be sorted and warm washed to a quality that was attractive for the next actor to purchase, and afterwards recycled through an established plastic value-chain in Denmark, the innovation consortiums should consist of relevant actors across the plastic value-chain. The innovation consortiums would in collaboration develop the necessary technologies and the necessary cooperation in order to ensure the MSW plastic to actually be recycled and up-cycled instead of down-cycled or incinerated as the current option of exportation.

In this step of establishing innovation consortiums via tender-less contracts, Roskilde Municipality should create a plan for the process. This plan should consist of overall targets and milestones that can structure the process for both the public and private actors:

"Der skal selvfølgelig være nogle overordnede udviklingsmål og der skal forklares hvorfor et opi skal være med til at løse udfordringen og hvordan. Det er vigtigt, at man går ind og laver mål og milepæle og opdeler processen. Det skal ikke være fuldstændig detaljeret, men det er vigtigt, at der er en form for overordnet plan, så man har noget at holde sig til (Raagaard Ernst, Gate 21.29.05.2016).

Within this overall plan of the process there should be incorporated exit strategies. By doing so it is possible for both the public and private actors to withdraw or stop the process even though a tender-less contract has been made:

Men det er også rigtig vigtigt at man har nogle exit strategier for det. Hvis man når til, at det viser sig, at der er et eller andet med plast, hvad gør vi så. Og det er rigtig fint, at man i løbet af sådan et år laver kvartalsvise exit strategier. Og det beroliger både de offentlige og private parter. Så en eller anden form for aftalestruktur, og den kan se forskellig ud juridisk" (Raagaard Ernst, Gate 21, 29.05.2016).

As mentioned in the second step of the public-private innovation process, it is necessary that Roskilde Municipality has the right competences for facilitating this process. The innovation happens when the public and private actors cooperate on the development, which naturally means that the municipality should be able to participate and contribute to the discussions and help the private actors whenever needed:

"... kommunen skal jo være gearet til at indgå i samarbejdet. Så hvis det er en kommune som ikke er så moden i det ift. sådan nogle dialogprocesser – det stiller krav for at kommunen også kan indgå i det her samarbejde og kan komme med bidrag for det er jo det det kræver. Innovationen sker jo i et krydsfelt mellem leverandøren og myndigheden, så hvis myndigheden ikke kan være en aktiv deltager i innovationsforløbet og kan give feedback og har nogle medarbejdere, der har den viden der skal til for at komme med feedback til leverandøren, så tror jeg ikke det er en god udbudsform" (Jarlov, Rønne & Lundgren, 29.04.2016).

6.1.4 The innovation is put out to tender

When the third and last step of the public-private innovation process is finalised and the development of the innovative solution is made, the procurement is put out to tender as illustrated in figure 4:

"Når man er færdig med OPI (offentlig-privat innovation) og når i mål, så kan det være man står med en eller anden prototype for et produkt, og nu vil man (ordregiver) så gerne begynde at købe det ind. Så opstår udbudspligten, for så vil man jo gå over i at foretage et decideret indkøb. Og der skal man så gennemføre et udbud" (Jarlov, Rønne & Lundgren, 29.04.2016).

This means that the process of public-private innovation should have resulted in various specification for the solution to be included in the tender documents, which have been formed and developed firstly through the internal and external market dialogue and afterwards though the innovation consortiums. Based on this process of public-private innovation, Roskilde Municipality should be ready to shape the tender documents to fit the demanded innovative solution that has been developed based on the success criteria set by the local government of Roskilde and developed during the process. After the public-private process, the way of putting the public procurement out to tender would then be via a normal tendering procedure and not via the new tendering procedure innovation partnerships:

"Man har en markedsdialog og et udbudsfrit OPI og så har man efterfølgende et traditionelt indkøb - måske udbud med forhandling (...) Jeg tror ikke på, at man vil have et forløb hvor man laver markedsdialog, udbudsfrit OPI og efterfølgende udbyder et innovationspartnerskab – det tror jeg simpelthen ikke på. Fordi hvis du både har markedsdialog og OPI så tror jeg ikke du har et behov for at lave et innovationspartnerskab fordi så har du jo haft innovationsforløbet – det har du så bare haft i det udbudsfrie OPI (...) Så jeg tror ikke på at man har to udviklingsforløb med afprøvning som man jo vil have både i et udbudsfrit OPI og i et innovationspartnerskab – jeg tror ikke man vil køre den der mulighed for at have konkret feedback to gange" (Jarlov, Rønne & Lundgren, 29.04.2016).

Naturally as mentioned previously, it is also possible for the municipality to use the new tendering procedure of innovation partnerships, but in this case of seeking to establish an entire new actor-network constituted by the various relevant actors across the plastic value-chain, as well as building a new sorting and warm water washing plant, it is recommendable to initiate a process of public-private innovation in order to test the market and in collaboration shape the municipal demand and the innovative solution:

"Det er klart, hvis det er et helt nyt område som det her er, så vil det da nok være en god idé at man tester markedet af og får markedet motiveret til at gribe opgaven når den så efterfølgende kommer i et udbud" (Jarlov, Rønne & Lundgren, 29.04.2016).

Another aspect to consider is the main difference between the process of public-private innovation and to put innovation partnerships out to tender. The difference between a process of public-private innovation prior to a tender and the new tendering possibility of innovative partnerships, is that the economic actors are not obligated to develop and deliver a certain innovative work, good, or service. Considering that this specific area of seeking to ensure closing the loop of MSW plastic is completely novel in Denmark, it might be difficult to get relevant economic actors within the plastic value-chain to bid on the tender because they would be obligated to deliver a solution:

"Jeg har ærlig talt svært ved at forestille mig, at virksomhederne har lyst til at indgå den slags forpligtelser som der ligger i et innovationspartnerskab. Selvfølgelig er de sikret at vinde opgaven og at deres løsning bliver købt, men det kan være svært for dem at overskue om de har kompetencerne til at løse opgaven og imødekomme kommunens behov, og det tror jeg er nok til at de holder sig væk og fortsætter med det de er vant til" (Jørgensen, Affaldskontoret, 5.04.2016).

Contrary, the process of public-private innovation is emphasised as a lighter version, which makes it more approachable for private actors:

"Vi arbejder ofte med den udbudsfri opi-proces, og vi har erfaringer med, at det er en aftalestruktur, som er light i sin version, at folk ikke føler de bliver bundet til noget og at det samtidigt for de private håndterer problematikker som inhabilitet og at man på ingen måde kommer til at indgå i noget konkurrenceforvridende" (Raagaard Ernst, Gate 21, 29.05.2016).

6.2 Additional initiatives to promote closing the loop

Recognising that Roskilde Municipality is able to initiate a facilitation of developing an innovative sorting and washing plant as well as establish cooperation in the plastic value-chain that leads to actual recycling and up-cycling, it might be necessary to include other initiatives for promoting and accelerating an establishment of a market in Denmark. This means that various initiatives by other actors than the municipality could be implemented as means for establishing the necessary new actor-network and as a way to promote closing the loop of MSW plastic. Firstly two means that potentially could promote the market establishment will be discussed, followed by a brief discussion of implementation of taxes, subsidies, and labelling schemes. Finally it is assessed how these various means and initiatives might promote a market establishment for the secondary plastic.

- Extended producer responsibility
- Extended deposit system
- Taxes, subsidies, and labelling schemes

Recognising that a large constraint lies within gathering enough volume (chapter 5), a way to collect more plastic from the households could be by implementing extended producer responsibility in Denmark, which is defined as *"an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle"* (EU, 2014, p 10). This implies that the producing companies would be obligated to collect used products and goods to be sorted and treated for recycling. Ideologically it makes sense that the producers of the plastic products and packaging waste should have the full responsibility throughout the lifetime of the products - from the production of the goods, to the collection, and finally to the recycling - instead of the municipalities. An implementation of extended producer responsibility *"should aim at internalising environmental externalities and should provide an incentive for producers to take into account environmental considerations along the products' life, from the design phase to their end-of-life"* (EU, 2014, p 10). This means that the responsibility for collecting, sorting, and recycling might have a positive effect on the design of the products, which could lead to products and packaging that are more easy to recycle with the purpose of feeding the resources back into the cycle. One particular example worth mentioning is black plastic. This plastic is especially used as packaging for food, and every year approximately 120.000 tonnes black plastic packaging are wasted in Denmark due to the fact that it is not currently possible to mechanically separate black plastic at sorting plants (European Media Partner, 2016). If an extended producer responsibility was implemented, and the producers of black plastic packaging had the responsibility of sorting and recycling, it probably would be beneficial to change the colour of the plastic in order to recycle the plastic. Therefore, when focusing on the need for transitioning towards a more circular model where the resources are effectively utilised over and over, the take-back obligation could definitely be favourable in relation to products. Especially products like TVs, furniture, bikes, tools etc., could presumably lead to more repairing of products and to a redesign of

the products so they are easy to repair in the end. Furthermore this could lead to increased leasing and renting of products, which is closely related to the goal of transitioning to a circular economy. Another means for gathering more volume of the MSW plastic could be to extend the current deposit system. Todays deposit system includes plastic and glass bottles and cans for beverages (Miljø- og Fødevareministeriet, 2015a). Various new types of plastic packaging has been developed and put on the market, which could be included in the current deposit system and thus more MSW plastic volume would be gathered for recycling.

Naturally these emphasised means cannot be implemented from a municipal level or via the process of public-private innovation, but should be implemented by legislation. The extended producer responsibility would firstly force the producing companies to collect their products and secondly lead to more MSW plastic being separated for recycling. Similarly the extended deposit system would lead to more MSW plastic being separated for recycling when the consumers return the plastic. By implementing these two means, more plastic would be gathered for recycling, which is necessary in order for the private actors on the market to focus on establishing a business for recycling (DI, 2016). Furthermore, promoting a MSW plastic market establishment could potentially be initiated by additional governmental lead initiatives like taxes, subsidies, and labelling schemes. To cope with the negative externalities of using virgin plastic in production, the virgin plastic could be subject to taxation. This way the plastic producing companies in Denmark would be 'forced' into using secondary plastic instead. Another way could be to give subsidies for plastic producing companies using the secondary plastic in their production, but compared to the taxation this incentive might not be as effective. A third option for the government to motivate the market to include secondary MSW plastic in their production, could be to establish a labelling scheme for products or packaging that contains or has been made of secondary plastic. By doing so, a choice is given to the consumers and not only to the producers, which could result in a rising demand from the consumers and thus increased incentive for the plastic producing companies to include secondary MSW plastic in production. It is obviously necessary to recognise that Denmark is not a closed market, but an open market and multiple imported products and packaging are sold here. In order to implement subsidies, taxes, or a labelling scheme it requires the current government to be willing to make long-term political strategies and invest the money in accelerating the circular economy in Denmark.

Therefore, promoting a market for secondary MSW plastic, presumably requires initiatives to be made from the governmental level, while the authorities at the municipal level can push and accelerate the market both by demanding development of innovative solutions as well as procuring products made from recycled plastic instead of virgin. Even if Roskilde Municipality is able to facilitate a development and building of an innovative MSW plastic sorting and warm washing plant, it is essential that there be created a Danish market for the secondary plastic. This is crucial in order to ensure the sorted and washed plastic to proceed further to the next stages in the plastic value-chain and finally be included in new plastic production in Denmark. It is necessary that the secondary MSW plastic obtain enough value through the stages in the value-chain for the plastic producing companies in Denmark to demand it. Thus, it is crucial to ensure that it is not more feasible in periods to direct a large part of the MSW plastic from the sorting plant to the incineration plant, which is depended on both the quality of the secondary plastic as well as the demand from the market and prices on the plastic.

6.3 Sum-up and reflections on the roadmap to an innovative recycling solution

This chapter has firstly recognised the process of public-private innovation as a potential way for an ambitious municipality to facilitate a transition towards establishing a Danish rooted innovative solution. By doing this tender-less process prior to a tender it is possible for Roskilde Municipality to shape and test the market and establish the necessary cooperation between various relevant actors before the procurement is put out to tender. This is especially useful due to the fact that there is currently no Danish recycling solution of the MSW plastic and therefore the market is not yet supporting this. The process of public-private innovation could lead to an establishment of a new actor-network consisting of relevant actors across the plastic value-chain whom in cooperation add value to the MSW plastic and finally ensures that the output is not just down-cycling and incineration like the output of the only currently available recycling option.

It is necessary to emphasise how the process of public-private innovation is initiated. Even though the waste planners in Roskilde Municipality are ambitious and possibly have the vision of facilitating and finding a better recycling option for the MSW plastic, it requires more:

"Det starter ikke nede på embedsmandsniveau – det er jo helt oppe på chefniveau, at man tager en beslutning, hvor man siger 'den her ressourcer, den frikøber jeg' eller køber nyt personale ind, så man kan frikøbe nogle ressourcer og man siger 'nu lægger I de projekter I har på hylden, og så committer I 100% til det her projekt, og så er det jer der er tovholdere og projektledere'. Men det e jo en chef, der laver en investering. Det er en der kan se, at det godt kan betale sig, dvs. det er en der er visionær – og de hænger altså ikke bare på træerne. Men det er der det starter. Og jeg vil vove at påstå, at hvis du ikke har din ledelse med, og hvis du ikke engang har fået det næsten dikteret af ledelsen, så kommer man ikke særlig langt. Det her er jo langvarige samarbejder og en meget lang investering" (Raagaard Ernst, Gate 21, 29.05.2016).

Thus, because the process of public-private innovation is a demanding process both in terms of time and resources, it naturally requires support and ambitiousness from the municipal decision-makers and politicians in order for the process to be initiated and for the investments to be approved. When the new waste scheme in Roskilde Municipality was planned and it was discussed which fractions to include, the municipal city council initially wanted to collect the plastic (chapter 4; Sejersen & Fallov, Roskilde Kommune, 15.04.2016). This indicates that the municipal city council are not currently envisioning Roskilde Municipality as potential frontrunners, but considering their municipal goal of becoming the leading municipality of resource circularity (Roskilde Kommune, 2015), the city council should be willing to initiate various initiatives that seek to meet this goal. In this relation, the waste planners in Roskilde Municipality do not reject the thought of the political city council to grant an investment in a plastic sorting plant:

"Når man har kastet 25% af 1,4 mia. i et forbrændingsanlæg, så tænker jeg da hvorfor skulle man ikke også gøre det med et plastsorteringsanlæg. I Aalborg har de bygget for ca. 100 mio., så hvis vi skulle have et plastsorteringsanlæg i Roskilde ville det jo være et langt mindre beløb. Så det er jo ikke i nærheden af investeringen som vi har gjort i forbrændingsanlægget. Så hvad er vi så forsigtige med? Jeg tror det handler om, at der bliver taget en politisk beslutning om, at nu skal vi tage et initiativ og så hvem skal vi have i spil" (Sejersen & Fallov, Roskilde Kommune, 15.04.2016).

Whether or not the political city council and the municipal decision-makers would be willing to initiate a process of public-private innovation to facilitate an innovative recycling solution in Denmark is uncertain. But it is certain, that in order to actually initiate and facilitate the process, it requires extensive work, resources, and competence from the municipality. Roskilde Municipality should be geared to work together with the relevant private actors in the plastic value-chain in order to collaborate on developing the innovative solution and set the standards for the recycling. This obviously requires specific knowledge and insights to technological, institutional, political, economical, and juridical aspects that the process of public-private innovation would include, and in order for the waste planners in Roskilde Municipality to gain this specific knowledge, it is necessary that the political city council and municipal decision-makers are willing to invest in this. Thus, in theory it is not impossible for a municipality like Roskilde to initiate the process of public-private innovation, but the question is if the municipality would be able to facilitate this process single-handedly or if it is necessary to collaborate with e.g. an organisation like Gate 21, whom has specialised in this kind of public-private cooperation:

"Men sådan rent teoretisk er der jo ikke noget til hinder for, at en kommune ikke også kan facilietere det her arbejde – dvs. sætte sig ned og sætte sig helt ind i det. Men jeg tror det kræver, at man allokerer nogle ressourcer, der så kan være committet til det – det kan ikke være en person, der skal sidde også lave andre opgaver, som tager hele dagen. Det er decideret projektledelse, og det er constant caring (…) Så metodisk tilgang kan sagtens replikeres, men det kræver, at man kan se alvoren i metoderne, og de steps, og den ledelse der skal til og hvis man ikke kan investere i den, så kommer man ingen steder (Raagaard Ernst, Gate 21, 29.05.2016).

According to the theoretical approaches applied in this project, the current Danish waste system is a complex actor-network constituted by various human and non-human actors that in collaboration continuously reinforce the outcome of this network. Chapter 5 emphasised that the current actor-network supporting exportation of MSW plastic is in a state of lock-in, which can limit the municipal possibility of choosing an alternative recycling option and thus the municipal room to manoeuvre. A radical change is necessary in order to redirect the current way of exporting MSW plastic for recycling towards establishing a Danish actor-network that includes the various stages in the plastic value-chain and cooperation between the various relevant actors within. In order to reconstruct this current actor-network into a necessary new actor-network, Roskilde Municipality should specifically focus on the processes of translation. These translation processes are the interactions and connections that should be promoted between the various relevant actors across the MSW plastic value-chain. Therefore, Roskilde Municipality should focus on the theoretically emphasised necessary processes of translation when seeking to facilitate the process of public-private innovation with the aim of establishing a Danish rooted innovative recycling solution of MSW plastic.

7 Conclusion

A big waste resource challenge faced today, is how to utilise and sustain the valuable resources within MSW plastic. Based on this recognition, the purpose of this project was to analyse how to potentially redirect the currently unsustainable overexploitation of natural resources by ensuring a way to sustain the resources within MSW plastic. Today half of the municipalities in Denmark are collecting MSW plastic for recycling, which seen from a resource point of view, is simply not good enough. The problem is not the amount of municipalities collecting the MSW plastic, but rather the fact that the only currently available option of recycling is to export the plastic to sorting and treatment facilities in other countries, where the actual amount of MSW plastic being recycled is far from satisfying. Considering both EU and national goals of ensuring and securing the valuable resources in the waste, it is therefore a necessity that the current way of recycling the plastic is fundamentally changed. It is necessary to accelerate initiatives that seek to close the loop of MSW plastic, where the secondary plastic can substitute the use of virgin plastic in the production of products and packaging, instead of just being down-cycled and incinerated as today.

Initiating and facilitating a transition away from the currently available recycling option of exportation is a challenging task for a municipality. It is emphasised that the current system can be characterised as being in a state of lock-in to exportation of the recyclable MSW plastic, which can limit the possibilities for an innovative solution to emerge on the market. This is due to various constraining technological and institutional actors and aspects. Briefly emphasising some of the constraints identified, the aspects of market exposure of company recyclables and the municipal responsibility of individually reaching recycling targets, can have a constraining effect on the possibility of assuring the right volume necessary to make investments in a plastic sorting and washing plant feasible and attractive. Recognising the importance of gathering a large volume, these aspects together form a large constraint. Another potentially constraining actor is the municipal waste company - especially if the owner municipalities are obligated to deliver their MSW plastic to them, as in the case of K/N. This means that K/N is entitled to sell the MSW plastic to recycling facilities of their choice, which means that the municipality have no certainty of the recycling procedure, thus if the plastic is finally recycled for satisfying purposes. Added together, various constraints potentially can limit the municipal room to manoeuvre, thus the municipal possibility of choosing a different and more ambitious MSW plastic recycling solution than the currently available is limited.

Therefore the main focus of this project was to analyse how a municipality like Roskilde potentially can facilitate a development towards increased and better recycling of MSW plastic, and thus seek to un-lock the system. Roskilde municipality has two choices: to be reactive and await for an innovative recycling solution to emerge, or to be proactive and seek to facilitate this development themselves. Recognising that the municipality has already chosen not to collect MSW plastic due to the current option and recognising the municipal goal of becoming the leading municipality of resource circularity, Roskilde Municipality should choose to be proactive. In this relation, the three-step public-private innovation process prior to a tender is emphasised as the optimal way for Roskilde Municipality to accelerate and facilitate the development of a Danish innovative recycling solution, that ensure the resources within the recycled MSW plastic to substitute virgin plastic. Developing the innovative recycling solution in interaction with the private actors across the plastic value-chain makes it possible to facilitate a solution that reaches the quality requirements, and thus an establishment of the necessary market conditions for the MSW plastic would be promoted.

The first step of the public-private innovation process is where the municipality internally decide and specify the municipal vision and which public demand the innovative solution should be able to cover. The vision for Roskilde Municipality should be to ensure actual recycling and up-cycling of the MSW plastic, thus to close the loop of recycling in Denmark. General recommendations for the first step:

- Be ambitious and envision an innovative solution that ensure the MSW plastic to gain the quality required by the market and the actors in the plastic value-chain
- Initiate cooperation with the other eight municipalities in the area of K/N in order to gather large volume, with the purpose of making the MSW plastic an attractive commodity and as well as ensuring the innovative solution to be feasible
- Establish an internal market dialogue consisting of experts and specialists in order to determine and specify the public demand for the innovative solution, thus laying the optimal groundwork for the external market dialogue with the private actors on the market.

The second step of the public-private innovation process is where Roskilde Municipality establishes a market dialogue that consists of relevant private actors across the plastic value-chain as well as relevant actors within and outside the waste sector. By bringing together as much knowledge and ambitiousness as possible, the best foundation for the development of the innovative solutions is established. General recommendations for the second step:

- Emphasise the municipal vision of closing the loop of MSW plastic and demand an innovative solution that ensures the plastic to actually be recycled and up-cycled
- Emphasise the necessity and the demand of visibility and transparency in the system
- Facilitate a market dialogue about which quality requirements of the MSW plastic the innovative solution should be able to meet, in order for the plastic to further move though the stages of the plastic value-chain as a valuable commodity that the actors on the Danish market is willing to purchase.

The third step of the public-private innovation process is where the private actors form innovation consortiums based on the public demands and requirements determined in the previous step. The purpose is to actually test and develop the specifications for the innovative solution in collaboration with the municipality. General recommendations for the third step:

- Create a plan for the third step consisting of overall targets and milestones that can structure the process for both the public and private actors
- Incorporate exit strategies in the tender-less contracts with the innovation consortiums, in order for both parties to be able to withdraw from the cooperation.

Hereafter the developed innovative solution is put out to tender. It is necessary to emphasise, that the process of public-private innovation requires extensive work and competences within the municipality, and therefore support and ambitiousness from the political city council is essential if Roskilde Municipality should be able to facilitate the development of an innovative recycling solution and thus seek to close the loop of MSW plastic in Denmark.

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