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The Use of Pay as You Throw Schemes and Central Sorting in Municipal Solid Waste Management.

-A case study of potential measures to increase sorting and recycling rates of plastic packaging in More and Romsdal, Norway.

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Globalization
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Problem Description

The objective and purpose of this study is to investigate the potential of increasingly using pay as you throw (PAYT) schemes and central sorting as instruments in municipal solid waste management to increase sorting- and recycling rates of plastic packaging, as well as their possible contribution to achieving future recycling targets for household waste.

Main content

•Introduction to the topic and research questions

•Overview of theoretical resources and concepts relevant to this study

•Presentation of status and trends in Norwegian municipal solid waste management and the use of selected tools: PAYT schemes and central sorting.

•Presentation of qualitative data with relevant waste management actors regarding their view on selected waste management tools to increase recycling rates of plastic packaging and achieve recycling targets for household waste.

•At the end follows analysis, discussion and results around the potential use of PAYT schemes and central sorting as tools to enhance recycling rates of plastic packaging in More and Romsdal and if possible give recommendations.

Preface

This study is written and supervised by the Department of Industrial Economics and Technology Management (IØT) during the spring of 2018. This thesis is the final result of the MSc in Globalisation, Transnationalism and Culture at the Norwegian University of Science and Technology (NTNU) in Trondheim.

This thesis was inspired by a personal interest in sustainability, in addition to a previous case study written the fall of 2017. The study was conducted as part of an internship at the recycling company TerraCycle and involved how TerraCycle and their brand partners have developed sustainable business models together by creating new products out of waste. One such product was a shampoo bottle made of recycled ocean plastic. The internship taught me that sustainability doesn't need to undermine profitability and likewise the other way around. It is necessary and possible to come together to find better and smarter solutions for how to utilise more of our waste and close the resource loop. For this experience, I would like to thank my previous colleagues and supervisors at TerraCycle. Thanks to them I found my desired career path.

For this thesis, I would like to extend my gratitude to my supervisor John Eilif Hermansen, Associate Professor at IØT, NTNU, for his useful guidance and feedback throughout the process of writing this study. To my co-supervisor Haley Knudson, thank you for your "nit-picky" English and helpful comments on the study. I would also like to thank the general manager of ÅRIM, Øystein Solevåg, for sharing his knowledge and time for this study. I must also say thank you to all of the participants in this study. This study would not have been possible without you. Lastly, I would like to thank my friends and parents for their supportive words, grammar checks and discussions throughout this semester.

Abstract

As a contribution to achieving the future recycling targets for household waste as stated in the Waste Framework Directive (Directive 2008/98/EC), the potential of increasingly using differentiated waste fee (pay as you throw-schemes) and central sorting in the local municipal solid waste management has been explored. These measures were identified and recommended by the Norwegian Environment Agency (Miljødirektoratet) as important drivers towards reaching recycling targets set at 50 % for specific waste fractions in household waste, and especially with focus on plastic packaging waste and organic waste. This recycling target further increases to 65% by 2030. According to Statistics Norway, the recycling rate for household waste in Norway, was measured to be 38% in 2017, which means that Norway is lagging behind and urgent measures are needed to achieve international agreed targets. Efficient sorting by the source in households is still viewed as the most important measure to increase recycling rates, however, it is necessary to evaluate if automated post-sorting of municipal solid waste (MSW) can function as an additional tool in today's municipal solid waste management systems.

This project is conducted in collaboration with the inter-municipal waste management agency Ålesundregionens Interkommunale Miljøselskap IKS (ÅRIM), situated in Aalesund and seek to explore the possibilities of establishing a local central sorting facility in Aalesund, through an association between the waste regions in More and Romsdal. The study provides a qualitative analysis of current MSW management systems in the different waste regions and evaluates how the use of PAYT schemes and central sorting can enable higher sorting rates – and thereby recycling rates of plastic packaging in households. Results from the study indicates that PAYT schemes have a larger effect in municipalities with already low sorting rates of plastic packaging. In municipalities with higher sorting rates, the use of information and campaigns seems to release more effects and have helped enhance and stabilise consumers support of already existent sorting- and collection system. The study suggests that the use of PAYT schemes has its limitations when it comes to increasing sorting rates of plastic packaging and achieving future recycling targets. Increased regional cooperation is suggested to enhance the efficiency of PAYT- schemes. In this study, the use of central sorting is assessed as a constructive and necessary solution to recycle more complex plastic materials, achieve future recycling targets and align the waste management with circular economy principles. A local central sorting facility is therefore deemed to be a positive supplement to existent sorting by the source systems in More and Romsdal.

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Acronyms and Abbreviations

EEA- European Economic Area (EØS)

EC- European Commission

EMF- Ellen MacArthur Foundation

EU- European Union

GPN- Green Dot Norway Plc (Grønt Punkt Norge). Non-profit organisation responsible for the collection and recycling of plastic packaging waste from industry and households in Norway

IMA- Inter-Municipal Waste Management Agency (Interkommunalt Avfall Selskap)

MSW- Municipal Solid Waste

NEA- Norwegian Environment Agency (Miljødirektoratet)

PCC- Paper, Cardboard and Carton

PWD- Packaging Waste Directive

SDG- (United Nations) Sustainable Development Goals

SSB- Statistics Norway (Statistisk Sentralbyrå)

UN- United Nations

WFD- Waste Framework Directive

Inter Municipal Waste Management Agencies and other Waste Management Organisations.

Avfall Norge- A Norwegian waste management and recycling association.

VØR– IMA in Volda and Orsta area (Volda/Ørsta Reinhaldsverk)

ÅRIM- IMA in Aalesund area. (Ålesundregionens Interkommunale Miljøselskap IKS)

RIR- IMA in Molde area (Romsdal Interkommunale Renovasjonsselskap IKS)

NIR- IMA in Kristiansund area (Nordmøre Interkommunale Renovasjonsselskap)

SSR- IMA in Ulsteinvik (Søre Sunnmøre Reinhaldverk)

TAF- Incineration facility located at Grautneset, Aalesund (Tafjord Kraftvarme AS)

NoMIL- IMA in Sandane, Sogn and Fjordane County (Nordfjord Miljøverk)

Bingsa- Industry sorting facility in Ålesund

ROAF- Central sorting facility located at Romerike, close to the Oslo Area (Romerike Avfallsfordeling)

SESAM- A central sorting facility project to come in Trondheim

IVAR- A plastic sorting facility to come in Stavanger

1 Introduction

Today, the production of plastic relies almost entirely on feedstocks of non-renewable resources. With limited fossil resources to produce plastic and a growing population, one now knows that this road is not sufficient anymore. In addition, there has been more land-based and marine littering of plastic and micro-plastics, which increasingly are threatening eco-systems, animal life and human's livelihood. When striving towards a circular economy, one needs to decouple the production of plastic from non-renewable resources and reuse or recycle the plastic already produced to close the material loop and maintain the world's natural resources.

Norway is obliged through EU's Waste Framework Directive (WFD) to move its waste management towards a 50% recycling rate of household waste and similar waste from the industry by 2020 (measured in weight). This target for recycling and preparation for reuse of municipal solid waste (where plastic is one component), has recently been raised to 65% by 2030. In 2014, the European Commission published the Circular Economy Package, where they reviewed the targets set out in the WFD, in addition to the Packaging and Packaging Waste Directive (PWD) (EC, 2015a). Following the circular economy action plan, it was then proposed changes to the PWD where it was suggested that 75 % of all packaging should be recycled within 2030. Whereas, 55% of plastic packaging should be prepared for reuse and recycling by 2025 (European Parliament, 2016).

According to Statistics Norway, Norway has currently an average recycling rate of 38 % of MSW and is therefore behind the 50 % recycling target by 2020 set by the WFD (SSB, 2017a). According to Green dot Norway (GPN), Norwegian households produce 97 957 tonnes of plastic packaging each year. This equals 18 kilos per capita (GPN, n.d). In an industry analysis done by the Norwegian waste management and recycling association, Avfall Norge, in 2016, it was identified a huge potential in collecting, sorting and recycle plastic waste from MSW in Norway. According to random samples from diverse MSW, these showed that as much as 76,4 percent of plastic materials are lost or mismanaged in collected MSW, while only 23,6 percent are recovered and recycled (Avfall Norge, 2016). This situation is also evident in Denmark and Sweden, where studies show that between 9 to 20 kilos of plastic packaging per capita are lost in the MSW, even though municipalities are offering separate sorting and collection systems for plastic packaging (Fråne et al., 2015). For

the purpose of this study, the meaning of the term "mismanaged" is the use of thermal treatment instead of recycling (also known as material recovery). According to GPN only 25% of the total amount of plastic packaging generated in Norway is recycled to become new materials. 73,7 % is used for energy recovery (GPN, n.d). In order to comply with future recycling targets, Norway needs to focus on how to retrieve more of the plastic fractions ending up in MSW and incineration facilities and put this back into the production circuit.

Numbers and figures presented by the research agency Ostfold Research (Østfoldforskning) and the Norwegian Environment Agency (hereby NEA) shows an increased sorting and recycling potential of 64 000 tonnes of plastic packaging from today's MSW (Raadal et al., 2016; Miljødirektoratet, 2017). Based on a report from Ostfold Research, the NEA in their own report suggested in 2017, for municipalities to increasingly differentiate their waste fee and for regional analysis to be carried out, to identify the necessity for more central sorting facilities in Norway. Both measures are meant to enhance the sorting rates, and thereby, recycling rates of plastic packaging (Miljødirektoratet, 2017). The NEA in their conclusion recommends a legal obligation to sort out organic waste and plastic packaging, and to increase the use of central sorting to replace sorting by the source systems for plastic waste (Miljødirektoratet, 2017).

1.1 Problem Description and Research Questions

With the recommendations given by Ostfold Research and the NEA in mind, this study seeks to explore how increased use of differentiated waste fee (PAYT schemes) and central sorting in MSW management, can enable higher sorting- and recycling rates of plastic packaging from households. While the use of central sorting is a rather new measure, the use of differentiated waste fee has been a well-known instrument in Norwegian MSW management systems to motivate households to reduce waste generation and increase sorting efforts. Still, information regarding how the use of differentiated waste fee affects sorting rates of plastic packaging is limited. However, the NEA suggest a differentiation based on the size of the bin will give the largest effect and incentives for households to sort their waste better (Miljødirektoratet, 2017).

In 2017, the inter-municipal waste management agency, ÅRIM, asked the consultant company Mepex to investigate the sorting potential and estimated costs, related to building a

central sorting facility in More and Romsdal. This resulted in a report, which is an important basis for this study, to explore whether this is possible to realise and how such facility can contribute to increasing sorting rates of plastic packaging and increase the overall recycling rates of the involved inter-municipal waste management agencies. The Mepex report, in addition to the Ostfold Research and NEA reports, will be more thoroughly explained in chapter 2.13 and chapter 3.2. In order to limit the topic and length of this thesis, restrictions were necessary. To easier structure the study and concretise the problem description, the description has been further divided into four research questions. To understand how the selected waste management tools can contribute to inter-municipal waste management agencies achieving recycling targets for household waste, and increasing recycling rates of plastic packaging, it is necessary to understand their current context and existent barriers. Therefore, the first question needs to be answered, before answering the other questions.

Research Questions

- What do inter-municipal waste management agencies identify as the largest barriers to achieving recycling targets for household waste by 2020 and 2030?
- How are the use of PAYT schemes evaluated by the inter-municipal waste management agencies and how can increased use of this instrument enhance recycling rates of plastic packaging?
- To what degree is a local central sorting facility in More and Romsdal deemed constructive and attractive to key actors in the local waste management industry?
- Can the use of central sorting substitute PAYT schemes, increase plastic packaging sorting rates and achieve future recycling targets of household waste?

1.2 Structure of the Study

First, in order for the reader to familiarise itself within the topic of this study, chapter 2 starts with an overview of relevant concepts and theoretical resources used to shape the background and framework for this study. Relevant frameworks of laws and regulations within international and national waste management are presented, together with the waste management tools PAYT schemes and central sorting. Secondly, chapter 3 introduces the case chosen for this study. Here, background information regarding the collaboration with the inter-municipal waste management agency, ÅRIM will be presented, as well as the other involved actors in this study. Chapter 4 includes the methods used to collect data. This chapter

includes a literature review and an elaboration of the chosen research strategies, in addition to evaluation of the reliability and validity of this study. At last, empirical data are presented in chapter 5 and analysed and discussed in chapter 6. Due to the large amount of empirical data and to better structure this study, chapter 6 has been divided into two separate themes: the use of PAYT schemes and a local central sorting facility in More and Romsdal. These themes consist of separate analysis and discussions sections. The results from the discussions are used in a final discussion, to give a short conclusion in chapter 7, in addition to recommendations and suggestion for further work.

2 Theoretical Resources and Background

In this chapter theoretical resources and concepts of relevance for this study are presented. These resources form the context for this study, and the most used concepts and terms will be further defined and explained.

2.1 Concepts

Terms and concepts used in different contexts may have a variety of definitions and meanings. Therefore, it is necessary to clarify the meaning of the concepts used in this study.

Waste

According to the waste framework directive (WFD), 'waste' is defined as any substance or object which the holder discards, intends or is required to discard (EC, 2008)

Municipal Solid Waste (MSW)

Municipal solid waste is defined by the Directive on the Landfill of Waste as "waste from households, as well as other waste which, because of its nature or composition, is similar to waste from household" (EC, 1999). In this paper municipal solid waste will be referred to as MSW in short.

Waste Management

Includes the collection, transport, recovery and disposal of waste, in addition to the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker (EC, 2008).

Recycling

Means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. Energy recovery and reprocessing into materials for the use as fuels, were initially excluded in this context (EC, 2008), however, there were suggested changes to this last point in the Commission Decision of 2011, where the definition of recycling should include municipal incineration facilities with an energy recovery rate over 60%, or over 65% for new facilities (EC, 2011). The term recycling will in this paper be used when talking about the recovery action where waste materials are reprocessed into products, materials or substances for the original or other

purposes. The first definition is aligned with the Norwegian term “gjenvinning”, which in the Norwegian Pollution Law is defined as every action, where the main result is for waste to be used to replace other originally purposed materials or that waste has been prepared for this purpose (Forurensningsloven, 1983, §27a).

Material Recovery

Is defined as any recovery operation, excluding energy recovery and the reprocessing into materials which are to be used as fuel (EC, 2011). In this paper recycling and material recovery are given the same meaning, and the term recycling will be used to cover both terms.

Re-use

Means any activity where products or components that are not waste, are used again for the same purpose as they were made for (EC, 2011).

Waste fee

It is stated in the Norwegian Pollution Law that municipalities carry the main responsibility for the collection of MSW. The municipality is to decide the fee to be paid by the subscribers in order to cover costs related to collection, transportation, reception, storage, treatment and post-control. The costs should cover all expenses related to capital- and operation costs. The waste fee should not exceed these costs (Forurensningsloven, 1983, §34).

Extended producer responsibility

This is a bunch of measures member states of EU can use to ensure that any natural or legal person who develops, manufactures, processes, treats, sells or imports products has extended responsibility for the product. This may include making sure the products or the waste related to the products are returned, subsequent managed and take financial responsibility for these actions. This extended producer responsibility is introduced in order to strengthen the re-use and the prevention, recycling and recovery of waste (EC, 2008).

2.2 Circular Economy

Today’s economic development is still characterised by a linear ‘take, make, dispose’ model. This model relies on large quantities of cheap, easily accessible materials and energy, and has been at the heart of industrial development, as well as it has generated an unprecedented level

of growth (Oppenheim et al., 2017). However, while this has resulted in better living standards for millions of people around the world, it has also resulted in higher costs to lost biodiversity and ecosystem damage. There have been more natural disasters triggered by climate change, pollution in air and water due to increased consumption and mass production with finite resources (Oppenheim et al., 2017). According to Oppenheim et al. (2017) the circular economy is identified as the successor of today's linear model. This is an industrial system that is restorative and regenerative by design. It is characterised as a market driven solution to balance the use of finite resources on this planet. It is also about creating value out of waste, by using it as a resource for the next product or process. In a circular economy the resource loop will be closed so finite resources such as metals and minerals are captured and reused (EMF, 2015). The Ellen MacArthur Foundation (EMF) explains how the circular economy is based on three principles: preserving and enhancing natural capital; optimising resource yields; and fostering system effectiveness (EMF, 2017). These principles are illustrated in figure 1. To achieve circular economy, one first has to secure and control the finite stocks and balance it with renewable materials. The second principle and level are where the already circulating resources and products are put in use at the highest utility at all times through either biological or technical cycles. This is where the resource loop is optimised and preferably closed. The third principle and level, foster system effectiveness by revealing and designing out negative externalities through feedback from consumers and users (EMF, 2017).

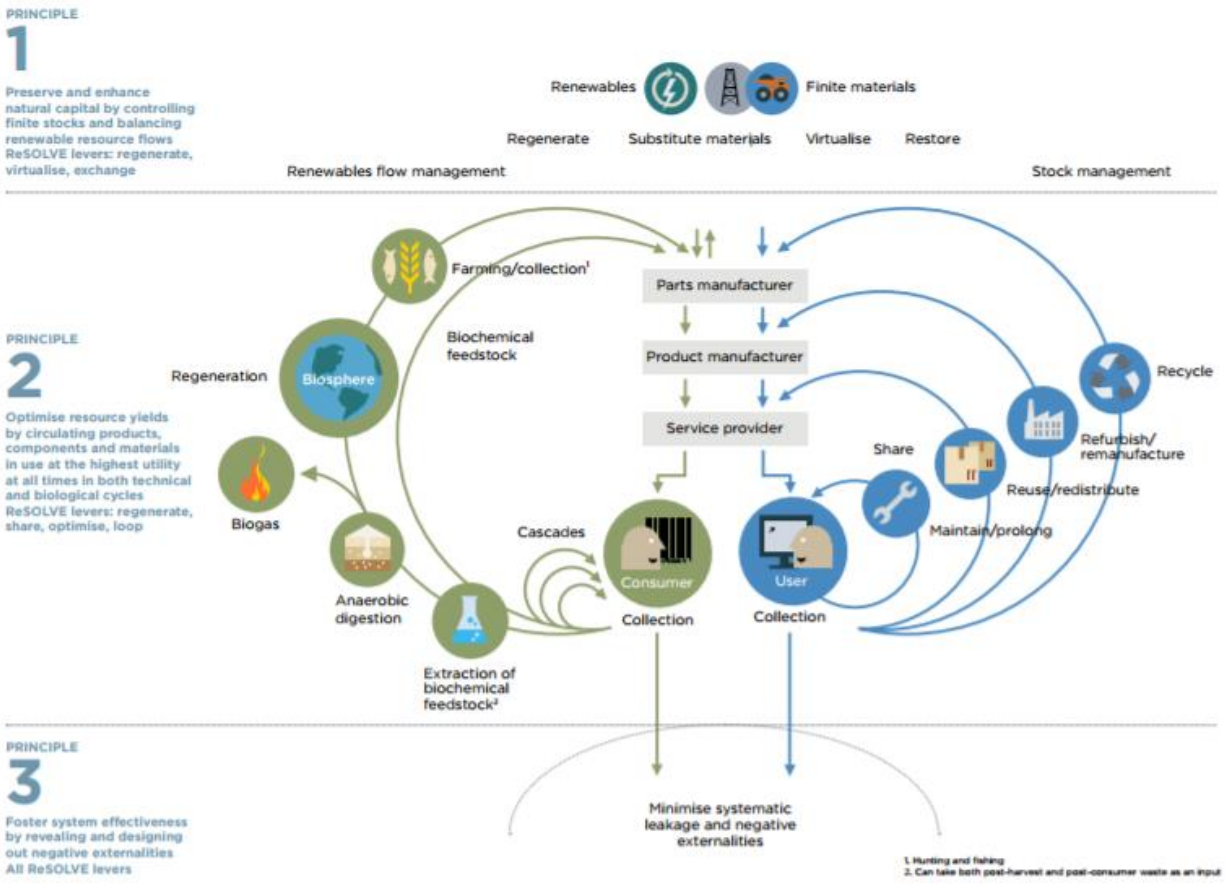

Figure 1- Figure showing the three principles of a circular economy, derived from Ellen MacArthur Foundation report (EMF, 2017).

2.3 Sustainable Development Goals (SDG 12)

In 2015, the United Nations General Assembly agreed and initiated on 17 Sustainable Development Goals (SDGs) and 169 belonging targets which covers action for people, planet and prosperity by 2030 (UN, 2015). They are built on the Millennium Development Goals and aim to achieve what they did not. The goals are integrated, indivisible and balance the three dimensions of sustainable development: economic, social and environmental (UN, 2015). The SDGs considers different national realities, capacities and levels of development and inspire governments to set their own national targets guided by the global level of ambition (UN, 2015). To help track progress, indicators have been developed for each goal and target. Goal number 12, to ensure sustainable consumption and production patterns, are closely related to the development of a circular economy. The belonging target 12.5 aims for countries to substantially reduce waste generation through prevention, reduction, recycling and reuse by 2030 (UN, 2015). Indicator 12.5.1 suggest countries can track their progress on

target 12.5, through national recycling rates (tons of material recycled) (Medium, 2016). The recycling and recovery targets in the WFD are a contribution to this target, where member countries are encouraged and pushed to implement better waste management practices, the use of new technology and innovations, as well as changed consumption patterns (UN, 2015).

2.4 EU's Circular Economy Action Plan and New Plastic Strategy for 2030.

In 2015 the European Commission (EC) published its Circular Economy Action Plan, which sets the ambitious objective of treating waste as a resource by year 2020 and turning the European economy into a circular economy (Hollins et al., 2017). Hollins et al. (2017) explains the Circular Economy Action Plan like this:

> The Circular Economy Action Plan comprises various legislative proposals and measures in the areas of production (product design and production processes), consumption and waste management, as well as concrete targets for creating an ambitious long-term roadmap for waste management and recycling in Europe (p. 22).

The key objective for this plan is to set incentives for the waste sector to no longer consider waste primarily as a threat, but instead as a potential source of future secondary resources (Hollins et al., 2017). Although circular economy includes more than just waste management, the EC emphasise that waste infrastructures are an essential element for reducing linear patterns of production and consumption (Hollins et al., 2017)

EU's ambitious plastic strategy for a circular economy was presented 16th of January in 2018 as a part of the 2015 circular economy action plan. This plan aims to help European businesses and consumers to use resources in a more sustainable way (EC, 2018). With this new plastic strategy, EU seeks to transform the way plastic products are designed, used, produced and recycled in the EU. The strategy aims for all plastic packaging sold within EU and EEA to be either reused or recycled in a cost-effective manner by 2030 (EC, 2018). Higher plastic waste recycling rates and more and better quality recyclates will help boost the market for recycled plastic and will deliver greater added value for a more competitive, resilient plastics industry (EC, 2018). This will contribute to Europe's transition towards a circular economy and reaching the SDGs, as well as the global climate commitments. It is reckoned that this plastic strategy will help protect the environment, reduce marine litter, greenhouse emissions and the dependence on fossil fuels (EC, 2018). The EU's Circular Economy Action Plan and new plastic strategy offers a great opportunity to increase the

recycling capacity in Europe and develop supply chains based on recycled plastic waste (Avfall Norge, 2018).

2.5 International Waste Management Framework

This sub-chapter presents an overview of relevant legislations and policies that shapes both international and national waste management frameworks. Norway has a tight connection to the EU through the EEA- agreement and this also affects how waste management and producer politics is shaped in Norway. Norway follows EEA-legislations for waste through the WFD, in addition to regulations regarding specific waste fractions and how these should be handled. New amendments in Directives also affects Norwegian waste management policies and are binding (Meld. St. 45. (2016-2017). Both the WFD and the PWD, have been updated and changed several times, where new measures and targets have been incorporated.

2.5.1 Directive 2008/98/EC- Waste Framework Directive

The EU recognises that the economy loses a significant amount of potential secondary raw materials which can be found in today's waste streams. The WFD sets the basic concepts and definitions related to waste management, which includes definitions of waste, recycling and recovery (EC, 2016; EC, 2008). The Directive lays down some basic waste management principles. The most important is that waste management should to a best degree avoid endangering humans and their surrounding environment such as water, soil, air and animals. Waste legislation and policy of the EU member states should follow the priority order of the waste management hierarchy as shown in figure 2.

Figure 2- The waste management hierarchy and preferred waste management strategies (Probst et al., 2016).

The waste management hierarchy implies how waste management strategies should aim to prevent the generation of waste and to reduce its harmfulness. Where this is not possible, waste materials should be reused, recycled or recovered, or used as a source of energy. As a final and last resort, waste should be disposed of safely by either incineration or in approved landfill sites (REC, 2008). The model seeks to move the waste management in countries as high as possible in the hierarchy in order to avoid landfilling and secure the value of waste produced (Probst et al., 2016).

The WFD incorporates two recycling and recovery targets to be achieved by 2020. The one target relevant for this paper is the 50 % recycling and recovery target for certain waste materials from households and other origins similar to households. In December of 2015, it was suggested to amend the WFD. It was seen as necessary with an alignment of the definition of household waste. In the amendment it is suggested that municipal waste means mixed waste and separately collected waste from households which includes (EC, 2015b):

- Paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, waste electrical and electronic equipment, waste batteries and accumulators
- Bulky waste which includes white goods, mattresses and furniture
- Garden waste which includes leaves and grass clippings

It is also stated that municipal waste includes mixed waste and separately collected waste from other sources, where the waste is comparable to household waste in nature, composition and quantity. However, it does not include waste from sewage network and treatment, including sewage sludge and demolition waste (EC, 2015b). To calculate whether the targets have been met, the weight of the municipal waste recycled should be understood as the weight of the input waste entering the final recycling process (EC, 2015b).

The Directive also includes the polluter pays principle and extended producer responsibility:

- Extended producer responsibility: Manufacturers of products must be involved in the objective to close the life cycle of substances, components and products from their production throughout their useful life until they become waste (REC, 2008).
- Polluter pays: This principle states that those responsible for generating or for the generation of waste, and consequent adverse effects on the environment, should be required to pay the costs of avoiding or alleviating those adverse consequences (REC, 2008).
- Proximity principle: Another important principle in EU's waste management legislation, which states that waste should be disposed of as close to the source as possible (EC, 2016).

2.5.2 Directive 94/62/EC- Directive on packaging and packaging waste

Closely related to the WFD, the Directive on packaging and packaging waste aim to harmonise national measures on the management of packaging and packaging waste (REC, 2008). The Directive is meant to motivate and steer EU member countries to implement measures to prevent or reduce the production of packaging waste, by developing for instance national programmes and systems that encourages the reusing of packaging waste. Other measures include minimum standards and criteria for packaging materials as well as minimum and maximum targets for the recovery and recycling of packaging waste (REC, 2008). Further, the Directive states that member countries should introduce collection-, return- and recycling systems for used packaging waste to meet these agreed targets (EC, 2015a). The Directive states that 75% of all packaging waste should be prepared for reuse and recycling by 2030. For plastic packaging the minimum target to be achieved is 55% by 2025 (EC, 2015a).

2.6 National Waste Management Framework

Member countries of EU and EAA members are obliged to follow international agreed waste management policies, in addition to regulations regarding specific waste fractions and how these should be handled. The Norwegian government determine the ambitions of the national environmental policy and specific national objectives, while the subordinated Ministry of Climate and Environment has the main responsibility for ensuring integrated governmental climate and environmental policies (Regjeringen, 2014). The Ministry also works as a promoter and coordinator to make sure the authorities in various sectors implement policies in their particular areas. The Ministry has four departments whereas the Norwegian Environment Agency is one of them. This agency is responsible for implementing and giving advice on the development of climate and environmental policy in Norway. These themes may range from waste management and recycling, living oceans and coasts, a toxic free environment and a stable climate (Regjeringen, n.d). Their main functions include collating and communicating environmental information, supervising and guiding regional and local government level and exercising regulatory authority (Miljødirektoratet, n.d). At the local level, the Norwegian municipalities are given the responsibility to ensure that household waste in their area is being collected and treated environmentally sound and safe at an approved waste-facility of their choice (Miljødirektoratet, 2017). The County Governor function as a supervisor and is responsible for following up the different municipalities regarding the government's environmental policies (Fylkesmannen, 2018). Each municipality is free to choose their own MSW sorting and collection system, which gives a variety of solutions between each municipality and county. Each household is obligated to comply with their municipality's chosen MSW system. They pay an annual waste fee to cover the collection and treatment costs associated with the MSW treatment. This idea follows the "polluter pays" principle (Miljødirektoratet, 2017).

The municipalities and every actor that manages waste are obliged to follow national frameworks and guidelines. The Pollution Control Act (Forurensingloven) and the Waste Regulation (Avfallsforskriften) are such frameworks which state how waste at regional and local level should be treated and how to minimise waste and emissions to protect the environment. As mentioned, Norway is obliged through the WFD to achieve a 50% recycling rate of household waste and similar waste from the industry by 2020. In the European

commission's Circular Economy Action Plan, further mandatory recycling targets for 2025 and 2030 are set, with recycling rates at 60% and 65%.

Enhancing the Norwegian recycling capacity demands not only that more waste fractions are sorted and recycled than it is today, but also that the waste treatment systems already established are made more efficient. The NEA has suggested an increased recycling rate of 600 000 more tonnes of household waste if Norway should be able to meet the first target by 2020 (Miljødirektoratet, 2017). This number has increased to 1,1 million tonnes by 2025 and 1,4 million tonnes by 2030. This is not attainable without urgent and more profound measures to increase the sorting and recycling rates of organic waste and plastic packaging from household waste according to the NEA (Miljødirektoratet, 2017).

The research institute, Ostfold Research, found the total amount of plastic packaging generated in households in Norway (based on numbers from year 2014), to be 95 500 tonnes with 18,1 kilos plastic packaging generated per capita. Out of this total amount of plastic packaging, approximately 30 % (28 540 tonnes) was sorted in households, and 25,6 % of this (23 500 tonnes) was recycled after being sent to a sorting plant (Raadal et al., 2016). These numbers show that only a small percentage of the total generated plastic packaging waste per capita is being sorted, and less is being sent for further recycling. This picture is also evident in Denmark and Sweden, where studies show that between 9 to 20 kilos of plastic packaging per capita is lost in MSW, even though the municipalities are offering separate sorting and collection systems for plastic packaging (Fråne et al., 2015).

By using the numbers presented by Ostfold Research and the NEA, it is estimated an increased sorting and recycling potential of 64 000 tonnes of plastic packaging from today's MSW (Raadal et al., 2016; Miljødirektoratet, 2017). It is identified higher potential for increased plastic recycling in municipalities with an already existing sorting system for plastics compared to the ones without. This is because the 90-95 % that lives in municipalities with such sorting system, have sorting rates that are to a high degree varied and in average quite low (Raadal et al., 2016).

2.7 The Role and Challenges Related to Traditional Waste Management

Traditionally, the waste management could be described as a 'collect and dispose' operation, where the waste treatment options would be to send the waste to either landfill or incineration (Hollins et al., 2017). In the later years, it has become more obvious that the waste

management industry will essentially become an integral part of a circular economy, closely linked to patterns of production and consumption (Hollins et al., 2017). To enable the circular economy, it is necessary to implement circular thinking already at the design level of products, which will require feedback from the waste management sector on how products or components could best be remanufactured, dismantled and recycled. The idea is to close cycles to turn waste back into a resource.

From a Norwegian perspective, a transition to circular economy is crucial for increased competitiveness and value creation, and the waste management industry is recognised as one of the main catalysators according to Norsk Gjenvinning et al. (2016). The role of traditional waste management is experiencing a transition from mainly collecting and processing waste, to become producers, distributors and sellers of recycled raw materials and fuel. By readjusting to a more resource-efficient economy, is it estimated that plenty of new jobs will be created, CO2 emissions will be significantly reduced, and the trade balance will be improved. To realise this potential, both the waste management industry and the authorities needs to act. The waste management industry needs to take an offensive role and dare to take risks and drive the transition to a circular economy. At the same time the authorities must set high demands to the industry and be an active driving force to decouple welfare from high consumption patterns (Norsk Gjenvinning et al., 2016).

According to Hollins et al. (2017) MSW comprises around 10 percent of total waste and it is identified as one of the most polluting streams and has a high potential for improvement through better management and integration of circular economy practices (p. 62). Two key challenges for the future are to reduce levels of waste generation and align waste management objectives with those of the circular economy (Hollins et al., 2017). Expanded and strengthened policies will be a key priority for reducing environmental burden and move the economy toward a more resource-efficient economy. To develop a circular economy, high-quality secondary raw materials are needed, which can replace or substitute virgin materials in production processes. The waste management sector will therefore be crucial in building new business models that can focus on both waste prevention and turning waste into new resources (Hollins et al., 2017).

2.8 Waste Collection systems

Dahlen and Lagerkvist (2009) states that "how waste is collected around the world, vary from no collection at all, to the collection of 10 separate recyclable fractions at the doorstep using multi-compartment vehicles" (p. 24). Household waste collection systems can be divided into curb-side collection, where waste is collected in either bins or bags at people's property. Or collection at drop-off points, where people bring their waste to containers (Dahlen & Lagerkvist, 2009).

2.8.1 Collection and Sorting Systems used in Norway

All municipalities are free to choose how they collect household waste in their respective area. This means that some municipalities are offering the bare minimum when it comes to MSW sorting and others are more ahead with separate sorting solutions for waste fractions such as cardboard/paper, organic waste, plastic packaging, and glass/metal packaging. Currently, between 90-95% of the Norwegian population is offered a municipal sorting solution for plastic waste according to Raadal et al. (2016). Out of these, 60 % are using a collection system with a transparent bag or plastic bin and 12 % needs to deliver their own plastic waste to collection points or stations. 18 % have an Optibag-system where organic waste, plastic packaging, paper, cardboard and carton (PCC) and municipal solid waste are sorted at home into bags of different colours, and 3,5 % of the population has a collection system where the plastic is included in MSW and which gets sorted when entering an automated central sorting plant (Raadal et al., 2016).

2.9 Waste Policy Instruments – Pay as you throw schemes

Countries use a variety of policy instruments for diverting waste from landfill and incineration and move more waste towards recycling treatment. The same policy instrument can be designed and implemented in many ways, and therefore have different types of effect (EEA, 2016). Waste management policies include a variety of complementary measures, such as educational, economic, regulatory and informative instruments.

One economic instrument is the waste fee, which main purpose is to cover expenses related to the collection and disposal of waste and increase recycling rates. The waste fee is paid by

each household covered by the waste collection system. The EC (2012) uses the term pay-as-you-throw (PAYT) schemes about billing systems for waste collection implemented by municipalities, where the overall cost of the waste collection and disposal is funded through a combination of flat rate fees or taxes and one or more variable element:

> The variable element may be linked to the choice of container size (volume-based schemes), the number of sacks set out for collection (sack- based schemes), the frequency in which a container is set out for collection (frequency-based schemes) and the weight of material collected in a given container (weight-based schemes) (EC, 2012, p. 86).

In a study conducted by the EC (2012), the relationship between the performances of the waste management systems of the EU member countries and their use of economic instruments is analysed. The use of economic instruments such as PAYT schemes, is used to improve waste management in many member countries. They found the PAYT schemes to be most effective when the fees paid by the households are high enough to encourage people to reflect on their waste generation behaviour, and their support for separate collection systems. However, it is emphasised that this fee must not be set too high in order to avoid illegal dumping or burning of waste. It is proven that such schemes have helped decrease waste generation and increase sorting rates (EC, 2012). However, this effect needs to be considered together with the overall management system.

Of all the PAYT-schemes, the EC (2012) assess the weight-based PAYT schemes as the most successful, followed by volume- and frequency-based schemes. This is contrary to the NEA, which deems volume-based schemes as the most successful (Miljødirektoratet, 2017). However, the NEA emphasis that there is limited research regarding how different PAYT schemes affect and improve waste management performance, which suggest it is difficult to conclude which scheme has the most significant effect (Miljødirektoratet, 2017). Nevertheless, the EC (2012) indicates that volume-based schemes in general gives the least incentive for waste reduction and recycling. They reason this partly with the fact that once a bin of a certain size has been subscribed to, the marginal cost of reducing the quantity of waste tossed in this bin, is effectively zero. This is not evident in the other PAYT-schemes, and they have been assessed as better measures to enhance sorting rates. A study conducted by Dahlen & Lagerkvist (2009) of Swedish municipalities and their use of weight-based billing system, explains how the aim of using such system is to reduce the amount of waste generated in households and increase sorting and recycling rates. There is also a wish for the

waste fee to be seen as fair by the households. The study found that these municipalities collected 20% less household waste per capita than municipalities without this system. However, this was not explained through better recycling rates (Dahlen & Lagerkvist, 2009). Dahlen & Lagerkvist (2009) suggest this might be explained by the ones having a weight-based billing system, being more aware of their waste generation or/and they dispose waste outside the ordinary collection system to a larger degree than the ones without a waste fee based on weight. The same study lists general strengths and weaknesses with such system, with some of the strengths being waste reduction, less garden waste in household waste bins, transparency of waste management costs, increasing sorting of recyclables and that it is well accepted by the householders. Weaknesses is increased costs associated with investment and operation, technical problems, more illegal waste dumping (even though this has not been proven), increased number of contaminants in recyclables and waste moving to neighbouring communities (Dahlen & Lagerkvist, 2009). It needs to be mentioned that divergent effects of weigh-based billing have previously been reported from different countries, and municipalities often use a variety of combination of PAYT schemes, making it more difficult to assess which scheme releases the highest effects (Dahlen & Lagerkvist, 2009).

Nevertheless, the EC (2012) suggest regional cooperation in waste management may enhance the effectiveness of PAYT billing systems, by optimising the planning of collection routes, simpler implementation of separate waste collection services (e.g biowaste, packaging, recyclables) and economising overall waste processing (EC, 2012). This is done in Finland, which shares similar waste collection system with Norway. In 2012, there were 30 regional municipal waste treatment organisations in Finland and regional cooperation has been identified as a means of improving the collection and processing of MSW throughout the country (EC, 2012). The systems also gain greater support through more consumer awareness campaigns and by making illegal dumping and burning of waste harder. However, one important measure identified to achieve optimal performance of PAYT schemes, is that these should be based on the precise quantification of actual generated household waste.

2.10 Waste Treatments

This subchapter provides an overview of established and emerging waste management treatment and technologies used in the recovery of the most common material streams, including plastic packaging.

2.10.1 Bio waste treatment

Composting (also called aerobic digestion) and anaerobic digestions(AD) rely on the segregation of organic wastes and their degradation to a stabilised material. This is called bio rest and can, if of the right quality, be used as a fertilizer or soil improver. Hollins et al. (2017) explain how in an anaerobic process “a methane and carbon dioxide rich biogas are produced which can be used for combustion in transport or energy production” (bio-gas production facilities) (p. 71).

2.10.2 Thermal treatment

This is a waste treatment where waste is turned into energy through incineration of combustible non-hazardous waste. In North European countries such as Norway and Sweden, energy from waste is either converted into heat and electric power, while other countries mainly produce electricity. Hollins et al. (2017) mentions how public opinion is the major barrier to this type of waste treatment, due to traditionally suspicion of dangerous emissions from such facilities. While the waste hierarchy states that recycling should be preferred over waste incineration, incineration of certain hazardous waste can be more suitable than recycling if the product contains materials or substances of very high concern. In the future it is predicted that the capacity of such facilities will increase to around 116 million tonnes in 2019 (Hollins et al., 2017). Much of this will be in the United Kingdom and Ireland. However, the EC has pointed out that it will be necessary to consider the right capacity of member states incineration plants over their lifespan to avoid re-diversion of recyclable materials to feed the energy production in such plants (Hollins et al., 2017). Bottom ash recovery is a part of thermal treatment of waste after is has gone through the incineration ovens. What is left after the rest has been incinerated is what is called bottom ashes. These ashes can contain toxins such as heavy metals or important resources such as phosphorus.

2.10.3 Separation and Sorting Technologies

There are different treatment options for collected MSW. Waste management organisations dealing with waste disposal and sorting of materials will most often use one or more of the listed pre-treatment technologies below. The first four are common in mechanical biological treatment, better known as MBT. This is a pre-treatment technology for tackling mixed waste with a mechanical phase separating out the technical materials, combined with a biological phase, such as AD or composting of the organic fraction (Hollins et al, 2017). The last two, especially near-infrared sensors, are most often associated with central sorting facilities.

- *Trommel separators/drum screens*: These machines separate materials according to their particle size. Materials smaller than the diameter of the holes of the rotating drum will be able to drop through, while larger particles will remain in the drum (Waste Management World, 2008)
- *Eddy current separator*: This is a method used specifically for the separation of metals. Electromagnetic fields are separating ferrous and non-ferrous metals (Waste Management World, 2008)
- *Induction sorting*: Materials are feed on a conveyor belt with a series of sensors underneath. By the use of fast air jets linked to the sensors, materials such as metals are being identified and separated by the sensors (Waste Management World, 2008).
- *Manual Sorting*: A technique that is still very much used today. Waste is being feed on conveyor belts or similar, and then sorted by hand. Many companies use shredders prior to the sorting to make the particles large enough for the ones picking out the waste by hand (Waste Management World, 2008).
- *Near infrared sensors (NIR):* Materials reflect light in the near infrared wavelength spectrum, making the NIR sensor capable of distinguishing between different materials based on the way they reflect light. This technology has increasingly become more important and used for the separation and sorting of different plastic materials. Edward, A. Bruno explains the NIR sorting technology for plastic sorting like this: "Near-infrared spectroscopy is a technology that involves irradiating the unsorted, unidentified plastic, with near-infrared waves (…). When the infrared light reflects off the surface of the plastic, each resin's characteristic infrared absorption band can be measured. These measurements can then be compared to known polymer values to determine the resin type" (Bruno, n.d, p. 6).

NIR technology is often used together with visual spectrometry which recognises all colours that are visible and works for both transparent and opaque objects (Waste Management World, 2008).

- *X-ray technology*: can be used to distinguish between different types of waste based on their density (Waste Management World, 2008).

2.11 Plastic Recycling

It has been highlighted by the EEA that the sorting of plastics at the preliminary stage is the most significant activity in the recycling loop. In this regard, this means to sort the plastics in the households (Hollins et al., 2017). According to Hollins et al. (2017) it is not economically viable to source-segregate plastics and a recycling process therefore requires separating each type and grade of polymer at a pre-treatment stage (Hollins et al., 2017). This has typically been a manual process; however, it is difficult to manually distinguish polymer types due to the condition of the plastics as they reach the sorting phase. The plastic products may be crushed or the resin label hard to identify. Especially PET and PVC are sometimes indistinguishable by sight. This causes problems, because if one want to recycle plastic into useable resin with desired characteristics, a pure stream of resin categorised waste must be achieved, and preferably with same characteristics as virgin resin. To help solve this issue automated technologies are continually being developed. An automated sorting system which can distinguish the plastic after their resin characteristics, can distinguish the different plastic types in a lot of situations where a consumer cannot. As products become more complex, future recycling efforts may use a different approach where they focus on the specific components of a product and ways to separate and recover them.

Lightweight packaging plants have developed from manual sorting system to automated systems that are able to detect and sort different material types. These types of facilities are effective in separating mixed packaging waste streams collected through for instance segregated municipal waste collection. The return rates are between 60-95% depending on the material type according to Hollins et al. (2017) and can therefore contribute to achieving recycling targets. This type of plant works exceptionally good for ferrous metals which has a recovery yield at over 95%. Using NIR technology, air separation, foil grabber as sorting technology, up to 70 % of plastic foils can be recovered, while up to 70-90 % of hard plastics such as PE, PP, PS, PET can be recovered using NIR. Mixed plastics has up to 80% recovery yield.

Own plastic sorting facilities are developed to solely sort different types and grade of plastic polymer and facilitate the recovery and re-use of plastics. It exists different sensor technologies for sorting complex plastics. Technological advances when it comes to removing contaminants has increased the value of recycled plastic. Especially recycled PET and HDPE are significant markets. Of course, price is a key determinant in the demand of such recycled materials, since it is used as a substitute for virgin fossil fuel-based products (Hollins et al., 2017). Therefore, the prices on oil will influence the development of secondary markets for plastic, and further, the economic viability of plastic sorting facilities. Due to the differences in the purity of post-producer and post-consumer waste, a greater variety of technologies are needed to sort and recycle plastic than any other waste type according to Hollins et al. (2017). Hollins et al. (2017) states that these technologies are important in the recovery and re-use of plastic and can contribute to the achievement of recovery and recycling targets.

2.12 Central Sorting of MSW

Source separation and separate collection has traditionally been viewed as the best waste management approach in terms of technology and the environment, which is reflected in the European waste legislation today (Cimpan et al, 2015). There is a pressure on many countries to extend separate collection systems and increase national recycling rates to comply with international and national recycling goals. Advantages of such systems can be high public participation due to convenience, it is seen as a simpler collection system (less vehicles and people) which often results in lower costs compared to other systems. It can also collect high levels of “clean” waste fractions when the support of the system is high. But this system has also received criticism related to the overall costs, various local implementation issues and often disappointing results in quality of the collected waste in terms of contamination levels. This is especially a problem in urban areas according to Cimpan et al. (2015). This has led to a discussion if central sorting might substitute separate collection of certain materials or to be applied complementary to source separation.

There are different central sorting and separation solutions available today. Sorting and separation facilities using NIR technology and the other listed technologies in chapter 2.10.3, are most known as material recovery facilities (MRFs), packaging sorting plants and MBT. According to Cimpan et al. (2015), these play a pivotal role in waste management and material recovery systems today. Such facilities have been assessed to be the possible

solutions to achieving recycling targets in countries with a yet insufficient treatment capacity, but also in countries where there are well integrated waste management systems. However, Cimpan et al. argues that:

> "there is a lack of publicly available comprehensive analysis of sector wide or interregional approaches to central sorting, technological solutions and their efficiency. This makes it more difficult to understand the role and the contribution of sorting systems in order to achieve sustainable resource management." (2015, p.182)

Still, Cimpan et al. (2015) wants to challenge the widely accepted belief that source separation and separate collection should always be preferred. Technological limits and possibilities of central sorting are explored in their study, together with material quality issues, collection and recycling efficiency and the role of central sorting of mixed MSW to achieve higher recycling rates.

Through a series of comparative studies of the use of central sorting in Europe and US, Cimpan et al. (2015) found that many of the quality issues linked to cross-contamination (plastic, paper, cardboard mixed in MSW) have been solved through new technology being developed and sorting facilities today being able to produce high quality products. Still, there are some inefficiencies that needs to be addressed related to this area. Plastics and metal recovered from MSW through central sorting are deemed to be similar in quality with the plastic and metal collected in separate collection systems. But this depends on the degree of cross-contamination with other MSW residuals. A problem with the MSW fraction is often higher moisture content and surface contamination, from residuals of food or other organic wastes. Nevertheless, the sorted materials are still being bought by the market and recycled according to Cimpan et al. (2015). This is seen as an important contribution in turning Europe into a circular economy, since the recovery of large quantities and a variety of recyclables from MSW contributes significantly in achieving recycling rates of household waste set by the WFD and PWD, in some countries (EC, 2008; EC,1994).

Today, increasingly complex material composition is mentioned as one of the main challenges in waste management, since this requires a high level of flexibility and in some situations, new technology to sort and recycle (Cimpan et al., 2015). It is also expected that due to new material use and evolving patterns in consumption, such as the increased use of bio-plastic or less newspapers, there will be a general decrease in material quality of the collected waste, by the adding of more problematic products and low-quality materials.

Central sorting has been deemed especially favourable to extract plastic packaging from MSW in some countries. In Netherland 10% of all municipalities have chosen this solution, and post-separation is viewed as technically simple, require less collection infrastructure and more convenient for the households due to less bins. However, critics has counter-argued the last point, emphasising the importance of people understanding the impact of their waste. This they get through the source sorting in the households (Cimpan et al., 2015). As a summary Cimpan et al. (2015) suggest the role of central sorting of MSW might be to supplement source-separation and separate collections, where these systems are deemed inefficient. Due to increased material complexity, growing urban areas and the growing global needs for secondary raw materials, central sorting will inevitably play a crucial role in the future.

2.12.1 The Norwegian Experience with Central Sorting

The waste and recycling company Romerike Avfallsforedling IKS (RoAF) has one of the world's most modern automated sorting technology used to separate green bio-waste bags and recyclable fractions from MSW (Tomra, n.d). The sorting plant is located at Skedsmokorset, close to Oslo, and began operating in January 2014. The plant now serves 10 municipalities with over 190.000 inhabitants in total and has the capacity to manage 40 tonnes waste per hour (Tomra, n.d., RoAF, 2017b). This is the first sorting plant for MSW requiring no manual labour for the sorting and quality control of recyclable materials. The automated sorting plant is a representation of a circular production process. There are three autosort sorting units installed in the plant's waste reception hall, using Near-Infrared sensors(NIR) and Visual Spectometry. Due to this combination of technology, the system is able to separate and clean the different bags containing bio-waste or other MSW. The inhabitants covered by this facility, are encouraged to separate their bio-waste into green bags so it doesn't contaminate the other waste fractions, such as plastic and paper thrown into a separate MSW bag. This separation enables the organic waste from the green bags being used to produce bio-gas, after the green bags are sent to a bio-gas production site. This bio-gas is then used by RoAF as fuel for their waste collection trucks (Tomra, n.d). Meanwhile, after the green bags are separated from the rest, MSW bags are opened and transported to different drum screens where the waste is separated by size into different streams. By using a combination of mechanical processing such as ballistic separators and 13 autosort optical machines, the waste is subjected to further sorting and at this point waste fractions such as different plastic (PELD film, PEHD, PP, PET and mixed plastic) and paper are separated from other wastes (Tomra, n.d). Further,

magnets and eddy current separators are used to recover ferrous and non-ferrous metals from the waste (Tomra, n.d). Recyclable fractions are then stored in bunkers and baled before being sent to material recovery facilities. The waste streams not fit for recycling are used for energy recovery.

Since its opening in 2014, RoAF's plant has been delivering high quality recyclable plastics and paper fractions, which can be further marketed in the recycling industry. The geographical location is ideal with a highly populated area (approximately 1,3 million of Norway's population), short geographical distances between each municipality, in addition to other companies and facilities in Sweden. Each citizen in RoAF's area produced 433,6 kilos waste in 2016, 129 kilos of this amount can be classified as MSW residuals (RoAF, 2017b) RoAF sent close to 40 000 tonnes of MSW through central sorting in 2016. The result was 2,129 tonnes of sorted plastic or 11 kilos per capita (in tonnes and types of plastic: PET:28, PP:251, PE:144, FILM: 1,347, Mixed Plastic: 357). In addition, it was collected in average 7 kilos residual paper and 3,4 kilos of metal from each citizen's MSW in 2016 (RoAF, 2017b). The leftovers which amounted 28 600 tonnes or 148 kilos per capita, were sent for energy recovery. RoAF's central sorting facility has increased the plastic collection rate in Southern Romerike from 4,5 kilos to 11 kilos per capita. RoAF claims they sort approximately 2500 tonnes of plastic waste each year (RoAF, 2017b). According to their annual report from 2017, RoAF measured 47,4 % in recycling rate the same year. Since the plant's opening, this recycling rate has increased from 29,9 % to the rate measured in 2017 (RoAF, 2017a).

To this date, three more central sorting facilities are planned and some of them are already under construction. The SESAM project in Troendelag covering 55 municipalities and 463 000 inhabitants are planning to build a central sorting facility similar to RoAF (SESAM, n.d). Samples taken from the waste in Trondheim in 2012, showed a total potential of 30 kilos plastic packaging being sorted per capita each year. In 2014, approximately 6,5 kilos per capita were sorted and collected from households through curb-side programmes in the SESAM area. This is a common number for the majority of the municipalities in Norway, with a few exceptions. An important argument for a central sorting facility in the SESAM area is the identified potential of increased plastic packaging sorting rates from MSW. Today, only 20 % of the plastic packing generated per capita is sorted in this area (SESAM, n.d). Another central sorting facility in Stavanger, called IVAR, are taking one step further, by adding a washing and processing facility where the plastic waste can be washed and granulated into new raw materials.

2.12.2 MSW Treatment in Norway

In Norway it was registered 433 kilos of household waste generated per capita in 2016 (SSB, 2017a). In contrast to neighbouring countries and EU members countries, Norway has experienced a small decrease in the amount of waste generated per capita with one percentage point from 2015-2016. While the use of landfilling has tremendously decreased in Norway from 2002 to 2016, there has been a significant increase in the use of incineration treatment and some increase in the use of biogas production (SSB, 2017a). This corresponds with Hollins et al. (2017), who states that there is a strong correlation between a reduction in landfilling and the use of landfill bans and taxes, and how such ban can lead to shifting waste, especially plastic from landfills to incinerators. Norway introduced a ban on landfilling of biodegradable waste in 2009 to reduce greenhouse gas emissions. Further the statistics from Statistics Norway shows that waste delivered for recycling decreased somewhat from 2002 to 2015, but this recycling rate had a small uplift in 2016 (SSB, 2017a). However, one should be aware that in Statistics Norway's measured recycling rates, composting and biogas production was included in the 2002 number. Figure 3 shows the preferred waste treatments chosen for Norwegian household waste from 2006-2016. The figure is presented in Norwegian, with the colour green representing waste sent for recycling, purple for incineration treatment, yellow shows the amount of waste being landfilled, and blue is other treatment.

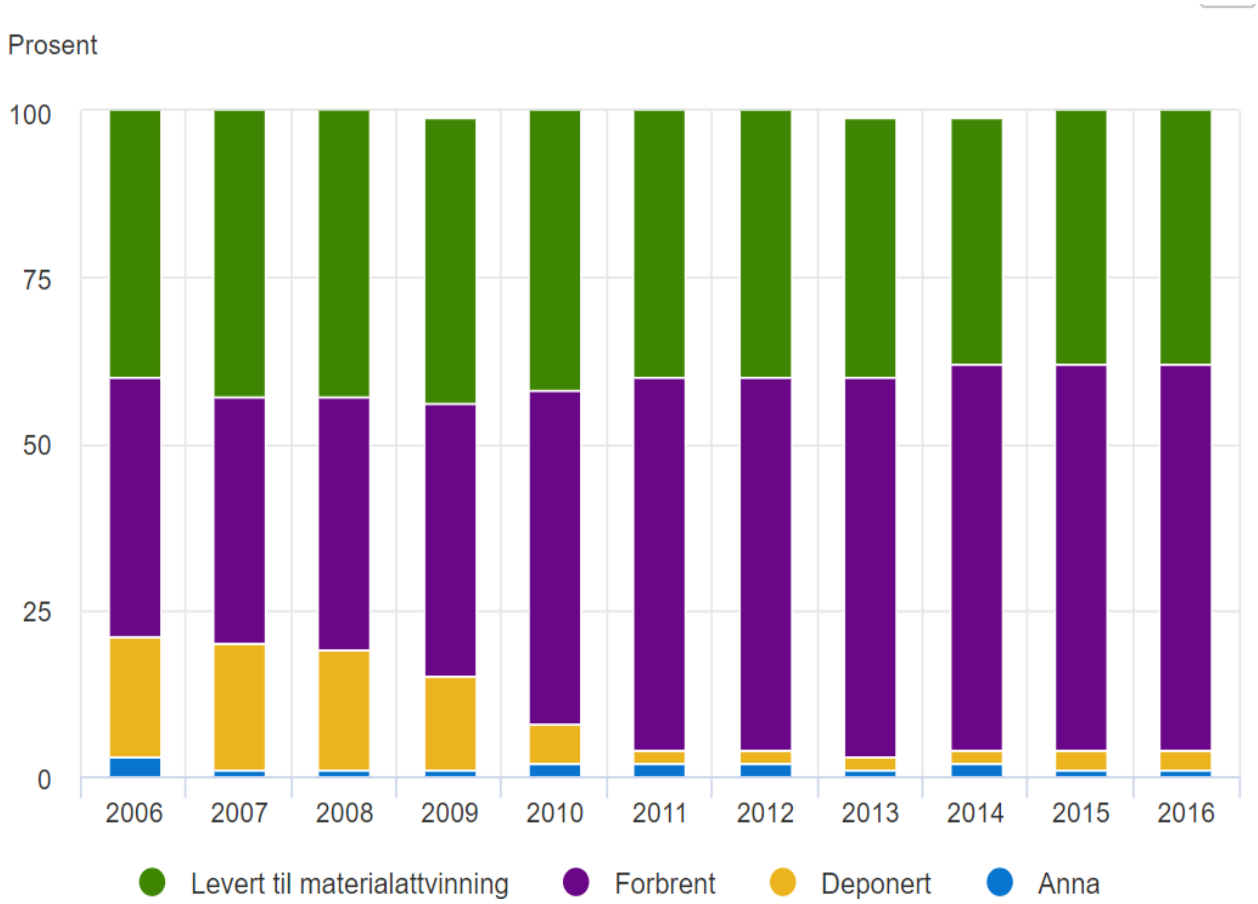

Figure 3- Figure showing the preferred waste treatment of household waste in Norway from 2006-2016, retrieved from Statistics Norway (SSB, 2017a).

As shown in the figure, incineration treatment has been the preferred MSW treatment in Norway since 2009, while the recycling rates has decreased since the same year. A variety of climate accounts shows that there is a lot to be saved in emissions, due to its fossil material, if plastics is separated from the MSW fraction before sending it to incinerators for energy recovery (Raadal et al., 2016). Even though transportation of plastic packaging for recycling needs longer distances in average, the benefits of recycling are still larger than using incinerators with energy recovery. This is because the recycling treatment gives lower emissions compared to incinerators and it benefits the climate more to replace virgin plastic than use the plastic for district heating (Raadal et al., 2016).

In their report, Hollins et al. (2017) refers to analysis conducted of selected waste management technologies. The analysis highlights that from a purely technological point of view, almost all waste could already today be treated as a potential resource and that every material could potentially be recovered. However, the real recovery rates for many raw

materials are very low and this emphasise the need for integrated approaches that embed these technologies into systems of separation at source, and separate collection and production of high-quality secondary raw materials. The aim is for these to replace virgin materials in production processes (Hollins et al., 2017). Plastic is especially identified as a material that will need a greater variety of recycling technologies and therefore this area experience high levels of innovation. However, there is a lot of barriers related to the recycling of plastics. Hollins et al. (2017) mentions the move towards more complex multi-layer and multi-material products in the food packaging sector as one of the barriers.

2.12.3 Barriers to increased recycling of plastic waste

Many municipalities and private waste management companies are currently lacking effective solutions or economic incentives to secure high rates of recycling or have suboptimal solutions. This often results in valuable waste fractions being delivered to incinerators to create energy instead of being recycled. One reason for choosing incineration is that it is more economically beneficial for municipalities and companies to send all their waste together to incinerators to create energy, instead of sorting the waste fractions for recycling. This is also supported by the decreasing prices on incineration as a waste treatment in the international market, low prices on crude oil and a lack of investments in recycling technology that benefits economically. This is also related to a political wish from the municipalities to maintain the municipal waste fee at a lowest rate as possible (Miljødirektoratet, 2017).

To increase sorting rates of plastic packaging, it is necessary to understand what barriers exist and how to overcome these. The NEA mention two categories: barriers might range from will and costs to implement better sorting system in different municipalities, to low knowledge of the use of recycling among consumers, which then gives low motivation to do so. Some municipalities have less efficient systems for collecting plastic waste and the minority have no solution for plastic packaging at all. There are also barriers related to households covered by such a system (Miljødirektoratet, 2017). Some households might have less space for different bins, they might lack incitement to sort or the plastic packaging are being sorted wrong due to bad branding, laziness or confusion. In many cases households also fail to clean dirty plastic packaging which further destroys its potential for recycling (Raadal et al., 2016). In general, the largest barriers attached to plastic packaging from households seem to be the support for the sorting systems that already exist and quality on the collected plastic packaging (Raadal et al., 2016). According to some of the findings in the report done by Ostfold Reasearch,

experience seems to be the key to achieve higher sorting rates for both households and industry. The ones who have been offered recycling solutions the longest, also have the highest sorting rates (Raadal et al., 2016).

2.13 Suggested Instruments to Increase Sorting Rates of Plastic Packaging

In 2016, the research institute, Ostfold Research, was given the mission of providing an overview of cost-efficient measures to increase sorting rates of plastic packaging and organic waste in Norway. The study aimed to reduce greenhouse gas emissions and better utilise resources in the waste, in a transition towards a circular economy (Raadal et al., 2016). Findings showed a necessity for new measures to increase the sorting of plastic waste and organic waste, and not only for those who still lack a sorting system for plastic. A great potential for increased sorting of plastic waste was also identified in municipalities with an already existent system.

According to this study, only 26% of plastic packaging from households are sorted today (Raadal et al., 2016). The relationship between municipalities and their waste fee was also analysed, and this showed that the municipality's size and geographical location will have a significant impact on the operation costs and yearly fees for the waste treatment, while the sorting rates in municipalities were of less significance. According to Raadal et al. (2016) this is important to include in a discussion regarding socio-economic costs related to measures for increased sorting and increased support for waste collection of plastic packaging. Good solutions and synergies can be found when analysing the whole waste system, instead of looking at one waste fraction separately. Based on the results of the study, Raadal et al. (2016) assessed several measures to be effective to increase sorting rates. The most important measure was a legal obligation for sorting of organic waste and plastic packaging from households and businesses.

As part of the legal obligation for sorting, it is proposed that municipalities increasingly use differentiated waste fee (PAYT-schemes), as a means of enhancing support for sorting by the source systems and provide incentives for the consumers to generate less waste. In addition to this, Raadal et al. (2016) recommends that comprehensive analyses should be carried out of potential central sorting facilities for specific selected regions in Norway, to investigate the environmental and cost-effectiveness of such solutions as the basis of a national strategy.

Raadal et al. (2016) emphasise that such analysis should consider "all (or at least most) of the waste system, to highlight synergies in collection and treatment and to avoid future duplication of effort" (p. 3).

It is expected that a legal obligation to sort plastic packaging will first of all release potential for the municipalities operating without a sorting solution for plastic packaging, but also give a significantly increment for municipalities with an already existing solution. This estimation is based on the expectation that municipalities at a larger degree will use fee differentiation to encourage their subscribers to sort their waste better. It is calculated that this measure will bring the sorting rates for municipalities, without a system for plastic packaging to an average 41% and the ones with an already established system up to 65 % (Raadal et al., 2016).

A legal obligation to sort plastic packaging, allows and encourage municipalities without a system for sorting of plastic to establish one, while the municipalities with an already existing system can increase their support of such solution. It was initially suggested that this legal obligation should include regulations on preferred treatment of sorted plastic packaging, in order to avoid plastic being sent to incinerators. It was also evaluated a potential prohibition of incineration of recyclable plastic together with a legal obligation to sort organic waste and plastic packaging, which would be targeted towards municipalities and companies that generate the waste as well as the incineration facilities. The purpose of such proposal is for plastic packaging to be treated as high as possible according to the EU's waste hierarchy, where recycling should always be the preferred waste treatment before the use of incinerators. This would be possible if MSW would be sent through central sorting before incineration treatment. The NEA do not, however, recommend a prohibition of incineration of recyclable plastic, but opens up for the increased use of central sorting to retrieve more plastic packaging from today's MSW (Miljødirektoratet, 2017).

3 Case Study

In this chapter, relevant actors in this study will be presented, as well as the Mepex report used as background data to explore the possibility of establishing a central sorting facility in More and Romsdal.

3.1 Meeting with ÅRIM

Speaking with my supervisor about my topic of interest, he advised me to reach out to the inter-municipal waste management agency (hereby referred to as IMA), ÅRIM, and tell them about the topic and problem description. After a short email correspondence, an interesting meeting with Øystein Solevåg, the general manager of ÅRIM, was conducted. He could tell that ÅRIM together with four other IMAs in More and Romsdal, had looked into the possibility of establishing a local central sorting facility through a pre-study. ÅRIM sees this as a potential solution for them to achieve the future recycling targets. In 2017, ÅRIM collected and handled 40 364 tonnes of MSW. This equals approximately 385 kilos per capita. Out of these 385 kilos of waste, 97 kilos were sent for recycling and 249 kilos was used for energy recovery. The rest was either landfilled, reused or categorised as hazardous waste. ÅRIM operates with a 32% recycling rate, and they are currently far away from the 50% recycling target of household waste by 2020 (ÅRIM, 2017). During the meeting, Solevåg showed the pre-study conducted by the consultant company Mepex, where different scenarios or alternatives of central sorting facilities are drafted for More and Romsdal. In this report, costs, technology, sorting rates and location were estimated and assessed for a potential sorting facility in Aalesund. The report will be further explained in chapter 3.2. Mepex based their study on 40 000 tonnes of household waste from the IMAs (Sørensen & Marthinsen, 2017). The IMA,

During the meeting, it was decided that the Mepex report should form the groundwork for this study. Solevåg also contributed to collect relevant respondents, through email correspondence with the other IMAs in More and Romsdal, in addition to the local incineration facility in Aalesund, Tafjord Kraftvarme AS (TAF). Before explaining the Mepex report, a presentation of the IMAs in this study is illustrated in table 1.

IMA:	ÅRIM	VØR	RIR	NIR	SSR	NoMIL
Municipalities:	Giske, Haram, Norddal, Sandøy, Skodje, Stordal, Stranda, Sula, Sykkylven, Vestnes, Ørskog og Ålesund	Volda & Ørsta	Molde, Aukra, Eide, Fræna, Gjemnes, Midsund and Nesset	Aure, Averøy, Halsa, Kristiansund, Oppdal, Rauma, Smøla, Sunndal and Tingvoll	Herøy, Ulstein, Hareid and Sande	Bremanger, Vågsøy, Selje, Eid, Hornindal, Gloppen and Stryn
Population:	103 228	19 714	50 731	62 101	25 083	32 932

Table 1- Overview of inter-municipal waste management agencies included in the study (based on table from Sørensen & Marthinsen, 2017 and NoMIL's webpage)

Table 1 illustrates the IMAs included in this study. While ÅRIM, VØR, RIR, NIR and SSR, was originally included in the Mepex report, NoMIL, which is situated in Sogn and Fjordane, was included at a later point in this study, due to its geographical proximity and future border adjustments. Together, these IMAs covers the waste collection and disposal of approximately 293 789 inhabitants. In addition to these IMAs, the recycling station and metal sorting facility Bingsa and incineration facility, TAF, was included in the study. Bingsa is owned by Aalesund municipality and receives today waste from industry and recycling stations, where they separate the recyclable materials from the non- recyclable and send these fractions for further sorting and recycling at other facilities. Bingsa has a close collaboration with the incineration facility TAF, at Grautneset, where they are each other's largest suppliers of waste inn and out. Bingsa receives bottom ashes from the ovens at TAF, which they are able to extract iron and metal from through their new and advanced metal sorting facility. Bingsa, on their hand, sends mixed combustible materials from the waste they receive at their facility, to feed the ovens at TAF. TAF is the only incineration facility between Trondheim and Bergen and receives MSW from the majority of the IMAs included in this study. TAF is owned by both Aalesund municipality and BKK (Bergenshalvøens Kommunale Kraftselskap, water- and energy power company, situated in Bergen).

3.2 A potential central sorting facility in More and Romsdal

Sørensen & Marthinsen (2017) argues that "the implementation of the WFD and PWD in Norwegian waste legislation framework, makes it necessary to decide on clear measures and targets for recycling of household waste and packaging materials" (p.1). With a current average recycling rate at 38%, it is obvious that many municipalities and companies handling MSW needs to increase their recycling efforts. Sørensen & Marthinsen (2017), evaluates sorting by the source as still the most important measure to increase this recycling rate, however, it needs to be considered how the use of automated sorting technology can function as a supplement to this.

As mentioned, Mepex was hired in 2017, by ÅRIM, to conduct a pre-study to investigate the potential of post-sorting MSW from five waste-regions in More and Romsdal. The pre-study focused on the potential use of central sorting technology to treat MSW from the selected regions, in addition to combustible waste from public recycling stations. The pre-study was conducted to give an evaluation of costs and sorting rates by increased MSW sorting. A solution by using already established waste treatment facilities in Aalesund, such as the incineration facility TAF or the industry facility Bingsa, has been the basis for analysis. The majority of MSW, waste from recycling stations and industry waste from the different regions in More and Romsdal, are currently being sent to these facilities. To create synergies, a potential idea was to transport MSW directly to an available silo at TAF, and after the waste has undergone sorting by NIR machines, the leftovers could potentially be transported to the incineration plant for energy recovery (Sørensen & Marthinsen, 2017).

The pre-study explored eight alternative sorting facilities using either NIR sorting technology or robotic sorting, or a combination of both. Only three of these will be further explained since these focuses solely on household waste, excluding waste from industry and recycling stations. These three alternatives are illustrated in table 2, which is translated to English from the Mepex report.

Waste	Sorting Technology	Sorted Waste	Downstream solution	Alternatives
MSW	NIR	Mixed Plastic fraction	Sale to GPN	1a Facility sorts mixed plastic fraction
		PCC	Sale through market/paper sorting plant	1b Facility sorts out several plastic types (Complete plastic sorting facility)
		Iron/Metal	Sale through market	1c Same as 1a, but mixed plastic fraction is further sold and sorted at ROAF/IVAR
		Leftovers	Energy Recovery TAF	

Table 2- Shows the central sorting alternatives as suggested for household waste in More and Romsdal (Sørensen & Marthinsen, 2017)

In table 2, MSW will be sorted in a central sorting facility using NIR technology. The idea is that all of the regions will maintain curb-side programmes for organic waste, glass- and metal packaging, paper, cardboard and carton (PCC). The plastic fraction will go back into MSW and be collected for post-sorting. In the first alternative, 1a, a smaller central sorting facility will sort a mixed plastic fraction and deliver this to GPN for further sale. In alternative 1b, the sorting facility will contain similar plastic sorting technology as RoAF and sort out the most favourable plastic fractions. These fractions are illustrated in figure 5. Alternative 1c is basically the same as 1a, but in this option, the mixed plastic fraction would be sent to other central facilities such as RoAF or IVAR for further sorting and recycling. Sørensen and Marthinsen (2017) emphasise that by using NIR sorting technology, one can increase the sorting rates of plastic packaging significantly, and due to this, also increase the overall recycling rates. In this context, the authors evaluate the sorting by source of plastic packaging as unnecessary. Even though paper and metal will be sorted at such a facility, they do not recommend liquidating the curb-side programmes for these waste fractions. High amounts of glass and metal can potentially damage and tear down conveyor belts and other components in the facility, and a high sorting rate of these fractions in households are therefore favourable (Sørensen & Marthinsen, 2017). The authors estimate a sorting rate potential released by the first three alternatives to be between 16-26%. The main alternative, 1a, is thought to bring a sorting rate of 20% (Sørensen & Marthinsen, 2017). This will be in addition to sorting rates from curb-side programmes. The costs related to building such facilities, are estimated to be 130 million NOK for alternative 1a and 1c, and this increases to 250 million NOK by building a complete plastic sorting plant as suggested with alternative 1b. These estimations are based

on prices from previous projects (RoAF and IVAR) and future MSW predictions where a potential central sorting facility in More and Romsdal will have the capacity of managing up to 40 000 tonnes of MSW from the regions included in the Mepex report (Sørensen & Marthinsen, 2017). The facility alternatives 1a and 1b and their estimated sorting potential using NIR technology, is illustrated in figure 4 and figure 5.

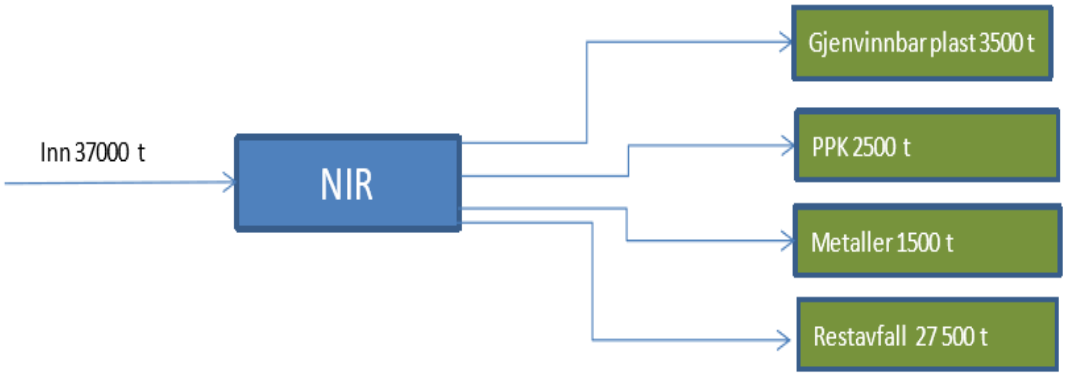

Figure 4- Shows central sorting alternative 1a and sorting rates measured in tonnes (Sørensen & Marthinsen, 2017)

Based on estimated amount of 37 000 tonnes of MSW being sent through sorting facility 1a, Mepex calculates an end result of: 3500 tonnes of recyclable plastic, 2500 tonnes of PCC, 1500 tonnes of metals and 27 500 tonnes of leftover waste being sent for incineration treatment. Figure 5 shows central sorting facility alternative 1b:

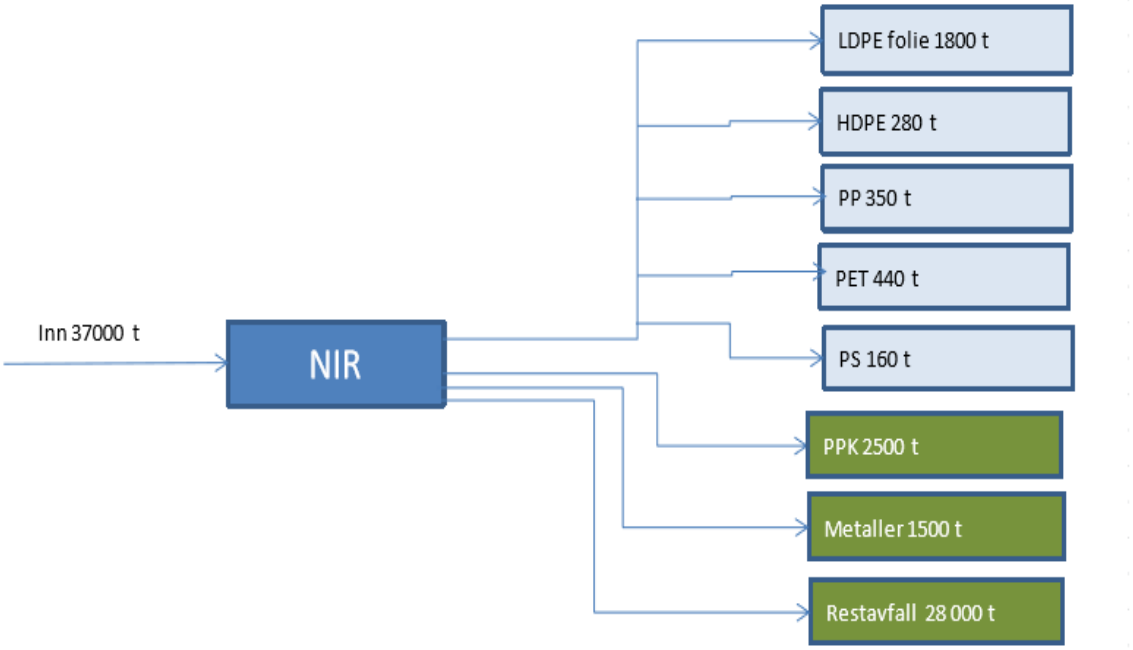

Figure 5- Shows central sorting alternative 1b and sorting rates measured in tonnes (Sørensen & Marthinsen, 2017)

With a complete plastic sorting facility such as alternative 1b, the total sorting rate is measured to be somewhat lower than 1a, but this is seemingly because the facility will sort out cleaner plastic fractions for direct delivery to plastic recycling facilities. This facility will sort five different plastic types, same amount of metals and PCC as alternative 1a, and 28 000 tonnes of residual waste for further incineration.

3.3 Municipal Solid Waste Management in More and Romsdal

In 2016 it was generated 107 000 tonnes of household waste in More and Romsdal according to Statistics Norway (SSB, 2017a). 24 000 tonnes of this waste was sent for recycling, while 68 000 tonnes was sent for incineration. 3 000 tonnes was used for biogas production, and only 4 0000 tonnes was sent to landfills. Based on numbers from ÅRIM, Sørensen and Marthinsen (2017) created a table for the assumed material composition in MSW in More and Romsdal. Figure 6 is based on these numbers to get a more visual representation of the different waste fractions in MSW. These numbers were measured before ÅRIM introduced a

separate food waste collection and metal/glass packaging collection, and therefore are more representative for the IMAs VØR, SSR and NIR, which similar to ÅRIM just recently started sorting food out of MSW or are about to do so this fall.

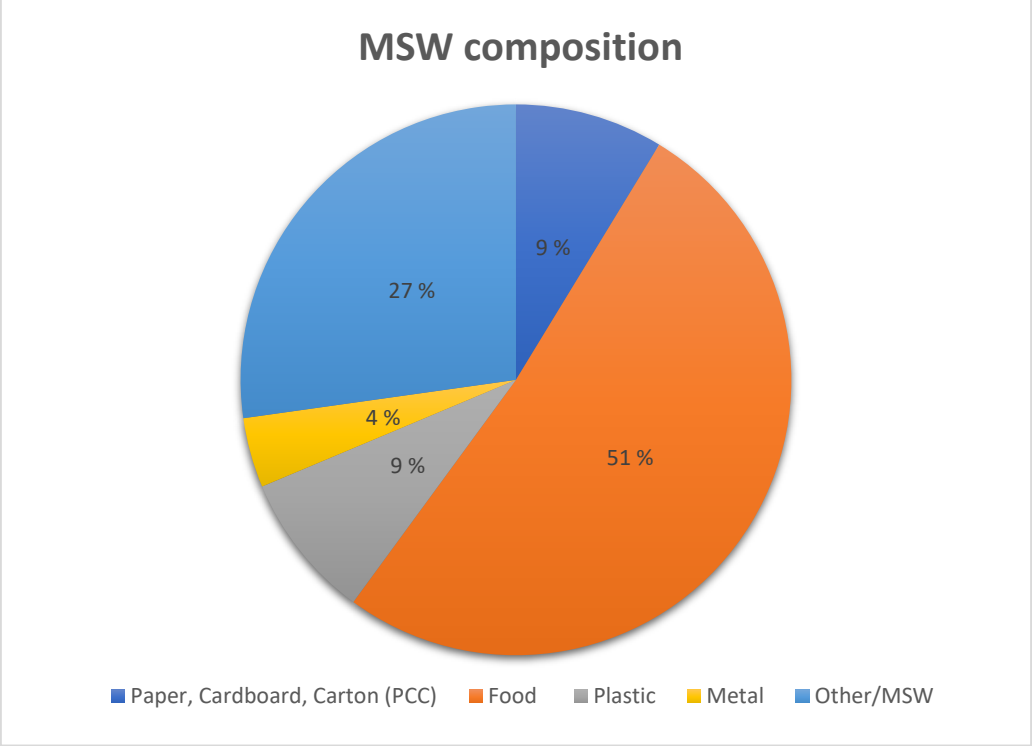

Figure 6- Pie chart showing the waste composition in MSW, based on statistics from the inter-municipal waste management agency ÅRIM (ÅRIM, 2017).

As figure 6 illustrates, the amount of food makes up for the most of the contains in MSW, and a lot of weight will be removed when this fraction is sorted into own bin. Such organic waste also contaminants the other waste fractions, making them less fit for recycling and this is especially a problem for the potential value related to the 18 % shares of plastic and PCC in the MSW. In order to come close to achieving future recycling targets, it is a prerequisite that the organic waste is being sorted out. While figure 6 represent the material composition with no food waste sorting, figure 7, shows the material composition after this fraction has been removed. The figure is in Norwegian but will be explained in English. RIR has had a separate collection for food waste from private households since 1999. Figure 7 is based on samples taken from MSW in four chosen areas in RIR's municipalities.

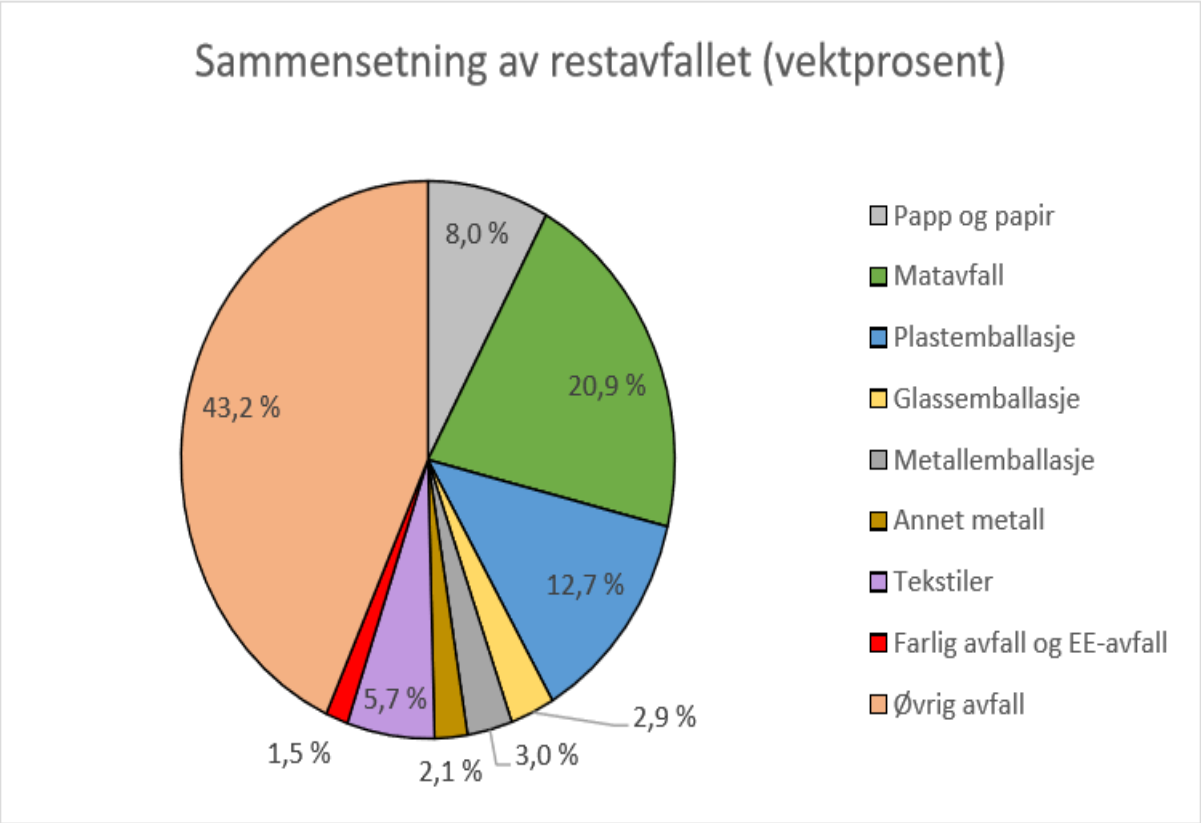

Figure 7- Pie chart showing material composition in MSW, where food waste is being sorted separately (RIR, 2017).

Figure 7 includes more categories than figure 6, as it shows fractions such as textiles, hazardous waste and E-waste. This would be part of the "other" category in figure 6. Figure 7 shows that the share of glass packaging and metal packaging makes up 6 % of the total weight in MSW, when food is separated from this fraction. Plastic packaging counts for over 12 % and PCC 8% of the total weight. The largest share is "other waste", which includes among other things: garden waste, Styrofoam, other plastic products, glass, and combustible and non-combustible waste (RIR, 2017). Even so, 21% of the total weight are still food waste ending up in the MSW bin. It needs to be mentioned that RIR implemented a separate bin for metal- and glass packaging the fall of 2017, together with ÅRIM, VØR, NoMIL and NIR. Samples taken from areas with this established sorting solution would maybe results in less metal and glass packaging than what figure 7 illustrates. However, this figure seeks to give an idea of the material composition once the food has been removed from MSW. According to the same Mepex report, the MSW consist of approximately 57 % waste that could have been sorted by the source and/or delivered at recycling stations such as other metal, hazardous waste or E-

waste. The rest consists of non-recyclable waste, combustible and non-combustible waste (RIR, 2017).

The sorting rates of plastic packaging in households with the different IMAs varies somewhat. VØR and ÅRIM measured in 2017, 4,2 and 5,4 kilos in collected plastic packaging per capita, NIR measured 6 kilos, while RIR, NoMIL and SSR, all have between 9- 9,9 kilos per capita in collected plastic packaging. Due to this variation in sorting rates, a comparison of the IMAs current waste collection system is necessary, to understand similarities and differences. This is illustrated in table 3, which shows that all of the IMAs offer separate bins for PCC and MSW. They also offer an own bag for plastic packaging which can be put either into the PCC bin or next to it, and these two fractions are collected together with all the IMAs. Four of the IMAs provides a separate bin for food waste, while VØR and SSR are planning to implement this during the fall of 2018. All IMAs, besides SSR are also operating with a separate bin for metal- and glass packaging. Even though it is not included in the table, it should be mentioned that some of the IMAs are also offering smaller red boxes for hazardous waste. As the table illustrates, the IMAs share a similar sorting system for households. However, if one glance at the collection frequency of each waste fraction, there are some small divergences between the IMAs. All of the IMAs, besides SSR and VØR, collects plastic packaging, together with PCC, every fourth week. MSW is collected every other week, except NoMIL which operates with a collection frequency of every fourth week.

Current Waste Collection System for Household Waste						
Waste Fractions	**ÅRIM**	**VØR**	**RIR**	**NIR**	**SSR**	**NoMIL**
MSW	Own bin	Own bin	Own bin	Own bin	Own bin	Own bin
PCC	Own bin	Own bin	Own bin	Own bin	Own bin	Own bin
Plastic Packaging	Own bag	Own bag	Own bag	Own bag	Own bag	Own bag
Food	Own bin (7/12 municipalities)	Coming fall 2018	Own bin	Own bin (1/9 municipalities)	Coming fall 2018	Own bin
Metal/Glass Packaging	Own bin	Own bin	Own bin	Own bin (3/9 municipalities)	Recycling stations	Own bin
Collection Frequency	**ÅRIM**	**VØR**	**RIR**	**NIR**	**SSR**	**NoMIL**
MSW	Every week/ every other week	Every other week	Every other week	Every other week	Every other week	Every fourth week
PCC	Every fourth week	Every third week	Every fourth week	Every other week	Every other week	Every fourth week
Plastic Packaging	Every fourth week	Every third week	Every fourth week	Every fourth week	Every other week	Every fourth week
Food	Every other week	Coming fall 2018	Every other week	Every week	Coming fall 2018	Every other week
Metal/Glass Packaging	Every 10th week	Every 12th week	Every 8th week	Every fourth week	Recycling stations	Every 10th week

Table 3- Current waste collection system for household waste, based on responses from interviews and Mepex report conducted by Sørensen & Marthinsen (2017).

The IMAs waste collection system are further discussed and used in the analysis of IMAs and their use of PAYT-schemes. For this study it is also interesting to investigate the material composition in the "clean" plastic packaging bag collected by IMAs. Statistics from GPN (2017) shows the expected amount and types of plastic being collected through normal plastic bag systems in municipalities. These numbers are based on analysis conducted by Mepex and represent 31 % of the annual tonnage from Norway. Of course, different municipalities and IMAs are operating with varying results with some having a high collection rate and others less. Figure 8 aims to give a visual representation of the different plastic types collected based

on statistics from GPN, even though the percentage of each type of material might vary between each municipality.

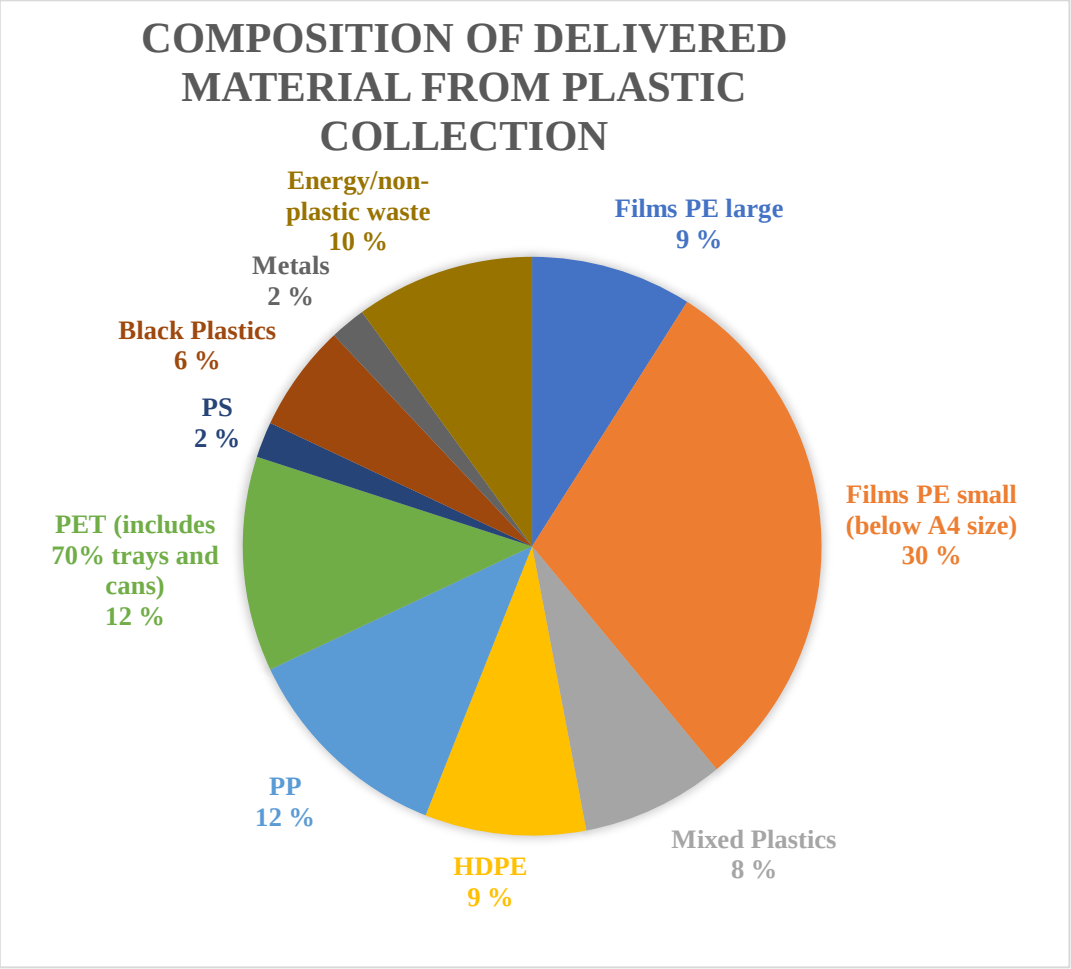

Figure 8- Shows the expected material composition of collected plastic from normal bags, based on numbers from Green dot Norway (GPN, 2017).

4 Methods

In order to investigate the study's problem description, a literature search and review was conducted both before and during the process of the data collection. The chosen research method for this paper was a qualitative study, and in this regard interview guides was designed based on theoretical resources. This chapter aims to explain how literature search was conducted, in addition to an evaluation of the interview guides as well as the interviews. It will also be elaborated about validity and reliability of the chosen research method.

4.1 Literature search and review

The use of literature as data material are key in most of research projects. Most often these are used as background- or additional data to the data collected from interviews, questionnaires or observation (Tjora, 2015). The literature or documents can be case specific, such as a company's annual statement or information from webpages regarding the issue being studied. They can also have a more general characteristic, for example political documents such as parliamentary reports, research reports or articles. Tjora (2015) explains review studies as "studies of all relevant research publications within a restricted research topic" (p. 165). This type of studies is used to create an overview of what theories and methods have been used within a specific research theme, as well identify important concepts which can help define search criteria.

The problem description for this study covers MSW management in More and Romsdal and how to increase plastic packaging sorting rates. This study touches concepts and theories within circular economy, waste management and policies, sustainable development and consumption. These where therefore some of the keywords used to define searches on Google Schoolar, JSTOR and Oria. Articles and documents where sorted and chosen for the study after year of publication and title. Reviews of introductions and summaries were conducted to evaluate their relevance for the study and which of them could be used as background- or additional data.

This study concerns MSW management, central sorting and PAYT-schemes. While there was abundant with literature about MSW management, there was limited research about the relationship between PAYT schemes and sorting rates. While there seem to have been conducted some studies of specific PAYT schemes and how these affects waste generation behaviour, only one article was found, where all PAYT schemes were compared to sorting

rates in different countries. This was a report conducted by the EC (2012). Another article used in this study, was a study conducted by Dahlen & Lagerkvist (2009) regarding the use of weight-based PAYT schemes in Swedish municipalities. It proved difficult to find relevant and up-to-date information about the relationship between central sorting and sorting rates, compared with sorting by the source systems. But an article written by Cimpan et al. (2015) was found relevant to include in this study.

In addition, literature and documents available at Ellen MacArthur Foundation's website (EMF), Avfall Norge (Norwegian Waste Management and Recycling Association), The EC and UN was of particular interest. The latest years, EMF has published several reports concerning the latest trends, status and innovative thinking regarding the utilisation of plastic within the circular economy paradigm. Especially the reports "New Plastic Economy- rethinking the future of plastics and catalysing action" (EMF, 22.11.2017) and "Towards a Circular Economy- a business rationale for accelerated transition" (EMF, 09.12.2015) were relevant to explain the current context in which the waste management organisations navigate themselves, with increased focus on material recovery. These reports together with UN's SDGs, the EU's WFD, PWD and circular economy action plan, provides the background for international agreed targets and strategies put forward to secure a sustainable waste management and put resources back into circuit.

Other public accessible literature and documents used for this study is the parliament report developed in 2017 with the title: "Waste as a Resource - Norwegian waste politics and circular economy" which explains the status for Norway and strategies towards a circular economy through higher sorting and recycling rates of household waste (Meld.St. 45. (2016-2017)). Reports from the NEA and Ostfold Research has been used as background data (Miljødirektoratet, 2017, Raadal et al, 2016). In addition, it has also been used non-published reports such as annual statements and pre-studies from some of the IMAs in the study.

4.2 Research Design and Data Material

In social research there are two distinctive research methods or paradigms when it comes to collecting and produce information related to an issue, and how to analyse it. A qualitative research method distinguish itself from a quantitative research method due to its focus on closeness to your respondents through interview or observation situations instead of questionnaires. In the data collection, one is most often working in an inductive manner,

which is more exploring and based on empirical evidence, than the deductive one, where one starts out with a theory and hypotheses and aim to prove them wrong or right (Tjora, 2012). Typical qualitative studies can be the study of phenomena, perspectives, opinions and case studies. In some situations, it would be beneficial to combine a qualitative research strategy with a quantitative one to get a wide composite research. However, this requires the researcher to have the resources and time available to do so, because it will often generate large amounts of data (Tjora, 2012). For this study, the aim was to uncover thoughts, reflections and perspectives of the different IMAs, TAF and Bingsa, concerning the problem description. Therefore, a qualitative research method through interviews was deemed the best way to collect this data. This method allows more in- depth responses and flexibility, while a questionnaire would limit the respondents chance to communicate different perspectives and opinions by giving them predetermined answers, so-called “closed questions”.

4.3 Interviewees

After email correspondence with each of the waste management agencies and incineration facility, two skype interviews and four face-to-face interviews were agreed upon. After these first interviews, it was found relevant and beneficial to include three more actors in the study to understand the relationship and collaboration between the different actors, and these were deemed especially significant in the question regarding a central sorting facility. Another face-to-face interview was conducted with Bingsa industry located close to Aalesund, and a video-call with the IMA, NoMIL, situated in Sogn and Fjordane. Communication was established with the third potential interview object, Aalesund municipality, and an interview was scheduled. However, the respondent was not available the day of the interview and did not respond to the follow-up email. In five of six interviews with IMAs, the general manager was interviewed, and the last one was conducted with an environmental consultant. At Bingsa, the interviewee was the general manager and one of the authors of the Mepex report (Sørensen & Marthinsen, 2017). At TAF, the interviewee worked as the sales manager for waste.

4.4 The Interview Guides

An interview guide is seen as a helpful tool to structure the interview and is commonly used to divide the interview into different themes depending on what one wants to know. The first

part of an interview guide consists often of simpler questions to give a comfortable and easy start of the interview for both the respondent and interviewer. The main part consists of questions where the respondent will need to reflect more around the topic and provide more detailed answers. The last part of the interview guide should preferably be questions that can help ease towards an end of the conversation (Tjora, 2015). The interview guides used for this study is available in appendix A and are presented in Norwegian.

One interview guide was originally made, but this had to be altered somewhat depending which agency was interviewed. Since TAF is an incineration facility and private company, they will have a different agenda and business model than IMAs. Therefore, the original interview guide had to be adjusted when interviewing TAF. While the IMAs were asked questions related to how they could increase plastic packaging sorting from MSW, TAF were asked how these solutions would affect their business, since they are dependent on a lot of waste going in to operate their facility. In relation to Bingsa, only a few questions were prepared before the interview, so an own interview guide was not necessary in this case.

The first part of the interview guides was questions where the respondents were asked to explain their waste - or incineration system. The main part of the guide included questions related to the measures; PAYT schemes and central sorting facility. The IMAs were asked to evaluate the different measures and how this could help them increase their sorting and recycling rates of plastic packaging. TAF was asked how these measures would affect their business and their services significance in the future. All of the respondents were asked to reflect upon a potential collaboration in establishing a central sorting facility as reflected in the Mepex report (Sørensen & Mathisen, 2017). Both interview guides ended with the question on how they picture the waste management industry in year 2030. Since the interview guides contained a lot of reflective questions and the expected duration of the interviews were to be between 30 to 60 minutes, the respondents were expected to be well prepared before the interview. Hence it was decided to send the interview guide together with the Mepex report to them a week before the scheduled interview. It was thought that this would help them reflect upon the questions and have them prepare well-thought answers, and in this way reduce the amount of digressions and confusion around the questions. The respondents were informed to reach out if anything in the interview guide was unclear or if they had any questions.

4.5 The interviews

The majority of the interviews took a semi-structured shape and lasted in average one hour. In a semi-structured interview, open questions are used to give the respondent a chance to talk freely about a chosen and restricted topic. In this type of interview, one will need to allow some digressions and new thoughts that you before the interview maybe didn't think of, but which later might prove useful. On the other hand, allowing digressions and "free speech" can sometimes lead to very long interviews and it might be hard to keep a structure throughout the interview. Using a questionnaire would be less time demanding and have me reach out to more respondents, but as the purpose of this study was to collect a lot of data from few respondents and to map thoughts and reflections of the local waste management actors, a semi-structured interview was deemed the best research strategy.

As mentioned, five of the interviews were conducted face to face. These were all at the respondent's office or workplace. According to Tjora (2015), the selected place for the meeting has a significance for the quality of the interview. Some places might be more prone to noises and disturbance than others, and some respondents might feel more comfortable if they get to choose their own interview setting. In this study, when the interview was conducted at the respondent's workplace, the interviews turned quickly into a more unformal and comfortable conversation and the guide was only briefly glanced at through the interviews. The otherwise quiet atmosphere gave good quality recordings and made it easy to transcribe the interviews afterwards without being disturbed by background noises. Another benefit by having the interview take place at the respondent's office were that they had the opportunity to show presentations and explain documents on their computers. This provided a better understanding of their organisation and how they operate. When reflecting upon the duration of the interviews, these turned out to last longer than expected. All interviews conducted face-to-face lasted over one hour, with one of them lasting for over two hours. This challenged the initial strategy of giving the respondents the interview guide before the interview. The long duration can also be explained by allowing too many digressions or not following the structure of the interview guide strictly enough. However, even though it gave a lot of data to process, most of it was found to be of value and relevant for the study, and allowing some digressions also opened to interesting perspectives and points that was not initially thought of before the interviews. In two of the interviews there were two people taking part in them. In one of this, the interview at Bingsa, the meeting was originally scheduled with the general manager, Per Oscar Slinning. However, during the interview with

Slinning, one of the authors of the Mepex report used in this study, Geir Sørensen, walked in on the meeting. He was at Bingsa for a tour at the facility. While the questions were initially only prepared for Slinning, this meeting turned into a one-hour interview, with both Slinning and Sørensen.

The remaining interviews were done over the communication and video-apps Skype and Hangouts, due to geographical distance. In two of the interviews some technical problems with the app Skype was experienced. In another interview, it was also some difficulties in finding the right username on Skype, and when trying to contact the respondent, it turned out that their Wi-fi at the office was down and it was not possible to achieve contact through this channel. Luckily, the Wi-fi issue was fixed shortly after, and the interview could be conducted over Skype as initially planned. In one interview the communication app Hangouts had to be used instead of Skype, which was originally planned. All of these interviews lasted shorter than one hour and this might be explained by respondents experiencing an interview through video-call as a more formal setting. It felt as these respondents were more occupied with sticking to the questions and the interview guide's structure to save time. The experience from the interviews was that there was a lot more digressions and follow-up questions with the respondents interviewed face-to-face. A personal meeting is often more relaxing and comfortable, and this might allow people to talk more freely around and out of topic, than they would over the phone or Skype. There were both pros and cons with the interviews conducted face-to-face and over the internet.

4.6 Transcription

Each interview was planned to be transcribed right after it was conducted, while the situation and impressions was still fresh in mind. However, since some of the interviews lasted well over an hour, some of the transcriptions had to be conducted over several days. All of the interviews were recorded as it was decided this would reproduce the interviews as detailed as possible and secure correct citation. Only major digressions where the interview left the topic was left out of the transcription. One issue with the transcriptions is that the interviews were performed in Norwegian, and then later translated to English when transcribed. This might lead to answers in Norwegian being lost in translation when written in English. This can be exemplified when the respondent came with a typical Norwegian expression or word, where there is no equal expression in the English language. However, efforts have been made to best formulate these sentences in a way that gives as true and same meaning as the original sentence.

4.7 Ethical issues

A lot of the ethical issues concerning interviews are related to the collection and presentation of data, such as anonymisation of personal information (Tjora, 2015). Ethical concerns during the interview are mainly if the respondent feels pressured or is in any danger to harm. All of the respondents were aware and comfortable with the conversation being recorded, and they were never in a compromised situation. As far as the anonymisation goes, some information and citations containing the respondents' names and work title are reproduced in this paper. This is approved by all of the respondents verbally and through form of consent. This research has been reported to and approved by the Norwegian Centre for Research Data, NSD. Records of interviews are safely stored and will be deleted two months after this study finishes.

4.8 Reliability and validity

To evaluate the quality of the research, the terms reliability and validity are most often used. Tjora (2015) explains how reliability evaluate the internal logic through the whole research process, while the validity has to do with the logical connection between the project's design, findings and chosen research questions.

4.8.1 Reliability

Within all social research the researcher will be coloured by some interest or engagement in the issue to be studied. This has to do with reliability. The ideal is an objective or neutral researcher (Tjora, 2015). However, a completely neutral position is deemed impossible. While some will say that a researcher's engagement in an issue might give rise to disturbance in the research, other might view it as a resource where the researcher's knowledge is used. This should be done delicately, and the researcher needs to be aware and make it clear how one's position might affect the research.

When evaluating my role as a researcher in this study, I cannot say I haven't been coloured by my interest and personal engagement in environmental questions. My interest formed this study and problem description, but I have aimed to stay as neutral as possible through the data collection and analysing. By being aware of my pre-knowledge and interest during the time

writing this study, this has helped me maintain a neutral perspective during data collection, analysis and discussion.

4.8.2 Validity

Validity makes us ask the question: do the answers we have collected in fact answer our questions? This requires the researcher to be transparent to how the research in fact was conducted, why did he or she do it the way they did? Why chose that theory instead of the other? (Tjora, 2015).

By collecting qualitative data and due to limited sample of respondents, it will be harder to generalise the results and decide if they are significant. However, since the study included several actors in the local waste management sector, findings in this study might also be applicable in other studies with similar context and problem description. The theoretical framework used in this study has been thoroughly examined and chosen to enlighten and discuss the problem description. As the thesis's purpose was to explore and investigate the experience and thoughts of the local waste management actors around potential measures to increase plastic packaging sorting rates, the study can be found to be valid, through the use of in-depth interviews.

5 Empirical Data

Empirical data has been collected through two reports, five face-to-face interviews and three video calls. Between the interviews there has also been some email correspondence with the interviewees. This chapter seek to present the most important findings from the interviews. The IMAs in More and Romsdal were asked to evaluate strengths and weaknesses with their current household waste systems, and how they are positioned to achieve recycling targets of household waste by 2020 and 2030. They were also asked to assess the suggested measures: increased use of PAYT schemes, and central sorting as tools to help them achieve the targets. Finally, all of the respondents were asked about their thoughts of establishing a local central sorting facility in More and Romsdal. In the next sub-chapters, a short summary of the most interesting findings with each respondent are reviewed.

5.1 ÅRIM- IMA in Aalesund area. (Ålesundregionens Interkommunale Miljøselskap IKS).

ÅRIM started restructuring their waste collection system in the spring of 2017, due to low recycling rates and not being able to achieve the first recycling target of 50% household waste. The removal of organic waste from MSW, in addition to the introduction of a separate metal- and glass packaging bin, is seen as one crucial step to achieving this target. In 2017 they measured 5,4 kilos per capita in collected plastic packaging. When asked about the potential of increased use of PAYT schemes, the general manager of ÅRIM, Øystein Solevåg, mentioned in his interview on 05.03.2018, how less frequent collection schedules and size of the bin has been evaluated and used as a tool to differentiate the waste fee. By tossing less MSW, one can get a smaller bin for a lesser price. In the same way if the subscriber wants a larger bin than the standard size, this will result in more costs. When reflecting upon the less frequent collection schedules as a measure to increase sorting rates, both positive and negative aspects were pointed out. If ÅRIM were to change their collection frequency of MSW to every fourth week, as others has done with success, this would lead people to sort their waste better due to less space in the bin. However, this effect would probably differ during the summer and winter season, with the winter giving less space in the bin, and therefore better sorting rates. But during the summer, when people are on vacation or toss less, this will lead to more room, and therefore more plastic packaging and other stuff might end up in MSW to fill the space. Solevåg admits that they have more plastic packaging ending up in MSW than

the amount of plastic packaging being collected as a clean fraction at subscribers' homes. To implement a measure where people would have less space in their MSW bin, would inevitably lead to more sorted and collected plastic. However, due to trouble with logistical solutions related to changes of a lot of transportation routes, and that this measure would most likely not help them achieve the recycling rate at 50 % anyways, ÅRIM needs to look at more drastic measures. ÅRIM started considering a central sorting facility as the answer to their low recycling rates. Solevåg is certain that together with the other regions and by the use of TAF's facility, a central sorting facility can help ÅRIM achieve the recycling rates by 2020 and 2030. Solevåg emphasise that is a necessity to think about flexibility when it comes to how plastic will be assembled in the future. Technology can help solve such issues and make the waste management sector less vulnerable in the future.

5.2 VØR– IMA in Volda and Orsta area (Volda/Ørsta Reinhaldsverk).

When asked how VØR is positioned to achieve the recycling rate of 50% household waste by 2020, the general manager Petter Bjørdal in his interview on 08.03.2018, could tell that VØR still have some way to go. In 2017, they measured a recycling rate at 39 % of household waste. In 2015 they measured 4-5 kilos per capita in collected plastic fraction. In 2016, VØR experienced a sudden increase in collected plastic, where they collected 9 kilos per capita. This, according to Bjørdal's opinion, was due to the introduction of collection frequency of MSW every other week, instead of every week. The result was that the subscribers panicked and therefore sorted their waste better. However, when the subscribers noticed they still had some room left in the MSW bin, they started filling this up again. In 2017 the plastic sorting rate dropped to 4,2 kilos per capita (VØR, 2017). In addition to low plastic sorting rates, VØR has had some problems with MSW polluting the plastic fraction. GPN has given a 5% tolerance of MSW content in this fraction, however, VØR has had an 8% MSW content (VØR, 2017). Bjørdal made it clear that there was no doubt, if one wants to achieve a certain number of kilos of plastic collected, it is not enough to offer people solutions for food, paper and cardboard. One also need to post-sort MSW. But he also wants to emphasise that the solution of reducing people's ability to deliver their MSW is probably a better and cheaper solution than building a central sorting facility. This is the best socio-economic way to work with the waste according to him. He also mentions that in order to achieve a 65% recycling rate, there is also a need to sort wood and plaster.

5.3 RIR- IMA in Molde area (Romsdal Interkommunale Renovasjonsselskap IKS).

In terms of sorting rates of plastic packaging per capita, RIR is one of the IMAs that operates with the highest numbers. They are also one of two IMAs that sees the recycling target by 2020 as achievable with their current waste system. RIR started a separate collection of organic waste as early as 1999 and introduced metal- and glass packaging collection during the fall of 2017. The general manager of RIR, Jan Egil Korseberg in his interview on 09.03.2018, estimated a total amount of 8-9 kilos per capita of collected plastic packaging. This has been possible to achieve, according to Korseberg, through a lot of information and offering user-friendly solutions. When it comes to collection frequency, RIR is collecting their MSW every other week. Korseberg believes that the introduction of an own metal/glass packaging bin will help them move forward from a recycling rate at 46 % to achieve the first milestone by 2020. However, when he was asked about the increased recycling target of 65% by 2030, Korseberg pictured this will be harder to achieve with their current system. When asked about the potential in increased use of PAYT schemes, he could tell that they had several ongoing projects and ideas related to this. An example is a pilot project to be realised in 2019. This includes a waste fee consisting of a basis fee, and then by the use of RF-ID chips (Radio-Frequency identification), the rest of the waste fee will be decided depending on how many times the bin has been emptied. This way it will be up to the subscribers how many times they will put their MSW bin out. However, they need to be charged for some emptying, so they are not tempted to empty their waste somewhere else. According to Korseberg, this is estimated to give approximately a 20% reduction in people's waste fee and will hopefully motivate their subscribers to sort their waste better. Korseberg believes that people are sorting their waste better when it shows on their bill.

When asked about a potential central sorting facility, Korseberg thinks that in the end, they will have to enter such project to achieve recycling targets by 2030. However, according to him, samples taken by the consultant company Mepex, shows that RIR will have less to gain when it comes to retrieving plastic materials out of MSW. The samples show that plastic packaging counts for 12,7 % of the contains in RIR's collected MSW. Korseberg thinks that others with less good results in plastic collection or the ones without such system will have a lot more to gain in entering a central sorting facility project. But due to the remaining percentage of plastic packaging, as well as 8 % cardboard, paper and some organic waste still

ending up in MSW, the use of central sorting is believed to be the solution to sort out these waste fractions and achieve the recycling target of 65% by 2030.

One problem that Korseberg mentioned in his interview, which was mentioned by almost all of the other IMAs as well, is the waste generated at cabins. If they would have proper recycling solutions for these, the amount of plastic sorting would increase together with the total recycling rate.

5.4 NIR- IMA in Kristiansund area (Nordmøre Interkommunale Renovasjonsselskap).

When asked how they are doing in regard to the first recycling target of 50% by 2020, the general manager of the IMA NIR, Hilde Harstad, said in her interview on 13.03.2018 that they consider themselves not too far away when the sorting of organic waste, as well as metal- and glass packaging, is set in motion. Harstad emphasise that the achievement of the targets depends on how EU decides to measure them. In terms of the 65% recycling rate, this is evaluated through what is technical possible. With a central sorting facility, it will be possible to sort out more, while at the same time there will be a lot more waste coming to the recycling stations in the future which needs to be handled.

In the discussion of a central sorting facility versus how to increase sorting in households, Harstad mentions how waste reduction happens when consumers get a relationship to their waste. She explained that people felt positive when the plastic sorting option was first introduced, as they realised how much plastic packaging they actually bought and tossed away. However, a problem with the plastic packaging sorting at home, according to Harstad, is that people are not aware of the different types of plastic and do not manage to separate the different types and decide what should go into the plastic bag. This has been tried solved through a lot of information. NIR has currently a collection rate of 6 kilos plastic packaging per capita.

Regarding the use of PAYT schemes and increased use of this, NIR has chosen to differentiate the waste fee through the size of the bin and stick with this scheme. Their experience is that when their subscribers are offered the option of a smaller bin, the amount of MSW has been reduced and the sorting has become better. At their last municipality the introduction of this measure led to an increase in plastic packaging collection rates from 2

kilos per capita to over 5 kilos in one year. Despite this, Harstad concludes that one can not only trust the consumers to sort their waste, because they are not as good at distinguishing different plastic types or sort as much as the waste management companies would like them to do. Therefore, a central sorting facility will be the answer according to Harstad. This will also bring the opportunity to sort out other valuable fractions when the technology continues to develop. However, NIR has already committed themselves to take part in the planning of a central sorting facility in Trondheim (SESAM), which means that a potential sorting facility in More and Romsdal is not relevant for them to take part in at this point.

5.5 SSR- IMA in Ulsteinvik (Søre Sunnmøre Reinhaldverk)

When asked about their current waste system, the general manager of SSR, Einar Heimdal in his interview on 21.03.2018, claims SSR has without doubt Norway's most expensive and best solution when it comes to PCC and plastic collection. Currently they are operating with a plastic packaging collection rate of 9 kilos per capita. Regarding their current waste system, they are offering their subscribers a standard size bin of 240 litres for PCC and 140 litres for MSW and both bins are being collected every other week. A separate bin for food are being introduced to their subscribers the fall of 2018. Heimdal explains that they have already achieved the first target of 50% recycling rate of household waste. However, when asked about the 65% target, he is less optimistic. When talking about the additional 75% recycling target for packaging waste by 2030 as stated in the Directive on packaging and packaging waste, he mentions this will be difficult to achieve without sending MSW through central sorting. However, Heimdal share a concern with the other IMAs regarding the expenses related to a local central sorting facility and how this will add even more charges to the subscribers.

When asked about the potential in increased use of PAYT schemes, this is evaluated to not be sufficient enough to achieve the recycling targets by 2030 as stated in both WFD and PWD. Currently they are basing the variable part of the waste fee on the size of the bin. They have previously tried to differentiate the waste fee based on weight of the bin, but this was of little use, when neighbours started filling up each other's bins during the summer and vacations. However, they offer reduced subscriptions, and one such planned reduced subscription is to offer households an 80-litre bin for food waste, instead of the standard 140 litre bin. They also plan to change the collection frequency of PCC and plastic packaging to once a month. By

providing information and the use of campaigns, the amount of collected plastic packaging has increased each year for SSR, but Heimdal emphasise there is still a lot of plastic packaging that could have been recycled but which ends up in MSW instead.

5.6 NoMIL- IMA situated in Sandane (Nordfjord Miljøverk).

In her interview on 19.04.2018, the environmental consultants at NoMIL, Janne Bareksten, could tell that NoMIL currently have a recycling rate at 42 %, where 18% of this is bio-waste treatment. In their recycling rate they include waste delivered at the recycling stations. This is also included with some of the other IMAs. When asked about the recycling targets to be achieved by 2020 and 2030, Bareksten emphasise that they still have some work to do, and especially the target of 65% by 2030, is deemed very ambitious and difficult to achieve. Regarding the use of PAYT schemes, NoMIL uses volume-based schemes as the variable part of the waste fee. Due to the less frequent collection of MSW, subscribers have the option of buying a larger bin, but this will cost them more. NoMIL is the only IMA in this study to collect MSW once a month. The same frequency is used for PCC and plastic packaging. Organic waste is collected every other week. Due to geographically dispersed households and the infrequent collection schedule of MSW, PAYT schemes based on weight or the amount of emptying is not seen as attractive.

NoMIL operates with a high rate of collected plastic packaging per capita, as much as 9,9 kilos. Bareksten still sees the amount of plastic in MSW as a problem. Plastic with complex material composition and the lack of will from GPN to expand their plastic “wish” list, has been a particular challenge. Bareksten points out that to sort out more types of plastic material from MSW and to “help” those who do not sort at home, a central sorting facility will possibly be the answer. When asked about the 65% recycling target, she responds with the same conclusion as the others, this is not possible with their current waste system.

5.7 Tafjord Kraft (TAF)

TAF were considered important to include in the study as they are the receiver of almost all MSW from the IMAs in this study, and changes in the composition of MSW will inevitably have a direct effect on their facility as well. Not at least, a potential central sorting facility is suggested to be put at their property using their bunker. The sales manager Richard Nilsen

was asked in his interview on 14.03.2018, how future recycling targets and better sorting and recycling rates will affect TAF. Nilsen explains how plastic is the most common waste sent to their facility for incineration and that plastic should be viewed as a common problem for all. Plastic is made of fossil-based material and have less incineration value, because the incineration of such materials releases a lot of NOx gasses. Nilsen mentions that even though more plastic fractions will be sorted out in a central sorting facility, there will still be approximately 20 plastic types left which there is yet no solution for or which is not valuable enough to be handled, seen from a cost-efficient perspective. Therefore, Nilsen still see TAF as a key player in handling the leftovers from MSW after it has gone through post-sorting. In addition, they will be needed to remove toxins and hazardous waste. Nilsen see the incineration facilities as the solution for the waste one cannot do anything about. Even if the recycling rate at 60% is to be achieved, there will still be 40% left which needs to be taken care of. Nilsen also mentions how Europe and the market will demand the finest materials to supplement the circular economy, hence, there is a need to sort the waste better. Before the waste goes through the incineration ovens, it is not filtered, and operators do not have the time to go through the waste to pick out less favourable materials before it gets incinerated. Therefore, a post-sorting facility doing the job will be the best option, as in this way, one is less dependent on the consumers sorting their waste correctly or not. This will lead the waste management sector to 2030 according to Nilsen. In the future, he pictures households only having own bin, and then a larger facility doing the rest of the sorting. However, if a local central sorting facility should be built, Nilsen emphasises that the time-perspective and local value creation is important to assess. If one wants to keep the waste and value of it within the county borders, it is urgent that a process of planning a sorting facility is soon began, or one might risk having to send it to other sorting facilities such as SESAM or IVAR in Trondheim and Stavanger. Nevertheless, Nilsen saw a potential central sorting facility at TAF's property as a positive and possible solution. However, the will to invest in such facility seemed to be limited.

5.8 Bingsa

When asked about his thoughts on the future recycling targets in his interview on 16.04.2018, the general manager of Bingsa, Per Oscar Slinning, agrees with the rest of the respondents, that one need to use central sorting to achieve future recycling targets set by the WFD and PWD. However, when asked about the potential of establishing a local central sorting facility,

Slinning thinks the alternatives Mepex has drafted for the IMAs in this study is not sufficient. If increased recycling rates are to be successful, another step needs to be added, where the sorting facility will be able to crush, wash and process the plastic coming out of it. This because it is not possible to see if the plastic coming out of the suggested sorting facilities is polluted or not. Slinning explains how the problem with sorting plastic is that a lot of the plastic are not easy to sell or do not fulfil the requirements of quality or purity from the organisation that buy the plastics. The Mepex report author, Sørensen, clarified in the interview how the next step concerning washing and granulating of plastic can potentially be handled by an external actor in Sweden. Sørenen mentioned that an enormous sorting and recycling facility for plastic in Nothalla with a capacity of 100 000 tonnes is currently being built. Sørensen disagree with the majority of IMAs in their choice of model of a central sorting facility. He believes a sorting facility where a mixed plastic fraction is the end result, would be the most realistic and best option for the IMAs when it comes to increasing their sorting and recycling rates. Slinning agrees to this and think this might be the only option Aalesund municipality would be able and willing to support.

5.9 Other Findings: Increased Producer Responsibility- Less Stricter Demands to Polluted Plastic- More Stricter Demands to Plastic from Industry.

In addition to evaluating the measures PAYT schemes and central sorting to increase their sorting rates, the IMAs, TAF, and Bingsa were asked to identify other measures to increase sorting rates of plastic packaging from MSW. There was a strong consensus of increased producer responsibility, to make the plastic products less complex and using recyclable plastic in new production. More information to the consumers and user-friendly solutions was also suggested. It was also a wish that organisations such as GPN would accept more types of plastic, making these more valuable to sort out. Some of the respondents also missed stricter regulations related to plastic treatment (as well as other waste streams) in the industry. It was emphasised that the largest share of plastic waste and packaging originates from this sector. A couple of respondents also pointed to the lack of support from the government in order for them to achieve the recycling rates set by EU. The respondents mentioned how they get ambitious goals pushed onto them, but with little or no guidance on how to achieve these.

Another finding was regarding the current waste system and the introduction of separate bins for food waste and metal- and glass packaging. In the interview with Bingsa, Slinning had a

comment regarding the current waste system with the separate bin for glass- and metal packaging. He means this sorting solution has proven to be less of a success, and that subscribers are tossing everything into this bin, polluting this fraction. In their annual report for 2017, VØR points out this problem, where they have experienced large objects that are not metal- packaging, being tossed into this bin (VØR, 2017). Sørensen agrees with Slinning and points out how extracting metal out of MSW, will have an impact on the remaining value of MSW. Metal is considered one of the most valuable waste fractions. Removing this from MSW, will potentially lead to increased costs for the treatment of MSW residuals. SSR is the only IMA in this study not providing their subscribers a separate bin for metal- and glass packaging. The general manager Heimdal sees a separate bin for metal and glass as expensive and unnecessary due to practical reasons. He points out that other places with such separate sorting, the quality of what is being collected is not that good. In addition, SSR operates 35 returning points for metal and glass which is geographically spread, and he deems this as good enough. However, during the interview, Heimdal also pointed to the large amount of metal being retrieved from MSW sent to TAF. As much as 17% has been calculated by SSR.

6 Analysis and Discussion

In this chapter, empirical data are coded, analysed and displayed in themes. The waste management instruments, PAYT schemes and central sorting, is assessed together with their relevance to increasing sorting rates of plastic packaging and meeting future recycling targets. The instruments are presented and discussed through the respondents' perspectives as well as presented theoretical resources in this study. Due to the large amount of data, the themes "PAYT schemes" and "central sorting facility" has been divided into separate analysis and discussion parts, to better structure the paper. The results from these discussions are further discussed, and a final conclusion and recommendations follows. To remind the reader of the research questions to be answered, these are re-presented in the text.

6.1 Achieving Future Recycling Targets

The IMAs were asked about strengths and weaknesses related to their current waste system. This was asked to answer the first research question: what do inter-municipal waste management agencies identify as the largest barriers to achieving recycling targets for household waste by 2020 and 2030? The majority identified wrong sorting of waste at home, lack of recycling solutions for waste from cabins, increased costs related to mess around recycling stations and strict demands to polluted plastic, as the biggest challenges. Strengths were evaluated to be the use of good information and campaigns on the use of recycling, new separate bins for organic waste and metal- and glass packaging which has resulted in higher sorting rates in households.

Two of the IMAs in this study managed to increase their sorting rates from 5-6 kilos to 8-9 kilos of plastic packaging in a span of few years, and this was considered to be a direct effect of better information, incentives to households and less frequent collection of this fraction and MSW. However, common for all the IMAs were the issue of plastic packaging still ending up in MSW despite having a separate sorting solution for it. When asked about their potential in achieving the recycling rate of 50% of household waste by 2020, three of the IMAs considered themselves far away from this, while the others saw this as achievable. The IMA SSR is the only one who has already achieved this first target. Nevertheless, there were several opinions on how to achieve the first recycling target by adjusting their current MSW system. The general manager of RIR, Korseberg operates with a recycling rate of 46% and believes they will achieve 50% after they have introduced a separate bin for metal- and glass

packaging. The general manager in NIR, Harstad, also mentions the removal of food waste, metal and glass-packaging from MSW, as an important step to achieving the first recycling target. But Harstad also points out an important factor, that in judging if the recycling targets have been met, also depends on how they are measured:

> When it comes to more sorting of food waste as well as metal and glass, then I would say we are getting very close to that goal. But it also depends on how EU decides to measure it, that is the big question. It has been said that the building and demolition waste are considered outside of what is defined as household waste, and this is what we have seen there has been huge amounts of, and which we haven't earned any significant profit on. But I think we'll be close to achieving the 50% goal by 2020.
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> - Harstad, (2018).

It became clear during the data collection that the IMAs measure their recycling rates in different ways. The need for a common standard on how to measure recycling rates was evident in this study. Some include plastic packaging from recycling stations in their recycling rates of household waste, while others operate with a clear separation between the plastic from households and plastic originating from recycling stations. Some also includes garden waste and sewage sludge treatments in their numbers, while others do not. Several of the IMAs suspects that certain amounts of the waste collected at recycling stations such as plastic packaging and cardboard might originate from local industry and businesses, suggesting that including waste from these sources might give a wrong image of the amount of sorted household waste. The different measurements affect the sorting- and recycling rates of IMAs and makes it more difficult to compare them to each other. By excluding or including garden waste and waste collected at the recycling stations, the household recycling rates of the IMAs will most likely be somewhat lower or higher depending on what they include in their measurements. According to amendments done in the WFD, definition of household waste includes waste similar to household waste from other sources than households and also garden waste such as leaves and grass clippings. However, it does not include construction and demolition waste, nor sewage sludge (EC, 2015b).

Nevertheless, with good support from the consumers and by removing the weight of organic waste, metal- and glass packaging from MSW, several of the IMAs evaluate the first recycling target of 50% household waste by 2020 as achievable. However, when this

recycling rate increases to 65 %, all the IMAs judge this as difficult to achieve with their current waste system.

> I believe that the glass (and metal) bin that we put out last autumn makes it possible for us to achieve the first milestone. But to achieve 65 % by 2030 will be harder and we will probably not achieve this with the current system today. We must move on. What we are most dissatisfied with, is the waste disposal from cabins, we get household waste from cabins as well, and we don't have recycling solutions for this waste. Everything goes into one bin, the same for almost all of Norway, but we need to improve this, so we can sort out plastic, paper and food.
>
> -Korseberg, (2018).

In order to achieve the recycling targets after 2020, Korseberg identifies the un-sorted waste from cabins as the biggest challenge and emphasise that a system to sort more plastic, paper and food from these needs to be established. This opinion was shared by several of the others IMAs. Implementing a better sorting system for cabins allow the IMAs to retrieve more recyclable materials and in this way increase their recycling rates. However, to sort out more plastic packaging from MSW is deemed difficult due to several reasons. One factor mentioned was the strict requirements related to polluted plastic from buying organisations. When asked about the potential of achieving recycling targets for household waste and packaging by 2030, the general manager in SSR, pointed to the non-existent solutions for littered plastics as a challenge:

> Well, that one is complicated, the one with plastic packaging, because the way the current solutions are, there exists no central reception for littered plastic. People are tossing a lot of plastic in MSW and this pollutes the plastic. GPN will not accept this and this is a challenge
>
> -Heimdal, (2018).

The majority mentioned in their interviews it would be difficult to achieve 65% recycling rate without sending MSW through post-sorting, but it was also a strong consensus in using measures where people's ability to deliver their MSW is reduced. Some meant this would probably be a better and cheaper solution. Nevertheless, all IMAs feels that sorting waste by the source, will still be the most significant measure as this also allows consumers to develop

a relationship to their waste generation. Such a relationship is deemed important in order to have a reduction in waste generation. However, limited knowledge among consumers about different plastic types and wrong sorting in their current MSW system is seen as a challenge. The general manager of NIR, Harstad emphasise that they would like as much waste as possible to be sorted in households, but they also see that plastic packaging is a problematic material for both the consumer and the existent waste system:

> (…). So, this has been our conversation when it comes to plastic and a central sorting facility. We would like as much as possible being sorted in customers' homes, so they can get a relationship to it, because that is when you get a reduction in waste generation, which is crucial in the large waste debate. You need a relationship to how much it is (waste), and feel it, and you need to know the more waste you have the more expensive it gets. It is a strength that the households get a relationship to their waste, and we have tried to introduce logical solutions making it as easy as possible for the subscriber, but we clearly see that the weakness is the thing with plastic packaging. People have a hard time understanding that it is only the plastic packaging that should be sorted out. We are thinking plastic is plastic, and that's that. This is logic for people, they do not have the technological expertise to separate what is what.
>
> -Harstad, (2018).

According to Raadal et al. (2016) the inefficiency of sorting plastic packaging by the source, stem from low knowledge of the use of recycling among consumers, which then gives low motivation to do so. This again, gives low quality on the collected plastic packaging and lower support from households in using this system. Raadal et al. (2016) states that low recycling rates are often explained by the lack of or less use of economic incentives, as well as effective solutions. In her statement, Harstad believes the use of economic incentives, by charging the consumers for the waste they generate, will develop an awareness in the households, and then motivate to less waste being generated. This thought was shared by Korseberg, who believes people are sorting their waste better when it shows on their bill. However, the theory suggests that there is a delicate balance in order get a wished effect using economic incentives. The EC (2012) emphasise that the waste fee paid by households needs to be high enough to encourage people to reflect on their waste generation behaviour, and their support for separate collection systems. However, this fee must not be set too high in order to avoid illegal dumping or burning of waste. Nevertheless, where this has been done right, this has given success through less waste generation. However, the EC (2012)

emphasise that this effect needs to be considered together with the overall management system. The IMAs current waste management systems and their use of economic incentives in form of PAYT schemes, are further analysed and discussed in chapter 6.2.

6.2 The Use of Pay as You Throw Schemes in More and Romsdal

Countries use a variety of policy instruments for diverting waste from landfill and incineration and move more waste towards recycling (EEA, 2016). Waste management policies include a variety of complementary measures, such as educational, economic, regulatory and informative instruments, and this can be designed in many different ways and give various of effect. To increase sorting rates, and hence recycling rates from household waste, economic instruments has been evaluated to be a favourable tool and this has given municipal waste management agencies good results in many countries. The European Commission uses the term pay-as-you-throw (PAYT) systems about billing systems for waste collection implemented by municipalities, where the overall cost of the waste collection and disposal is funded through a combination of flat rate fees or taxes and one or more variable element. The variable element may be linked to the choice of container size (volume-based schemes), the frequency with which container is set out for collection (frequency-based schemes) and the weight of material collected in a given container (weight-based schemes) (EC, 2012).

6.2.1 Volume-Based Schemes

In Norway, all households must pay a standardised waste fee to cover the expenses related to waste collection and disposal. In addition to a flat rate in the waste fee, all the IMAs in this study, uses volume-based schemes where they differentiate the waste fee by the size of the bin. If the household needs a larger bin, they will have to pay extra. In the same way, they offer smaller bins for a lesser cost to motivate consumers to reduce their waste generation and increase sorting rates. The IMAs have had different experiences when using such instruments to increase sorting rates in households. The volume-based schemes have had various effects. One challenge by using volume-based schemes, as mentioned by the general manager in RIR, was the difference between private households and housing cooperatives in waste generation behaviour. He explained how RIR two years ago changed the waste fee from calculating the number of litres, to divide this on a basic part, so a standard part and a variable part after how many litres were collected. This had the following consequence:

> They (housing cooperatives) have a 660-litre bin based in the waste room and if this is being loaded to the top, then they'll get a 140-litre bin. I mean, they are filling up their bins completely, while the private households are very rarely filling up theirs. So, they're paying a lot more per litre of waste they deliver. We found some housing

> cooperatives having as much as 70% reduction in their waste fee compared to regular households and they probably deliver the same amount of waste, even though they are living in such cooperatives.
>
> – Korseberg, (2018).

The differentiation of the waste fee, with a standard and variable part after number of litres collected, gave benefits to the housing cooperatives, in that they could fill up their bins completely, since they would receive another 140-litre bin after the first had been filled and in this way, pay less for the amount of waste they produced compared to private households. Such differentiation can be deemed to give little incentives for the housing cooperatives to sort waste, compared to the private households which will have more limited capacity in their MSW bin. RIR saw this effect, and changed the standard waste fee, making the difference between regular households and housing cooperatives less. But they still have some discount, due to the feasibility of collecting larger bins compared to smaller ones. The general manager in NIR, Harstad, has assessed the potential of using other PAYT-schemes, but have decided to stick with the volume-based schemes combined with the standardised waste fee, since this tool has proved to increase sorting rates in their households:

> Most of our municipalities offer differentiated waste fees in that way that people can buy smaller or larger waste bins according to their use and generated amount of waste (…). Our last municipality that implemented this was Sunndalen and they have had this for a year now. Previously, they could get as large bin as they wanted, they paid exactly the same. Each household paid for themselves, but after they got the opportunity to buy a larger or smaller bin, then it became much more focus on this, and we see that the amount of MSW has been reduced, and that the recycling at home has increased. So, this is a school example of how good it works.
>
> -Harstad, (2018).

In allowing households to choose the size of the bin, Harstad's perception is that people are developing a relationship to their consumption and their waste generation. The amount of MSW was reduced after this was implemented in Sunndalen. This suggest that people started to become more aware of their consumption, by maybe buying less products, extending products lives or/and better sorting of waste. The implementation of volume-based schemes in

Sunndalen can be viewed as having a direct impact on the sorting behaviour in the households when sorting rates of plastic packaging increased. This municipality was considered the worst in sorting rates, but after they introduced the choice of different sizes of the bin, the sorting rates of plastic packaging went from 2 kilos per capita to 5 kilos in one year. This economic incentive gave NIR the wished effect on waste generation and sorting behaviour.

6.2.2 Collection Frequency Together with Volume-Based Schemes

Currently, the majority of IMAs uses the same frequency when collecting the different waste fractions, together with volume-based schemes to enhance better sorting behaviour. However, the collection frequency decided by the municipalities must not be misunderstood as being the same measure as frequency-based schemes. In a collection frequency decided by IMAs, the households will still be charged the same amount regardless how many times they put their bin out or not. In the frequency-based schemes, the variable part of the waste fee is decided by the frequency in which a specific container is set out for collection. In other words, it is decided by the individual household's choice to put their bin out or not. Even though collection frequency is not an economic incentive, it is still an important waste management tool used together with the PAYT schemes and needs to be considered as part of the waste management system of IMAs. The most common frequency is collection of MSW every other week and plastic together with PCC every fourth week. Only SSR operates with a collection frequency of every other week for all their waste fractions. All of the IMAs evaluated the frequency in which the waste is being collected to be effective in order to force consumers to sort their waste better. The general manager in ÅRIM, Solevåg, hopes a change in the collection frequency of MSW will help them increase sorting rates of plastic packaging:

> We just recently reduced the collection frequency of MSW, so we hope this will contribute to people getting less space in their bin. We have worked a lot with motivation, we haven't been satisfied by the amount of plastic, but it has been good quality.
>
> -Solevåg, (2018).

Solevåg could tell they just recently reduced their collection frequency to every other week as a measure to increase sorting rates. While they have been satisfied by the quality of the

collected plastic packaging, households are still not good enough when it comes to sorting this waste. Raadal et al. (2016) means the inefficiency of plastic sorting systems stem from low knowledge of the use of recycling among consumers, which then gives low motivation to do so. This again, gives low quality on the collected plastic packaging and lower support from households in using this system. A low amount, but good quality plastics, might imply that there is less support from the majority of ÅRIM's households to their plastic collection system and that it is necessary to provide information of the use of recycling of this fraction. An opinion shared by the IMAs was that reducing people's ability to deliver their MSW, is an effective measure to increase sorting rates and in such more plastic packaging being collected. VØR also changed their collection frequency from every week to every other week and experienced good results in the beginning, however, it did not last for long:

> In 2015, we had MSW collection every week, then we had approximately between 4-5 kilos (of collected plastic packaging) (…) And then we started collecting MSW every other week, and then we suddenly had over 9 kilos of plastic collected. In 2017 this dropped again. So, there is no doubt, that people panicked and recycled better, but then they saw they still had room left in the MSW, and then they started filling this up again.
>
> -Bjørdal, (2018).

The introduction of reduced collection frequency resulted in a wished effect, when households in the municipalities covered by VØR, realised they had to sort their waste better due to potential lack of space in the MSW bin. However, this experience might suggest that the reduction to every other week was not drastic enough, since there was still room left in the MSW bin and the households started filling this up again. It was found that several of the IMAs have been thinking of reducing their MSW collection frequency to every fourth week, due to proven success in other IMAs. NoMIL was the only IMA in this study with this collection frequency already established:

> It is quite intentional that we are handing out 140 litres bins for MSW, with collection frequency of every fourth week, this will force people to sort their waste better. They need to pay more to have more capacity in their MSW, in the form of a larger bin.
>
> – Bareksten, (2018).

Environmental consultant in NoMIL, Bareksten, is certain a collection frequency of MSW every fourth week will lead to households sorting their waste better. This opinion is shared with all of the IMAs, and VØR is planning to implement this frequency this fall. However, Bjørdal, also think this can give unwanted consequences:

> There is one mechanism that is certain in this business, and that is to reduce the opportunities to deliver MSW (…). I mean you saw what happened in 2015-2016…. What made the number of kilos of plastic doubling itself these years? We started collecting MSW every other week. This is certain. Now we are going to reduce it to every fourth week the following year. What I fear is that you're going to have such a huge capacity in the food bin, that people will start toss MSW in this bin.
>
> -Bjørdal, (2018)

Bjørdal believes that reducing the times MSW is being collected, will force people to sort their waste better. However, a consequence of reducing households' opportunities to get rid of their waste, might tempt people to start tossing waste into other bins or outside the collection programme due to lack of space in the MSW bin. VØR is planning on offering their subscribers a separate bin for food waste this fall. By reducing the collection frequency of MSW to once a month, Bjørdal fear this will lead to people start tossing wrong things into the food bin after the MSW bin has become full, and a consequence of this might be a polluted waste fraction, less fit for biogas-treatment. Solevåg reflects on experiences made from another IMA in Romerike, when they reduced their collection frequency:

> I talked with a company in Romerike, ØRAS, which for odour reasons, collects MSW every other week during the summer and every fourth week during the winter. When doing test examples of the MSW, they have seen that the sorting has gotten a lot better during the winter, because then people have less space in their MSW bin. During the summer you have some more room, and then more plastic packaging and other stuff ends up in MSW since you fill it up with the volume that you have.
>
> -Solevåg, (2018).

In addition to potentially bad odours, the reduction of collection frequency to every fourth week may give sessional challenges according to Solevåg. Especially in the winter season, it is a known pattern, that households in general produce a lot of waste due to Christmas holiday and all that comes with this. The bins are being filled up quickly due to a lot of food waste, packaging and other stuff. During the summer, there is in general tossed less, due to people leaving for vacations or perhaps eating out more. As the experience with both VØR and ØRAS shows, when the household notice they have more space left they start to fill this up again with plastic packaging and other things. This pattern suggests that by reducing people's ability to deliver their waste do not necessarily establish a long-lasting sorting behaviour among the subscribers and support of the existent sorting system. Solevåg have some doubts if a four-week collection frequency is sufficient enough to increase sorting rates in households:

> Even with a four-week collection frequency, this could lead to wrong sorting, but I'm not sure. But there are some other things that comes with reducing the frequency and operational activities. It gives more work, so we could have gone for that solution (four-week collection frequency), but now I believe more in mechanical sorting of plastic. Experience shows that you're sorting plastic more correct this way than just using recycling solution at home. However, it was prerequisite that we got rid of the food.
>
> -Solevåg, (2018).

To increase sorting rates, and especially the plastic packaging rates, measures targeted at households might not be sufficient enough to sort out more valuable materials according to Solevåg. Additional help in form of mechanical sorting might be necessary to retrieve more of the resources.

6.2.3 Weight-Based schemes

When asked if there was any other way to differentiate the waste fee in order to motivate households to sort their waste better, several of the IMAs had assessed the possibility of using weight-based schemes, but only two have the possibility to do so, due to the technology already used in their waste management. Both SSR and RIR are using computer chips (radio-frequency- ID chips) to identify each bin and household. These chips are attached to the bins

and can collect information of how many times the bins are being emptied, as well as weight and volume of them. This is being "read" when it is loaded onto the waste collection vehicles. RIR have assessed the possibilities of using weight-based schemes and bill the households after the weight of the bins but decided not to follow up on this. Korseberg believes basing some of the waste fee on weight of the bins, might lead to people intentionally sort their waste wrong in fear of ending up with a more expensive bill, and especially if they need to get rid of heavy objects. This implies that a potential effect by using weight-based schemes may be just moving one problem to another bin and possible pollute other fractions. SSR is the only IMA who has tried this scheme in More and Romsdal and was also one of the first in Norway. They experienced a similar consequence with this scheme and had to quit using it in the end:

> A new term called neighbour-help was introduced, they were filling up the bin of their neighbour. With that system we could track the development of each subscribers on the weight, so people who were on vacation had full bins anyways, that's Sunnmoeringa! So that didn't work, and was put to rest
>
> -Heimdal, (2018).

Heimdal pointed to cultural differences as a possible explanation of why the households started to fill up their neighbours' bins. The people living in the region of Sunnmore are said to be close-fisted, so in order to avoid getting billed extra due to heavier object or full bins, a lot of them would move their waste to their neighbours' bins. However, even though this might be a known trait to people living at Sunnmore, this can also be a general consequence of implementing this measure other places as well. The weight-based scheme seems therefore to be less beneficial in this context.

6.2.4 Frequency-Based schemes

When it comes to the use of frequency-based schemes, RIR is the only IMA that will be trying out this scheme to improve sorting rates in households. They are planning to do a pilot project where they will bill their subscribers through how many times the bins are being emptied:

> When the bin is being attached to the waste trucks and emptied, then it gets registered. From 2019, we are thinking of driving a pilot in one of the municipalities, we haven't decided which one yet, but the waste fee will be decided by how many times the bin has been emptied through the year. So, it's up to the subscribers how many times they want to put their bin out for emptying when it's full (…). So, to count the number of times the bins are being emptied will be a whole lot easier and the subscribers can much easier control the bills and say: "ok, is this right? Did I put out my bin the 15th that month? So that number on the bill is right". How many kilos the bin consist of will be harder for the subscriber to control.
>
> -Korseberg, (2018).

Korseberg emphasise that by using a frequency-based scheme instead of weight-based, it will also be easier for the subscriber to control their bill and see if they have been charged the right amount or not. By leaving the choice of how many times the bin should be emptied to the consumers, and when less often emptying will result in lesser costs, this might help avoid the behaviour pattern where heavier objects are being moved to another bin. The EC (2012) found a strength of this scheme in other countries to be less garden waste ending up in the MSW. Even so, this may have the unwanted effect off people getting rid of their waste in other ways, by perhaps burning the waste or tossing it into the surrounding environment. One might suspect that this can also lead to the mentioned term "neighbour-help" where some people will seek to get rid of the waste in other people's bins, to avoid putting their own bin out for collection. However, this would more likely be a problem in areas with short distances between the neighbours or public drop-off points nearby. Korseberg pointed out that they will have to charge the households for some amounts of emptying to avoid the potential said negative effects with such measures. Due to their use of computer chips in SSR, Heimdal was also asked if they had thought of differentiating their waste fee based on the amount of times the bin is being emptied. Heimdal pointed to geographical differences in rural and urban areas as a reason to not implement this:

> Yes, I know this has been done in Bergen among others, no… there is one thing people are forgetting in all this, we might be able to do this in large urban areas, where there is a lot of people to share it, and there is short distance between each subscriber. It will be a lot cheaper in these areas. But in the rural areas such as here on Sunnmore, besides Aalesund centrum, this will be very expensive. It will be too much logistics (…) As long as you are driving the routes, it will cost a lot anyways. If there is one bin or two bins out has no saying in this.
>
> -Heimdal, (2018).

Heimdal emphasise that the waste collection vehicles need to drive their route anyways as they do not know which bins are out or not. In rural areas there will be larger distances between the subscribers, and this is common for all the waste regions included in this study. Longer transportation routes give more costs when it comes to logistics, suggesting that this measure would be more beneficial in urban areas with higher population density and shorter distances between the households and more housing cooperatives.

6.3 Discussion- Increased Use of PAYT-Schemes in More and Romsdal

This section seeks to answer the second research question: how are the use of PAYT schemes evaluated by the inter-municipal waste management agencies and how can increased use of this instrument enhance recycling rates of plastic packaging? As the analysis show, there are various opinions to which PAYT scheme seems to be the most efficient when it comes to increasing sorting rates and their pros and cons. The majority of the IMAs have chosen to stick with a volume-based scheme combined with a flat rate and use reduced collection frequency as a tool to enhance household's sorting rates. A four-week collection frequency of MSW, is deemed to be the measure releasing the most potential when it comes to increasing plastic packaging rates, due to households having less space in their MSW bin. But it is also pointed out that this might lead to wrong sorting into other bins or people getting rid of the waste outside the collection programmes. RIR is planning a pilot project where they will combine volume-based scheme and collection frequency together with a frequency-based scheme, where the subscriber will also be billed after the amount of times the bin has been put out for collection. They believe this will lead to a 20 % reduction in waste fees and enhance sorting rates. ÅRIM believes a four-week collection frequency of the MSW could help them improve sorting rates, but due to possible complications following such a frequency, Solevåg

implied differentiating the waste fee may not be a sufficient enough measure and believes mechanical sorting will be the answer to increase sorting rates of plastic packaging and other waste streams.

The EC (2012) assess the weight-based PAYT schemes as the most successful, followed by volume and frequency-based schemes in increasing sorting rates. The EC (2012) indicates that volume-based schemes in general gives the least incentive for waste reduction and recycling. They reason this partly with the fact that once a bin of a certain size has been subscribed to, the marginal cost of reducing the quantity of waste tossed in this bin, is effectively zero. This effect can be exemplified by the experience with RIR and their use of volume-based schemes. The differentiation of waste fee based on volume gave a huge reduction in the waste fee to housing cooperatives compared to private households and provided little incentives to reduce waste generation in these cooperatives. However, some of the IMAs experienced this differentiation as a useful tool to help increase sorting rates of plastic packaging and have the subscribers develop a relationship to their waste generation.

While the EC (2012) assess the weight-based schemes as the most successful, this perspective is not shared by IMAs in this study. Even though there were only one IMA who has tried the weight-based scheme as a measure to increase sorting rates in households, there was a general scepticism related to this scheme. In a Swedish study conducted by Dahlen & Lagerkvist (2009), it has been listed previously reported or assumed strengths of the weight-based scheme. These are general waste reduction, less garden waste in MSW bins, transparency of waste management costs, increased sorting of recyclables and that it is well accepted by the householders. Reported weaknesses is increased costs associated with investment and operation, technical problems, more illegal waste dumping (even though this has not been proven earlier), increased number of contaminants in recyclables and waste that moves to neighbouring communities (Dahlen & Lagerkvist, 2009). As Korseberg mentioned in his interview, they have the possibility to use weight-based billing schemes due to their use of RF-ID chips, but have decided not to, due to the assumptions that people will be motivated to move heavier objects or waste to other bins. As plastic packaging is of lighter weight, there will most likely be less incentives for the subscriber to sort this out of MSW with this scheme. Regarding the other assumed strengths of the weight-based billing system, such as transparency of waste management costs and waste reduction, the last point seems to be existent in the other PAYT-schemes as well. Korseberg also means it will be easier for the subscriber to control their bill after the number of times it has been emptied, rather than

weight. This suggest that the transparency is higher using a frequency-based scheme than a weight-based scheme. In addition, when it comes to the reported increased recycling rates by using a weight-based scheme, this was not evident in Dahlen and Lagerkvist's study of Swedish municipalities. However, they suggested that the low recycling rates related to the findings in the study, could be explained by people being more aware of their waste generation or/and they dispose waste outside the ordinary collection system to a larger degree than the ones without a waste fee based on weight. SSR's experience with the use of weight-based schemes might support the latter explanation when their subscribers started to fill up their neighbours' bins.

However, divergent effects of weight-based billing have been reported from different countries (Dahlen & Lagerkvist, 2009). As the EEA (2016) mentions, the same policy instrument can be designed and implemented in many ways, and therefore have different types of effect. This suggest that positive or negative experiences with the different PAYT schemes in this study, might not be the same in other regions. It also needs to be emphasised that only one IMA has tried the weight-based billing system, making it difficult to assess its pros and cons and if this is geographically or culturally conditioned. This also goes for the use of frequency- based schemes, since there is just one IMA, that will be trying out this scheme, based on the collected data.

A comparison of the IMAs found there is no huge significant difference in the design of the waste systems between the ones with highest recycling rates and the ones with the lowest. The majority of the IMAs differentiate their waste fee by letting the consumer choose size of the bin. They also try to motivate their subscribers to sort their waste by combining this choice with a less frequent collection of the various waste fractions. All IMAs points to a collection frequency of MSW every fourth week as the most cost-efficient measure to increase sorting rates, and some means this will help them achieve at least 9 kilos in collected plastic packaging per capita, as the experience has been with other IMAs. NoMIL is the only IMA currently operating with a four-week collection frequency of MSW, while the rest have every other week. Still, both RIR and SSR have a plastic packaging sorting rate of 9 kilos per capita, the same as NoMIL despite having a collection frequency of every other week. SSR experienced a jump in their collection rates of plastic packaging from 7,5 kilos per capita in 2016 to 9 kilos in 2018. The same happened to VØR when they increased their collection of plastic packaging from 4-5 kilos to 9 kilos in one year. The general manager of SSR explained their experience by their frequent waste collection and the use of campaigns. The general

manager of VØR explained their sudden jump with a less frequent collection of MSW, from every week to every other week. In addition, SSR allows their subscribers to put cardboard next to a full PCC bin (which has the standard capacity of 240 litres) and it will still be collected. Even though it results in extra expenses, this increases their collection capacity tremendously, but gives little limitations to the subscribers when it comes to filling up this capacity. In comparison, VØR restricts their subscribers in doing the same. If they want to have their plastic bag collected, this needs to fit in the PCC bin, which is being collected every fourth week. This suggests especially households of families, might have issues with full bins or needs to be aware of their waste generation to a larger degree than the ones covered by SSR. However, while VØR's collection rate of plastic packaging dropped some time after the introduction of less frequent collections of MSW, SSR's rate has remained stable. This suggest that campaigns and information has been more of help to increase consumers awareness of the importance of recycling, to a larger degree than just limiting their ability to deliver their waste. In the experience of VØR, it was an external measure imposed on them which had the consumers panicking, and increase the plastic packaging sorting, due to less space in the MSW bin. However, when they understood they still had more room left, they started filling this up again with more plastic packaging, resulting to a lower rate of collected plastic than before the change was introduced.

While a four-week collection frequency is deemed favourable by the IMAs, some of them still manage to achieve and maintain a sorting rate of 9 kilos per capita in collected plastic packaging, even with a MSW collection frequency every other week. The common denominator between these IMAs is their extensive use of information and campaigns targeted at their subscribers. Solevåg also emphasise how some IMAs that have implemented MSW collection every fourth week are still struggling to achieve a 50% recycling rate. This, in addition to the identified barriers with plastics' complex material and seemingly low support of existent collection system with some of the IMAs, might suggest that the use of PAYT schemes in current MSW management systems has its limitations when it comes to increasing sorting rates of plastic packaging and achieving recycling targets. The general manager in NIR, Harstad, believes it is necessary to hold the producers more responsible for the life cycle of their products than they are today:

> I believe we have reached as far as we can through the systems that we already have. What I think is missing has a lot to do with the producers, they need to look at what is happening in all the links and they need to be held responsible a lot more than they are today. It can be standardisation or simplifying of the types of plastic products that exists
>
> - Harstad, (2018).

Harstad's opinion was shared with some of the other IMAs as well. The problem with low sorting rates of plastic packaging is not only because of limitations in the current waste management systems, but it is due to external reasons as well. Harstad feel there is a lack of standardisation and responsibility when it comes to the producers of plastic materials. They should be held more accountable. The waste systems can only take IMAs so far, especially in cases where some of the plastic products consists of too complex material to separate and recycle, or they have no value in the market. This also creates confusion among the consumers resulting in wrong sorting and more plastics being tossed in MSW. Increased producer responsibility and less strict demands to polluted plastic would help increase sorting rates of plastic packaging, as mentioned by the most of the IMAs.

It was estimated by Raadal et al. (2016) that a legal obligation to sort plastic packaging and food waste, in addition to increased use of PAYT schemes in municipalities would bring sorting rates up to 65%. Data from the majority of the IMAs in this study suggest otherwise. While the use of PAYT schemes seems to release large effects in some municipalities where they have especially low sorting rates, this seems to give little effects in municipalities with already established schemes. These schemes were evaluated to be a good measure to achieve the first recycling target of 50% household waste, but far from the recycling target of 65% by 2030. The use of information and campaigns seems to be a key to enhance the support of such schemes and overall waste system and hence increase sorting rates. While a four-week collection frequency of MSW and PCC bin was deemed to be the best tool to increase sorting rates of plastic packaging, the experience of the different IMAs and the comparison of their waste systems, suggest this measure has its limitations.

In regions where PAYT schemes are deemed less efficient, the EC (2012) suggest regional cooperation in waste management may enhance the effectiveness of such billing systems, by optimising the planning of collection routes, simpler implementation of separate waste collection services (e.g biowaste, packaging, recyclables) and economising overall waste

processing (EC, 2012). Bjørdal argues that by organising in small entities as the IMAs in More and Romsdal do today, this puts them in a vulnerable position:

> As mentioned previously, to organise in such small entities as we do… there is no point. Because what happens with us, is that firstly we become very vulnerable. You are dependent on having a lot of people to keep the wheel going (…). We are doing a lot of things that are not optimal, it's not socioeconomic beneficial. I believe that when we are done with our new system with new bins, and the solutions between the regions are more similar, then it will be inevitable to not start discussing a joint ownership between the regions. That would be a lot more reasonable. Because if you go east of the mountains you'll find large companies everywhere. ROAF is 170 000, BIR is several hundred thousand, HAMOS has become large, everything south for Trondheim. So, the working spaces needs to be here to keep the recycling stations open, the collection needs to happen here, as well as some administrative, but to get some synergies by gathering the regions. But this is also a political issue.
>
> -Bjørdal, (2018).

Bjørdal's statement suggest it is not socio-economic beneficial to organise in smaller entities as the IMAs in More and Romsdal do today. They do not get the benefits of economies of scale, which the larger waste management agencies BIR, RoAF and HAMOS do. Bjørdal points to when the waste solutions between the regions become more similar, they will probably have to start discussing a joint ownership between the regions. Such organisation is already starting to become evident in Norway through the larger waste management agencies. This is also the case in Finland, who shares similar waste collection system with Norway. In 2012, there were 30 regional municipal waste treatment organisations in Finland and regional cooperation has been identified as a means of improving the collection and processing of MSW throughout the country (EC, 2012). The systems also gain greater support through increasing consumer awareness campaigns and by making illegal dumping and burning of waste harder. The EC (2012) emphasise that one important measure identified to achieve optimal performance of PAYT schemes, is that these should be based on the precise quantification of actual generated household waste. This calls for a standardisation on how to measure the household waste between the IMAs in this study, which is missing today.

6.4 A Potential Central Sorting Facility in More and Romsdal

Some municipalities in Norway have less efficient systems for collecting plastic waste and the minority have no solution for plastic packaging at all. There are different barriers related to households covered by such a system. Some households might have less space for different bins, they might lack incitement to sort or the plastic packaging are being sorted wrong due to bad branding, laziness or confusion. In many cases households also fail to clean dirty plastic packaging which further destroys its potential for recycling (Raadal et al., 2016). Some of these issues were also identified by the IMAs in this study. The largest barriers attached to plastic packaging from households seems to be the support for the sorting system that already exist, but not necessarily the quality of collected plastic packaging. Low sorting rates together with high recycling targets and available automated sorting technology, have presented central sorting of household waste as a possible substitute or supplement for already existing waste collection programmes. These factors resulted in a report initiated by ÅRIM and conducted by Mepex consultants Sørensen and Marthinsen (2017). Sørensen and Marthinsen (2017) has given estimates regarding costs and released plastic packaging sorting potential from MSW in More and Romsdal. Sørensen and Marthinsen (2017) drafted different potential central sorting facilities, situated at, or close by, TAF's property to create synergies in the waste management. With this report in mind, the involved actors in the report, VØR, ÅRIM, NIR, RIR, SSR and TAF, in addition to NoMIL and Bingsa were asked to evaluate a potential local central sorting facility, located in Aalesund, as a tool to achieving recycling targets by 2020 and 2030.

All the IMAs sees the future recycling target of 65% household waste as difficult to achieve with their current waste system. The respondents pointed to post-sorting of MSW as a favourable measure to retrieve more recyclable materials from this fraction and especially valuable plastic materials. The study found that all IMAs but one, was interested in the idea of establishing a local central sorting facility in More and Romsdal. However, there were different opinions on whether this should be built at TAF's property, Bingsa or on a neutral ground somewhere else. This is also the reason why Bingsa was included in the study to learn more about their perspective on this matter. Even though a central sorting facility is deemed beneficial to accomplish satisfactory recycling rates, Korseberg expressed in his interview that RIR and other IMAs with high collection rates of plastic packaging would have less to gain in participating in this:

> Yes, I believe that we need to enter this. However, we have had test examples done by Mepex, where it shows that 12.7 % of the waste being retrieved from the MSW were plastic packaging. So, there is something to collect, but I will believe that the ones that do not have their own recycling solution for plastic packaging in households and those without the same results as us, will have a higher amount of plastic waste in MSW. So, a central sorting facility will not retrieve that much plastic from our waste compared to others, but I believe that we need to go there. We have 8% of cardboard and paper and there is at the same time some food waste in our MSW which shouldn't be there. And therefore, we need to work a lot more on reducing the amount of food waste in our MSW. But if you are thinking in general, then yes, I believe that you have to build more central sorting facilities. The board in RIR has declined the offer to join SESAM and have decided to await and see what happens on Sunnmore with a potential central sorting facility. If there could be built something on Sunnmore with a shorter transportation than to drive it to Trondheim, then we're probably going to join this.
>
> -Korseberg, (2018).

Though Korseberg believes there is less plastic packaging to be sorted from their MSW compared to others with lower plastic packaging collection rates, he underlines that in addition to 12 % plastic packaging, they also have 8 % cardboard and paper, in addition to food waste in their MSW. In addition to working explicit with reducing the amount of food waste in their MSW, Korseberg believes there will, in general, be a need for more central sorting facilities. A requirement for them to join a central sorting facility located in Aalesund seems to be transportation based. While RIR declined the offer in participating in the central sorting project, SESAM, in Trondheim, NIR is currently in a process where they are about to commit themselves to this project. Since a central sorting facility in Aalesund, was deemed to be out of the question for NIR, and due to NoMIL's geographical proximity, it was found relevant to include NoMIL in this study, even though this IMA is situated in Sogn and Fjordane. While NIR has a population of 62 000, NoMIL has approximately 33 000 in population numbers, so the total estimated amount of MSW sent to a potential post-sorting facility in Aalesund would be somewhat lesser than the predicted 37 000 tonnes by Sørensen and Marthinsen (2017).

6.4.1 Alternatives to a Central Sorting Facility

All of the IMAs, TAF and Bingsa were asked to evaluate which alternatives of a central sorting facility, as suggested in the Mepex report, was deemed the best option for More and Romsdal. VØR, ÅRIM, RIR, SSR and TAF assess alternative 1b, a complete central sorting facility similar to ROAF, as the best option. A downstream solution with the central sorting plants ROAF or IVAR is evaluated to be less optimal, and in addition, it moves the value creation outside the regions instead of sorting and selling the plastic materials from a local sorting facility. It was mentioned that this might also leave the local waste management agencies in a vulnerable position, if there would come a legal obligation to post-sort MSW, and the only option would be to send this to larger facilities outside More and Romsdal. This is also seen as a potential problem for the incineration facility TAF, if this waste were to be sent out of the county, making them less competitive with incineration facilities in Sweden for instance.

Bingsa and NoMIL suggested central sorting facility alternative 1a, would be the most realistic option for More and Romsdal due to less investment requirements compared to alternative 1b. However, common for all respondents, is the limited economic framework in which they operate within. While all respondents agreed that a central sorting facility will help the waste regions achieve the recycling targets for 2030, the majority of the IMAs explained that such project and the investment needed, would be difficult to defend to their shareholders. Several of them had other ongoing projects and limited access to more resources to involve themselves in such project in the nearest future. The general manager in ÅRIM, Solevåg, suggest the waste management industry needs to prepare itself for future demands and think more about flexibility when it comes to the complexity of plastic materials:

> (…) we need to think flexibility when it comes to how the plastic will be put together in the future, how will the technology give us opportunities, for example related to the washing and pelleting industry which are totally out of question today, but we need to think of flexibility so maybe one day we can add another step, so we can meet this demand. Today NIR machines are considered as the state of the art on this type of flat material… there are a lot of technologies to choose between and we must evaluate which ones are right for us
>
> -Solevåg, (2018).

The complexity in plastic composition making it hard to sort or separate, is mentioned by several of the respondents as a challenge and a limitation to their current waste system. Solevåg believes the use of technology will help solve this issue in the future. In addition, it was emphasised that food contaminating valuable fractions in MSW, such as plastic packaging, paper and cardboard is another problem. Samples taken from RIR's MSW, shows food waste still counts for 20% of the contains, despite having offered a separate solution for this fraction since 1999, in addition to having a high sorting rate.

In their report and with regard to a potential central sorting facility, Sørensen and Marthinsen (2017) recommend curb-side programmes for food waste and metal-and glass packaging to be maintained to avoid these fractions being mixed with and pollute plastic and paper in MSW. In addition, can food waste and metal and glass contribute to smudging and tear down components in a facility. However, Sørensen and Marthinsen (2017) advise IMAs to cease the plastic packaging collection, and put these materials back into MSW, since these will be sorted with high precision in a post-sorting facility. Nevertheless, to ask the consumers to put the plastic packaging into MSW again, would not be met with a positive attitude according to the majority of the IMAs. Several of the IMAs mentions how a central sorting facility is a good measure to sort out more plastic types and will especially help target those who do not sort their waste at all, but they also believe their subscribers would react negatively to quit source-sorting plastic packaging and would have little understanding of why this is being done.

> If we are to reach 65%, it concerns a lot of discussion, we need to think a lot of thoughts, if we should think in percentage, but the main measures are to remove the food (from MSW) and then look at post-sorting of what is left. And I believe when the customers have gotten such vast recycling solutions, and we're not sure if we're going to do it, but if we put the plastic back into the MSW, then customers won't feel that we have totally betrayed them.
>
> -Solevåg, (2018).

Solevåg suggest that since the households will still have many sorting solutions at home, putting the plastic back into the MSW, will not necessarily lead to all negative reactions. This might also have to do with people's general resistance towards changes in established habits. Several of the IMAs could tell about the resistance and negative reactions they have received, when they have previously introduced new recycling solutions, such as the introduction of

waste bins instead of using bags. But people got used to it in the end. Nevertheless, there was a general scepticism to ending the collection of plastic packaging.

6.4.2 Location

To create synergies, it was suggested by Sørensen and Marthinsen (2017) to utilise the existing facility and available silo at TAF's property and build a central sorting facility nearby this. The idea is to use TAF's services after MSW has gone through post-sorting and transport the residuals to be incinerated. TAF is a private company and the public waste management agencies are affected by a public procurement framework, so the waste is obliged to be put out for bidding. This means there are several judicial and organisational problems that arises when involving TAF in such a project, and they are therefore not secured the waste after this has gone through post-sorting. Today, the majority of IMAs in More and Romsdal are sending their MSW for incineration at this facility through an intermediary such as Rekom and NG downstream (Norsk Gjenvinning), or through placing their bidding directly with TAF. VØR and NoMIL are currently sending their MSW through Rekom and Geminor to respectively Statkraft in Trondheim and Sweden, or to Fredrikstad. A potential location at TAF was deemed interesting to NoMIL due to their costs related to the transportation of MSW to Fredrikstad. When the representative for TAF, the sales manager, Richard Nilsen was asked to comment on Sørensen and Marthinsen (2017) alternatives to a central sorting facility in Aalesund, Nilsen uttered he was sceptical to the costs estimations done, suggesting they are trying to make the economics related to such facility less frightening. This thought was shared by most of the respondents. Nevertheless, while most of the IMAs saw TAF's property as a reasonable location and mid-point in More and Romsdal, some of them uttered scepticism to involving themselves with TAF, suggesting they would have less interest in a central sorting facility, and due to cheaper services in Sweden and better utilisation of the waste sent there. One would rather have the sorting facility be built on neutral ground somewhere else, and another suggested using Bingsa's location instead.

Nilsen were asked about the potential location of a central sorting facility at TAF's property. He implied TAF was positive to having such a facility at their property and he emphasised that there has been a larger consensus among the incineration business and waste management sector to find effective solutions together to manage the difficult waste fractions. However, as with the IMAs in the study, the investment will seem to be quite low from TAF as well.

> We have discussed this and to put things like this (central sorting facility) on Tafjord when it comes to treating household waste, this will be quite reasonable. This will remove a transportation link. But the problem is that Tafjord has a strategy that says that we are supposed to do end-treatment, not sorting. With the energy prices and the leaner years of the energy companies, this has made the investment will very low. So, to get Tafjord to invest in something like this, is probably less likely.
>
> -Nilsen, (2018).

While the location of a central sorting facility at TAF's property was deemed reasonable, Nilsen states that the investment will from TAF will probably be low due to previously lesser good years in the energy sector. However, he mentions in his interview how TAF can contribute in other ways through their competence around the operation of bigger machines, areal and available silo. He pictures a sorting facility which is organised the same way as SESAM in Trondheim, where the IMAs will have to invest and own the sorting facility, while renting property and services from TAF. However, him and others proposed the future municipal border adjustments, with smaller municipalities merging with larger ones, might give challenges to the IMAs and their given responsibility areas for waste management within these municipalities. An example of this is Aalesund, which is to merge with Sandoy, Skodje, Orskog and Haram from 2020. It was mentioned that this could potentially complicate matters for the IMA ÅRIM, if the new and larger Aalesund municipality was to take charge of their own household waste management. This also concerns the other IMAs. Because of ÅRIM's and other IMAs unclear role after municipal border adjustment after year 2020, in addition to the investments needed and judicial problems involved in public-private partnership, TAF has currently paused their discussion regarding such central sorting facility. However, Nilsen emphasise that this has potential and TAF has a positive attitude towards this. In addition, he suggests that by adding some steps to the current sorting facility at Bingsa, it is possible to cover the waste from the industry and additional coarse waste from recycling stations:

> (…). In addition, it is interesting that the course fraction, the things that are being delivered at the recycling stations, that fraction, in relation to the things we are doing today with shredding, mixing, and production of raw materials, there are only small steps that could be done to build a plastic sorting facility as an addition to the solution we already have today on Bingsa. Then you can cover the entire industry
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> -Nilsen, (2018).

When asked about the possibility of establishing a central sorting facility for household waste at Bingsa instead of using Tafjord, Nilsen states that this is possible as he sees it. However, some problems related to this, according to Nilsen, is that Bingsa are not allowed to receive organic waste or household waste in the same form as TAF. In addition, it will require a lot in buildings and masses. He mentions how there will always be some food waste left in MSW even though the municipalities have a separate collection for this. Nilsen also points to the neighbours surrounding Bingsa, and how they are already sceptical to the existing facility treating sludge because of the smell. If the organic- and household waste also were to be moved to Bingsa, to be treated in a central sorting facility, then it would start to rotten, Nilsen indicates. The general manager at Bingsa, Per Oscar Slinning, agrees with Nilsen's view, in that such facility treating household waste will not be received well by the neighbours if it was to be established at Bingsa.

> I believe that a central sorting facility for household waste, where you have a lot of food and similar things included, needs to be situated at Tafjord. In the second silo. But what you could have built here, this could be a smaller facility, as we have discussed previously, where you have an industrial facility which sorts out what comes in of waste from the recycling stations and waste from industry. This is more courser waste. And this waste, the MSW that should be burnt, will have such high incineration value, I mean, calorific value, that you need to add mixed waste, where one makes calorific value with waste of already high calorific value, to burn it at Tafjord.
>
> -Slinning, (2018).

Both Nilsen and Slinning believes in a separate solution and suggest two sorting facilities, one for household waste and one for industry waste in addition to coarse waste from recycling stations, at respectively Tafjord's property and Bingsa, would be the best solution. This is aligned with the recommendation from Sørensen and Marthinsen (2017). Bingsa and TAF has a strong collaboration, where they are each other's largest suppliers of waste inn and out of their facilities. Slinning agrees with the other respondents, that the use of post-sorting is needed to achieve recycling targets in the future. However, he points out a problem with the suggested sorting facilities in the Mepex report. It will be hard to see if the plastic coming out of the sorting facility is polluted or not, and this might cause problems with GPN, since they

are strict regarding accepting contaminated plastics. Slinning suggests that if one is to reap the full potential of the plastic coming out of such facilities one would need to add the steps where the plastic is crushed, washed and processed, and TAF does not have the space available to build a facility of such size. Nevertheless, the author of the Mepex report, Geir Sørensen, pointed out that this step would be conducted somewhere else. He recommends building a central sorting facility such as alternative 1a at TAF, where a mixed fraction of plastic is sorted and then sent to Sweden (as an example), where they are currently building a huge sorting and recycling facility for plastic with a capacity of 100 000 tonnes. The mixed plastic will then be crushed, washed and granulated here, and sold for new production.

6.5 Discussion- a Potential Central Sorting Facility in More and Romsdal

According to Cimpan et al. (2015), source separation and separate collection has traditionally been viewed as the best technically and environmentally waste management approach and this is reflected in the European waste legislation today. It is a pressure in many countries to extend separate collection systems and increase national recycling rates to comply with international and national recycling targets. There are several benefits related to these collection system, but they have also received criticism related to the overall costs, various local implementation issues and often disappointing results in quality of the collected waste in terms of contamination levels. This has led to a discussion if central sorting might substitute separate collection of certain materials, or if this can be applied complementary to source separation. This section seeks to answer the third research question in this study: to what degree is a central sorting facility in More and Romsdal deemed constructive and attractive to key actors in the local waste management industry?

The result of the data collection shows that all of the respondents deems the recycling targets for household waste in the future as difficult to achieve without using post-sorting technology to retrieve more recyclable materials from the MSW fraction. Central sorting is viewed as especially attractive to sort out more valuable plastic materials, however, a pre-requisite is to get rid of the food waste first, as this contaminates the other fractions in MSW. In regard to a potential central sorting facility in More and Romsdal, Sørensen and Marthinsen (2017) recommends curb-side programmes for food waste, paper and cardboard, in addition to metal- and glass packaging, to be maintained to avoid these fractions being mixed with and possible contaminate plastic and paper in MSW. Another reason to maintain a separate collection programme for these waste fractions, is that they might smudge and tear down components in

a sorting facility. However, Sørensen and Marthinsen (2017) advise to cease the plastic packaging collection, and put these materials back into the MSW, since these will be sorted with high precision in such facility.

As the study show, all IMAs have a separate collection for PCC + plastic packaging and MSW. All of them have already implemented or are about to implement a separate collection system for food waste. In addition, all, but one, offer their households a separate bin for metal- and glass packaging. Nevertheless, to ask the consumers to put the plastic packaging into MSW again, would not be met with a positive attitude according to the majority of the IMAs. Nevertheless, people's general reluctance to change established habits might enhance this scepticism. As the general manager of SSR stated in his interview, as much as 30-40 % of their subscribers still thinks collected plastic, cardboard and paper are being sent for incineration at TAF, regardless of the amount of information and campaigns that tell them otherwise. So, there is no doubt, that extensive communication is needed to defend the ending of sorting of plastic packaging in households. Even so, this measure needs to be discussed more thoroughly in a cost-efficient perspective.

The IMAs sorting rates of plastic packaging varies from 4,5 kilos per capita to 9,9 kilos in 2017. There are no significant differences in their waste collection systems, besides the collection frequency of some waste fractions. RIR is one of the IMAs with highest collection rates per capita in plastic packaging, and they are also the ones who have had separate collection of food waste and plastic packaging the longest. According to Raadal et al. (2016), experience seems to be the key to achieve higher sorting rates for households. The ones who have been offered recycling solutions the longest, also have the highest sorting rates. However, findings in this study suggest that there is a range of factors interacting with each other that affect the sorting rates of plastic packaging. Even with very good sorting rates and the long duration they have offered separate food waste bin, food waste still makes up 20 % of the total weight of RIR's MSW (RIR, 2017). This means there will probably still be a lot of food waste in the total amount of MSW from all the regions in the years following towards 2030.

As it has been mentioned, a challenge in increasing sorting rates of plastic packaging is the strict demands related to the acceptance of polluted plastic, in addition to wrong sorting at home which might be due to laziness or confusion around the different plastic types. Hollins et al. (2017) argues that due to the differences in the purity of post-producer and post-consumer waste, a greater variety of technologies are needed to sort and recycle plastic than

any other waste type. Automated technologies used to sort different types and grades of plastic polymer are important in the recovery and re-use of plastic and can contribute to the achievement of recovery and recycling targets according to Hollins et al. (2017). Through a series of comparative studies of the use of central sorting in Europe and US, Cimpan et al. (2015) found that many of the quality issues linked to cross-contamination (plastic, paper, cardboard mixed in MSW) have been solved through sorting facilities today being able to sort and produce high quality products. Plastics recovered from MSW through centrals sorting are deemed to be similar in quality with the plastic collected from separate collection systems. But this depends on the degree of cross-contamination with other MSW residuals. Nevertheless, Cimpan et al. (2015) emphasise that the sorted materials are still being bought by the market and recycled. The EC (2012) sees this as an important contribution in turning Europe into a circular economy, since the recovery of large quantities and a variety of recyclables from MSW contributes significantly in achieving recycling rates set by the WFD and PWD in many countries (EC, 2008; EC,1994).

Following the samples taken from RIR's MSW (figure 7, p.36), approximately 57 % of the waste could have been sorted by the source or delivered at recycling stations (RIR, 2017). This number also illustrated the amount of waste that could been sorted (excluded hazardous waste and E-waste) in a central sorting facility. The efficiency of a sorting by the source system is based on the trust in consumers doing their waste sorting right. But as previous samples from MSW illustrates, there is still large amounts of recyclable materials, including a significant amount of plastic packaging and food waste (RIR, 2017). This despite the extensive use of information or the duration a sorting solution has been offered to a consumer. There are several reasons for this, but it demonstrates the limitations to such systems.

Nevertheless, considering the recommendation from Sørensen and Marthinsen (2017), Nilsen admitts TAF has been a bit stressed about the food waste being separated from MSW, due to the facility's need for moisture. However, they are currently working together with Bingsa to replace this with a sludge mixture. Nilsen says TAF has no opinion regarding the removal of metal and glass. This is deemed to be a curious statement from TAF. One important factor regarding the removal of the metal fraction is that this fraction represents a profit to the IMAs, but also for Aalesund municipality which owns both Bingsa and partly TAF. The metal included in MSW is collected from the bottom ashes after incineration at TAF and sent to Bingsa for further sorting. This suggest that when maintaining a separate collection system for metal packaging, and if these sorting rates increases, this will represent a lost profit for TAF

and Aalesund municipality as the owner. This will most likely affect the total value of MSW when removing this valuable fraction, making the residuals potentially more expensive to incinerate. It was also pointed out by Sørensen and Slinning in their interview that such collection programme has had a variety of success, where there has been low sorting rates and a lot of wrong sorting, with larger metal objects such as brake discs and irons being tossed into this bin. This was also evident in this study. Despite having a separate bin for metal- and glass packaging. ÅRIM has measured larger amounts of metal in their MSW, than in the separate collected fraction. SSR has calculated that 17% of MSW sent for incineration contains metal. In their annual report, VØR states they have a problem with larger non-metal objects ending up in the metal- and glass packaging bins (VØR, 2017). SSR, is the only IMA in this study without a curb-side programme for metal- and glass packaging and this might explain the large amount of metal in their MSW. It also needs to be mentioned that ÅRIM and VØR just recently started their curb-side programme for metal and glass packaging, and it might take some time before the households get used to this solution, explaining these high numbers. Nevertheless, maintaining the curb-side programme for metal, in regard to building a central sorting facility nearby facilities which are able to extract and sort the metal, as well as the issue on how this will affect the remaining value of the MSW fraction, should probably be further investigated.

Sørensen and Marthinsen (2017) suggested two separate solutions for sorting facilities would be beneficial for More and Romsdal. A smaller sorting facility for household waste situated at TAF, where it will sort out a mixed fraction of plastics, and to then send this mixed fraction to a larger plastic sorting facility somewhere else, where it will be washed and granulated. In addition, a sorting facility to handle the industry waste and coarse waste from recycling stations at Bingsa were deemed positive. While the majority supported a complete central sorting facility for household waste at TAF, some uttered concerns regarding neutrality, when placing a sorting facility at Aalesund's property and the fear of a private company seeking to earn as much profit as possible on them. Some of the IMAs questioned TAF's agenda and interest in a central sorting facility and assumed they would seek to burn as much waste as possible, with little interest of sorting out plastic. This reveals the relationship between the waste management agencies which seeks to increase its recycling rates and the incineration facilities that needs certain amounts of waste to burn to gain profit. To increase recycling rates and comply with the circular economy perspective, there is a need to move more waste from incineration facilities to sorting- and recycling facilities. One would suspect a central sorting

facility which sorts out among other things, plastics, the one material which is the most of in incineration facilities, would be seen as a threat to these facilities. Therefore, it was interesting to learn about TAF's perspective regarding a potential central sorting facility in Aalesund. Nilsen emphasised that TAF has a common ground with the IMAs to sort out valuable plastic materials from MSW due to its contribution to large amount of NOx gasses and it has no significant calorific value. Nilsen points out that there will still be several types of plastic types not fit or profitable for recycling, and they will therefore still be significant in burning these in addition to handle environmental toxins.

Nilsen is also occupied with local value creation and shorter transportation lengths and believes a central sorting facility will enhance the regional competitiveness. These thoughts are shared with most of the IMAs. They are not interested in a downstream solution with IVAR or RoAF and will rather have the ability to sort the waste locally. Shorter transportation lengths were also mentioned by both NoMIL and RIR which are situated furthest north (excluding NIR) and south, and a central sorting facility situated in Aalesund is therefore an interesting thought to them. However, the biggest barrier to realising such facility is the low investment will, despite assessing this as a solution to achieving future recycling targets. In addition, the IMAs are legally bound to put their waste out for bidding through a public procurement framework, which means TAF are not secured the waste coming out of a central sorting facility established nearby their property. However, Nilsen mentioned this could be arranged through the IMAs having a joint ownership in the central sorting facility and allot the waste to TAF for a certain amount of years. This could give More and Romsdal increased competitiveness by keeping local waste management capacity intact, in competition with other central sorting facilities and incineration facilities. However, to restrict this thesis length, the issues regarding public procurement frameworks will not be discussed further in this study. This will need to be investigated further by the IMAs and the involved actors in such a collaboration.

6.6 Final Discussion- PAYT Schemes and Central Sorting in MSW Management

Many municipalities and private waste management companies are today lacking effective solutions or economic incentives to secure high rates of recycling or have suboptimal solutions. This often results in valuable waste fractions being delivered to incinerators to create energy instead of being recycled. One reason for choosing incineration is that it is more economic beneficial for municipalities and companies to send all their waste together to incinerators to create energy, instead of sorting the waste fractions for recycling. This is also supported by the decreasing prices on incineration as a waste treatment in the international market, low prices on crude oil and a lack of investments in recycling technology that benefits economically. This is also related to a political wish from the municipalities to maintain the municipal waste fee at a lowest rate as possible (Miljødirektoratet, 2017).

To increase sorting rates of plastic packaging, it is necessary to understand what barriers exist and how to overcome these. The theory suggest barriers might range from will and costs to implement better sorting system in different municipalities, to low knowledge of the use of recycling among consumers, which then gives low motivation to do so (Miljødirektoratet, 2017). Some municipalities have less efficient systems for collecting plastic waste while there are also barriers related to households covered by such a system. In general, the largest barriers attached to plastic packaging from households seem to be the support for the sorting systems that already exist (Raadal et al., 2016). This was also evident in this study. This leads to the last and final research question in this study: can the use of central sorting substitute PAYT schemes, to increase plastic packaging sorting rates and achieve future recycling targets of household waste?

When it comes to using PAYT schemes as a measure to increase sorting rates of plastic packaging, findings from the study suggest this will have the largest effects when implemented in municipalities with already low sorting rates. While the EC (2012) evaluates the weight-based schemes to give best results in sorting rates, followed by volume-based schemes and frequency-based schemes, the majority of IMAs assess the volume-based scheme combined with a frequency collection of every fourth week of MSW, as the best scheme. However, a comparison between the IMAs waste management system suggests information and the use of campaigns plays a larger role in increasing sorting rates, by educating the consumers by the use of recycling and enhancing support for the already existent schemes. However, a problem identified in this study is the different methods to

measure collected plastic packaging, when some of the IMAs include plastic packaging originating from recycling stations and others are not. There is a chance for plastic originating from industry being mixed with the plastic at recycling stations. This suggest that the IMAs who include plastic from recycling station in their collection numbers might, in reality, have lower plastic packaging sorting rates.

Findings from the discussion of the use of PAYT schemes, suggest that the use of such schemes can give various effects, but also limited results. The EC (2012) suggest regional cooperation in waste management may enhance the effectiveness of such PAYT billing systems, by optimising the planning of collection routes, simpler implementation of separate waste collection services and economising overall waste processing and having PAYT schemes based on the precise quantification of actual generated household waste. While smaller waste management agencies in Norway has started to organise themselves in larger entities achieving economies of scale, this could function as a future solution for the waste regions in More and Romsdal to enhance the effectiveness of PAYT-schemes. However, this calls for a standardisation on how to measure the household waste, which is lacking today.

While the quality of plastic packaging in the collection systems to the IMAs are deemed to be of good quality, the amount is not satisfactory to a lot of them. In addition, the increasingly complex material composition in plastic products, and the strict demands related to buying contaminated plastic, makes it harder to achieve recycling targets with their current waste system. This has opened a discussion around using central sorting to solve these issues and using available facilities in More and Romdal to create synergies. However, a problem arising with the use of central sorting and ending curb-side programmes for plastic, is to ask the consumers to put plastic packaging back into MSW. This will not pass without negative reactions from the subscribers, according to the majority of IMAs. The municipalities and the owners of the only central sorting facility operating in Norway today, have liquidated the separate collection of plastic packaging and have asked their consumers to put this back into the MSW bin. The results from the sorting facility has been a significant increase in the plastic collection in Southern Romerike from 4,5 kilos to 11 kilos per capita. However, 9 kilos are not far away from 11 kilos, if we think of the IMAs with the best collection rates in More and Romsdal (in addition to NoMIL). Also, RoAF reported a 47,4% recycling rate of household waste in 2017 (RoAF, 2017a). In this study a few of the IMAs measured higher or close to the same recycling rate with a regular sorting by the source system. RoAF's recycling rate increased tremendously from 2010 to 2017, where 2014 marks the highest increase when

the plant started operating (2010: 29,9%, 2014: 39,5%). However, in the years after 2014, the recycling rate has only had a small increase from 44,4% in 2015, to 47,4% in 2017 (RoAF, 2017a). This might be explained by its short operation time, but it can also indicate that the 50% recycling rate will be difficult to achieve even with a central sorting facility.

The central sorting facility in Romerike also enjoy the benefits of short geographical distances between each municipality with highly populated area, which gives them a significant volume in waste. They also have short distance to sorting- and recycling facilities, and incineration facilities in Sweden for further waste treatment. The municipalities in More and Romsdal are geographically dispersed, with rural areas where there are long distances between each household. However, the regions combined include waste management for over 200 000 inhabitants, even with NIR excluded, similar number to RoAF's facility. By organising in larger entities such as RoAF, SESAM or BIR, the IMAs in More and Romsdal will make themselves less vulnerable by creating economies of scale and most likely have better utilisation of their resources.

The respondents in this study are occupied with local value creation, and there is a wish to keep resources and waste management capacity geographically close. In the white paper from 2017 regarding waste policy and circular economy, it is emphasised that while there is already one central sorting facility established in Norway, three more are in the planning phase, and the NEA expect these to cover 50 % of the total amount of MSW from Norwegian households by 2025 (Meld.St. 45. (2016-2017)). They suggest there will be required more central sorting facilities to be established to cover the rest, or to buy this service with another nation. The large central sorting facilities being planned and constructed in Trondheim (SESAM) and Stavanger (IVAR) will without doubt have a huge catchment area. NIR has already committed themselves to the SESAM project and RIR was invited to participate, but declined, due to the possibility of establishing something in More and Romsdal. NoMIL assess a central sorting facility close to TAF as interesting due to saved costs in transportation. While it would have been beneficial to include more of the IMAs south of More and Romsdal in this study, the large amount of generated data and limited time, made this difficult. However, based on NoMIL's respond, this suggest that a central sorting facility in Aalesund might have a larger catchment area, if it were to include MSW from waste management agencies further south.

Most of the IMAs identified the amount of un-sorted waste from cabins as one of the biggest challenges to achieve recycling targets after 2020. By implementing a better sorting system for cabins or by putting the waste through central sorting, would allow the IMAs to retrieve more recyclable materials such as plastics, cardboard and organic waste, and in this way increase their overall recycling rates. Seen in a circular economy perspective, the waste management sector should view waste as a potential source of future secondary resources (Hollins et al., 2017). The EC published its Circular Economy Action Plan, which set the ambitious objective of treating waste as a resource by year 2020 and turning the European economy into a circular economy (Hollins et al., 2017). Higher plastic waste recycling rates and more and better quality recyclates, will help boosting the market for recycled plastic and will deliver greater added value for a more competitive, resilient plastics industry (EC, 2018). A transition towards a circular economy through better resource efficiency and recovery, will also help reaching the SDGs, as well as the global climate commitments. The recycling and recovery targets in the WFD are a contribution to SDG number 12, where member countries are encouraged and pushed to implement better waste management practices, the use of new technology and innovations, as well as changed consumption patterns (UN, 2015).

According to Hollins et al. (2017) automated technologies used to sort different types and grades of plastic polymer are important in the recovery and re-use of plastic and can contribute to the achievement of recovery- and recycling targets. Plastics recovered from MSW through central sorting are deemed to be similar in quality with the plastic collected from separate collection systems. But this also depends on the degree of cross-contamination with other MSW residuals. The EC (2012) states that the recovery of large quantities and a variety of recyclables from the MSW contributes significantly in achieving recycling rates of MSW and packaging as stated in the WFD in many countries. In Netherland 10% of the municipalities have chosen this solution, and post-separation is viewed as technically simple, require less collection infrastructure and are more convenient for the households due to less bins. However, critics has counter-argued the last point, emphasising the importance of people understanding the impact of their waste. This they get through the source sorting in households (Cimpan et al., 2015). This argument was also evident in this study. However, all the IMAs, still saw the achievement of the recycling target of household waste by 2030 as problematic without the use of central sorting. If the costs allow it, maintaining a separate collection scheme for plastic packaging together with PCC, might be necessary to avoid dissatisfied subscribers, especially with the IMAs with the highest collection rates today. The

IMAs with lower collection rates, might have more to gain by liquidating the curb-side programme for plastic packaging, as the experience with RoAF showed.

The role of a potential central sorting facility in Aalesund, which are to retrieve more plastic packaging and other recyclable materials from MSW, might be to supplement source-separation and separate collections, in the regions where collecting systems are deemed inefficient and where they hold the lowest recycling rates. In addition, Cimpan et al. (2015) points to the increasingly complex material composition as one of the main challenges to waste management systems today, since this requires a high level of flexibility and in some situations, new technology to sort and recycle. It is also important to consider future changes in consumption patterns. It is expected that because of new material use and evolving patterns in consumption (such as the increased use of bio-plastic or less newspapers), there will be a general decrease in material quality of the collected waste, by the adding of more problematic products and low-quality materials (Cimpan et al., 2015).

7 Conclusion, Recommendations and Further work

In this chapter, the background for the conclusion will be presented before the conclusion itself. Then follows suggested recommendations based on this study. In the end, further work will be suggested.

7.1 Background for Conclusion

The purpose of this study was to investigate the potential of using PAYT- schemes and central sorting as instruments in municipal solid waste management to increase sorting- and recycling rates of plastic packaging, as well as their possible contribution to achieving future recycling targets for household waste. The plastic packaging collection rates varies to a large degree between the different IMAs in this study. From 4,2 to 9,9 kilos per capita each year. The IMAs have similar waste systems, and the only significant variation is the use of collection frequency of the different waste fractions. While a few of the IMAs deems the first recycling target of 50% household waste in the WFD as achievable by 2020, the majority struggle to reach this. However, by implementing a separate bin for metal- and glass packaging, and organic waste, the target seems to be more attainable. Still, the recycling target of 65 % household waste by 2030, is assessed as difficult to achieve without the use of central sorting. The largest barriers are said to be complexity in plastics material and composition, low sorting rates in households and lack of waste system for cabins.

The use of PAYT-schemes to increase sorting rates of plastic packaging is evaluated differently by the IMAs. The majority saw the combination of volume-based scheme and collection frequency as the best option to motivate households to sort their waste better. There have been experiences where the sorting rates of plastic packaging has increased several kilos within a year, where such measures have been introduced. However, the common denominator for these municipalities were that they already had low sorting rates. A comparison between the IMAs waste management systems and their experiences with PAYT schemes, suggests information and the use of campaigns plays a larger role in motivating subscribers to sort more plastic packaging in households. Information also contribute to maintaining and increase support for already existent schemes. However, findings in the study suggest the increased use of PAYT schemes in increasing recycling rates of plastic packaging and achieving recycling targets might be limited, and the use of central sorting is therefore seen as a potential solution to this. Nevertheless, to enhance the effectiveness of PAYT-schemes, increased regional collaboration might be a possibility, to create more synergies.

However, this calls for a standardisation on how to measure recycling rates and what should be included in the category “household waste”. PAYT billing systems should be based on the precise quantification of waste.

7.2 Conclusion

The study indicates and shows that due to the complexity in plastics materials, making them hard to separate in households, and due to the overall low recycling rates with some of the IMAs, a central sorting facility is deemed to be a positive supplement to waste management systems covering municipalities in More and Romsdal. This will contribute to a larger degree, IMAs achieving future recycling targets and a transition towards a more circular economy paradigm, by retrieving more plastic packaging and other recyclables from MSW. All but one of the respondents in this study were interested in establishing a local central sorting facility, however, the investment will seem to be quite low among all the respondents. While both sorting by the source systems and central sorting have a problem with contaminated plastics, experiences from other central sorting facilities shows that sorted plastic fractions are still being recycled and bought, despite contamination. A central sorting facility is also deemed to give more flexibility by the continuously development of new technology. This will also contribute to sort out other complex material in the future when consumption patterns changes (more use of biodegradable plastic for instance). A local central sorting facility situated in Aalesund is also evaluated to be beneficial in order to enhance local value creation, if there is to come a legal obligation to post-sort MSW before using incineration treatment. However, a time perspective will be important in this matter. Several large central sorting facilities are to be built in Norway, with More and Romsdal situated between the facilities to come in Trondheim and Stavanger. Due to the fear of overcrowding, More and Romsdal might have limited time to build up local post-sorting capacity and secure local value creation opportunities.

7.3 Recommendation

To secure future local waste management treatment of MSW and increasing sorting rates of plastic packaging and achieve future recycling targets, the inter-municipal waste management agencies involved in this study, should continue to assess a central sorting facility as a supplement to their existent household waste system. In this matter, the actors need to evaluate if separate collection programme for plastic packaging should be maintained or liquidated.

7.4 Further Work

In regard to a potential central sorting facility, further work should be conducted to evaluate the cost-efficiency of the collection programmes for plastic packaging and glass- and metal packaging. While the Mepex report conducted by Sørensen & Marthinsen (2017) estimated costs related to building a central sorting facility, they did not include costs of transportation inn and out of such facility from the different regions. This would be interesting to investigate further.

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Appendix A. Interview guides

The interview guides used for the data collection in this study are presented below in tables.

Intervju guide (interkommunale avfallsselskap)	
Tema	Spørsmål
Introduksjon til studien *Målet og meininga med denne studien er å undersøke og analysere moglegheitene, samt potensialet for auka grad av sortering og materialgjennvinning av plast emballasje frå restavfall i Møre og Romsdal. Det vil verte tatt utgangspunkt i verkemidla differensiert avfallsgebyr og etablering av eit ettersorteringsanlegg som føreslått av Klima- og Miljødepartementet og Mepex.*	*Respondent blir spurt om det er greitt at bandopptakar vert brukt.*
Innleiingsspørsmål	-kven er respondenten (stilling), kva områder i Møre og Romsdal dekker selskapet, kor mange abonnentar er dekt gjennom deira tilbod, kor mykje hushaldningsavfall (om informasjon er tilgjengeleg) vert samla inn kvart år?
Dagens avfallssystem	-Kan du fortelje litt om dykkar kjeldesorteringsløysningar? (Kva vert sortert, bringe eller hente system ved nokre av avfallsfraksjonane, hente-frekvens, kva typar abonnement vert tilbedt). -Kva skjer med dei ulike kjeldesorterte avfallsfraksjonane? (tal på innsamla kjeldesortert materiale?) -Kva skjer med restavfallet? -Kan du fortelje om kva dykk opplever som styrker og svakheiter ved dykkar kjeldesorteringssystem? -Har dykk inntrykk av at abonnentane er flinke til å kjeldesortere? (Eventuelle plukk analyser, kva typar avfall vert kasta i restavfallet, tall, vekt)

	-Hamnar det mykje plast emballasje i restavfallet? -Kva inntrykk har dykk av tilfredsheita til abonnentane til dykkar kjeldesorteringssystem?
Barrierar og potensial i dagens og framtidas avfallssystem.	- Kva vurdera dykk som dei største utfordringane for avfallssektoren i Noreg når det kjem til kjeldesortering? (plast emballasje) - Opplever dykk at avfallsbransjen får nok insentiv og støtte frå myndigheitene i overgangen til ein meir sirkulær økonomi og betre ressursutnytting? -Kva kunne ha vore gjort annleis eller betre i så tilfelle?
Føreslått verkemidlar for å auke grada av plast-sortering og gjenvinning. Informasjon gitt til respondent for spørsmål: *I 2015 vart det føreslått juridisk bindande materialgjenvinnings mål I EU sitt avfalls direktiv. Dette var eit materialgjenvinningsmål på 50 % av hushaldningsavfall innan 2020. Dette har i seinare tid auka til 65 % innan 2030 og 75 % for emballasje innan same år. Desse måla har fungert som ein motor for å forbetre avfallshandtering, stimulere til meir bruk og innovasjon i resirkuleringsteknologiar, redusere bruken av deponi and skape insentiva for å endre forbruker mønster.* *I 2017 vart det sendt forslag og anbefalingar om ulike tiltak og politiske verkemidlar til Klima- og miljødepartementet for å auke grada av plast sortering og organisk våtavfall. Denne tilrådinga byggjer på ei konsekvensutgreiing frå Østfoldforskning og føreslo blant anna å lovfeste krav om sortering av våtavfall og plast emballasje, auka bruk av differensieringsgebyr, og at det blir utført regionale analyser for å undersøke moglegheitene for å opprette automatisert sentral sorteringsanlegg ulike stadar i landet.*	-Kva tenker dykk om materialgjenvinningsmålet på 50 % av hushaldningsavfall bestemt av EU? -Er dette mogleg å nå? -Er målet for 65% materialgjenvinning av hushaldningsavfall innan 2030 realistisk å nå med dykkar avfallssystem i dag? Kva må eventuelt forbetrast eller endrast? -Har dykk innført sortering av organisk våtavfall og plast emballasje? -Har dykk vurdert å tilby differensierte avfallsgebyr som eit verkemiddel (færre hentingar/mindre avfallsdunkar) slik at folk blir «tvungne» til å sortere betre i heimen? - Kvifor / kvifor ikkje? -Korleis vurderer dykk etablering av fleire automatiserte ettersorteringssanlegg i Noreg som eit verkemiddel for å auke plastgjenvinninga og nå materialgjenvinningsmåla?
Ettersorteringsanlegg i Møre og Romsdal *Informasjon oppgitt:* *Konsulentselskapet Mepex (på bestilling frå Årim) gjennomførte i 2017 ei utgreiing av ulike*	- Kva vurdera dykk som styrker og svakheiter (barrierar og moglegheiter) ved eit mogleg ettersorteringsanlegg som sortera ut blanda plastfraksjon slik som i alternativ 1 a?

alternativ for auka sortering av avfall i 5 avfallsregionar i Møre og Romsdal: *Ålesundregionen Interkommunale Miljøselskap IKS (ÅRIM), Romsdalshalvøyas interkommunale renovasjonsselskap IKS (RIR), Volda og Ørsta reinhaldsverk IKS (VØR), Nordmøre interkommunale renovasjonsselskap IKS (NIR) og Søre Sunnmøre Reinhaldsverk ISK (SSR)* *Hensikta med prosjektet var å gi ei overordna vurdering av kostnader og sorteringsgrad ved auka sortering av hushaldningsavfall i Møre og Romsdal og då spesielt gjennom etablering av eit ettersorteringsanlegg og bruk av NIR teknologi. Prosjektet la til grunn at anlegg som allereie er etablert i Møre og Romsdal vert utnytta, slik som forbrenningsanlegget til Tafjord Kraft på Grautneset, dette er føreslått sidan det vil gi synergiar ved direkte transport av restavfall til bunker. Det er kalkulert med at eit slik ettersorteringsanlegg vil omfatte sortering av restavfall frå renovasjonsordninga i alle regionane, totalt ca. 40.000 tonn/år. Prosjektet la til grunn tre alternativ som spesielt gunstig for ettersortering av hushaldningsavfall i Møre og Romsdal:* *I alternativ 1 a, som er hovudalternativet, sorterast ut ein blanda plastfraksjon i tillegg til papir og metall. Blanda plast vert forutsett omsett gjennom GPN (Investering: 130 000 000 kr).* *I alternativ 1b etablerast det eit komplett plastsorteringsanlegg med utsortering av 5 ulike plasttypar og sal i markedet. (Investering: 250 000 000 kr, men nedbetalar seg raskast)* *Alternativ 1 c er ein variant av 1 a der plastfraksjonen ettersorterast i ROAF eller IVAR anlegget, men dette er avhengig om ein kan oppnå ein god nedstrømsavtale med ROAF eller IVAR, og full støtte frå GPN. (Investering: 130 000 000 kr)* *Konklusjonen frå prosjektet til Mepex er at alle alternativa nemnt, vert vurdert til å vere gunstig for Møre og Romsdal å gå vidare med. Alle alternativa inneberer alle rundt 20 % utsortering til materialgjenvinning og kan etablerast med årleg meirkostnader i området 100 – 300 kr/tonn eller 30 – 100 kr/husstand.*	- Kva vurdera dykk som styrker og svakheiter (barrierar og moglegheiter) ved eit mogleg komplett plastsorteringsanlegg som sortera ut 5 ulike plasttypar og med vidare sal i markedet, slik som i alternativ 1 b? - Kva vurdera dykk som styrker og svakheiter (barrierar og moglegheiter)ved ein variant av 1 a der plastfraksjonen frå sorteringsanlegget ettersorterast i ROAF eller IVAR anlegget? -Kva tenker dykk er mest optimalt og realistisk av alternativa føreslått av Mepex for å auke sorteringsgrada av plast (samt andre avfallsfraksjonar) i Møre og Romsdal? -Ser dykk føre dykk å gå inn i eit slikt samarbeid mellom regionane i Møre og Romsdal der ei slik form for ettersorteringsanlegg vert etablert? -Er dykk villige til å investere i eit slik anlegg? -Kva tenker dykk om den eventuelle lokaliseringa ved anlegget på Grautneset som føreslått av Mepex? - Om eit eventuelt sentralsorteringsanlegg skulle vere aktuelt, korleis ser dykk føre dykk at kjeldesorteringa og transport av avfall vert organisert?

Avslutning	- Er der andre politiske verkemidlar eller tiltak dykk ser føre dykk kunne ha auka sorteringsgrada av plast avfall? - Korleis ser dykk føre dykk at avfallsektoren i Norge vil sjå ut i 2030?
Takk for at du tok deg tid til dette intervjuet!	

Intervju guide (Tafjord Kraftvarme AS)	
Introduksjon til studien *Målet og meininga med denne studien er å undersøke og analysere potensialet for auka grad av sortering og materialgjennvinning av plast emballasje frå restavfall i Møre og Romsdal. Det vil verte tatt utgangspunkt i verkemidla differensiert avfallsgebyr og etablering av eit ettersorteringsanlegg som føreslått av Klima og Miljødepartementet og Mepex.*	*Respondent blir spurt om det er greitt at bandopptakar vert brukt.*
Innleiing	-kven er respondenten (stilling), namn på selskap, kva områder i Møre og Romsdal dekker selskapet, kva (interkommunale avfallsselskap) og kor mange selskap nyttar seg av tjenestene deira.
Dagens forbrenningsanlegg	-Kan du fortelje litt om dykkar forbrenningsanlegg? kor mykje restavfall går til forbrenning kvart år? (tall frå Møre og Romsdal), korleis fungera anlegget? Kor stor kapasitet har det? -Er der andre avfallstypar enn restavfall som går til forbrenning? -Kor mykje av restavfallet inneheld andre avfallsfraksjonar som metall, papir, plast emballasje? -Vert det utsortert avfallsfraksjonar før restavfallet går til forbrenningsomnane? -Kan du fortelje om kva dykk opplever som styrker/ svakheiter og utfordringar/potensial ved dykkar forbrenningsanlegg? - Ved å sjå kva restavfallet dokke mottek inneheld, har dykk inntrykk av at abonnentane

	til dei interkommunale avfallselskapa som nytter seg av tenestene dykkar er flinke til å kjeldesortere?
Identifiserte barrierar og potensiale ved auka sortering og resirkulering av hushaldningsavfall og plast emballasje Oppgitt informasjon: *I 2015 vart det føreslått juridisk bindande materialgjenvinningsmål I EU sitt avfalls direktiv. Dette var eit materialgjenvinningsmål på 50 % av hushaldningsavfall innan 2020. Dette har i seinare tid auka til 65 % innan 2030 og 75 % for emballasje innan same år. Desse måla har fungert som ein motor for å forbetre avfallshandtering, stimulere til meir bruk og innovasjon i resirkuleringsteknologiar, redusere bruken av deponi og skape insentiva for å endre forbruker mønster.*	--Kva tenker du om materialgjenvinningsmålet på 50 % av utvalde typar hushaldningsavfall innan 2020 som bestemt av EU? Er dette realistisk å nå med dagens kjeldesorteringsløysningar i Møre og Romsdal? - Vurdera du EU målet for 65% materialgjenvinning av hushaldningsavfall innan 2030 som realistisk å nå? - Korleis vil auka sortering og materialgjenvinning av utvalde typar hushaldningsavfall (spesielt organisk våtavfall og plastemballasje) påverke dykkar bedrift og tenester? Om hushaldningar byrjar å sortere betre går vel mindre i restavfallet og dermed mindre til forbrenning? -Kva vurdera dykk som dei største utfordringane for forbrenningsanlegga i dag og i framtida?
Føreslått verkemidlar for å auke grada av plast-sortering og gjenvinning Oppgitt informasjon: *I 2017 vart det sendt forslag og anbefalingar om ulike tiltak og politiske verkemidlar til Klima- og miljødepartementet for å auke grada av plast sortering og organisk våtavfall. Denne tilrådinga byggjer på ei konsekvensutgreiing frå Østfoldforskning og føreslo blant anna å lovfeste krav om sortering av våtavfall og plast emballasje, auka bruk av differensieringsgebyr, og at det blir utført regionale analyser for å undersøke moglegheitene for å opprette automatisert sentral sorteringsanlegg ulike stadar i landet.*	Kva tenkjer du om eit lovfesta krav om sortering av våtavfall og plastemballasje som eit verkemiddel for å auke sorteringsgrad og materialgjenvinning av plast emballasje? Kva tenkjer du om auka bruk av differensieringsgebyr som eit verkemiddel for å auke sorteringsgrad og materialgjenvinning av plast emballasje? -Korleis vurderer dykk etablering av fleire automatiserte ettersorteringssanlegg i Noreg som eit verkemiddel for å auke plastgjenvinninga og nå materialgjenvinningsmåla? -Korleis vil fleire slike ettersorteringsanlegg påverke tenestene dykk tilbyr?
Ettersorteringsanlegg i Møre og Romsdal	

Oppgitt informasjon: *I 2017 utførte konsulentselskapet Mepex (på bestilling frå Årim) ei utgreiing av ulike alternativ for auka sortering av avfall i 5 avfallsregionar i Møre og Romsdal. Desse var som fylgjer:* *Ålesundregionen Interkommunale Miljøselskap IKS (ÅRIM), Romsdalshalvøyas interkommunale renovasjonsselskap IKS (RIR), Volda og Ørsta reinhaldsverk IKS (VØR), Nordmøre interkommunale renovasjonsselskap IKS (NIR) og Søre Sunnmøre Reinhaldsverk ISK (SSR)* *Hensikta med prosjektet var å gi ei overordna vurdering av kostnader og sorteringsgrad ved auka sortering av hushaldningsavfall i Møre og Romsdal og då spesielt gjennom etablering av eit ettersorteringsanlegg og bruk av NIR teknologi.* *Prosjektet la til grunn at anlegg som allereie er etablert i Møre og Romsdal vert utnytta, slik som dykkar forbrenningsanlegg på Grautneset, dette er føreslått sidan det vil gi synergiar ved direkte transport av restavfall til bunker. Det er kalkulert med at eit slik ettersorteringsanlegg vil omfatte sortering av restavfall frå renovasjonsordninga i alle regionane, totalt ca. 40.000 tonn/år.* *Prosjektet la til grunn tre alternative anlegg som spesielt gunstig for ettersortering av hushaldningsavfall i Møre og Romsdal:* *I alternativ 1 a, som er hovudalternativet, vert det sortert ut ein blanda plastfraksjon i tillegg til papir og metall. Blanda plast vert forutsett omsett gjennom GPN (Investering: 130 000 000 kr).* *I alternativ 1b etablerast det eit komplett plastsorteringsanlegg med utsortering av 5 ulike plasttypar og sal i markedet. (Investering: 250 000 000 kr, men nedbetalar seg raskast)* *Alternativ 1 c er ein variant av 1 a der plastfraksjonen ettersorterast i ROAF eller IVAR anlegget, men dette er avhengig om ein kan oppnå ein god nedstrømsavtale med ROAF eller IVAR, og full støtte frå GPN. (Investering: 130 000 000 kr)* *Konklusjonen frå prosjektet til Mepex er at alle alternativa nemnt, vert vurdert til å vere gunstig for Møre og Romsdal å gå vidare med. Alle alternativa inneberer alle rundt 20 % utsortering til materialgjenvinning og kan*	-Kva tenker dykk om ein eventuell etablering av eit ettersorteringssanlegg på Grautneset som føreslått av Mepex? -Med tanke på dei tre alternative ettersorteringsanlegga, kva tenker dykk er mest optimalt og realistisk av alternativa føreslått av Mepex for å auke sorteringsgrada av plast emballasje og som er mest gunstig for dykk? -Med tanke på at avfallet frå dei interkommunale avfallsselskapa må konkurranseutsetjast, korleis kan og vil Tafjord kraft sikre seg avfallet frå desse kommunane i framtida ved eit eventuelt ettersorteringsanlegg i nærområdet? Kva er motivasjonsfaktorane dykkar for å sikre og behalde avfallet frå regionane? (det har vorte foreslått ide om oppretting av ettersorteringsanlegg på Bingsa). -Ser dykk føre dykk å gå inn i eit slikt samarbeid mellom regionane i Møre og Romsdal der ei slik form for ettersorteringsanlegg vert etablert i framtida? -Korleis ser dykk føre dykk at eit slikt regionalt samarbeid kunne ha vore organisert? -Er dykk villige til å investere i eit slikt ettersorteringsanlegg?

etablerast med årleg meirkostnader i området 100 – 300 kr/tonn eller 30 – 100 kr/husstand.	
Avslutning	-Kvar ser du føre deg Tafjord kraft vil vere 2030?(det har vore lukta på et forslag om forbod mot av fossilt materiale og andre verdifulle materialar).
Takk for at du tok deg tid til dette intervjuet!	