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Master Degree Project in Innovation and Industrial Management

What Role can Municipalities take to Accelerate Development in Regional Waste Management Systems towards a Zero Waste Society

Jessica Ekdahl and Amanda Friberg

Supervisor: Johan Brink
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WHAT ROLE CAN MUNICIPALITIES TAKE TO ACCELERATE DEVELOPMENT IN REGIONAL WASTE MANAGEMENT SYSTEMS TOWARDS A ZERO WASTE SOCIETY

By Jessica Ekdahl & Amanda Friberg

Master of Science: Innovation and Industrial Management
School of Business, Economics and Law, University of Gothenburg,
Vasagatan 1, P.O. Box 600, SE 40530 Gothenburg,
Sweden

Contact: jessica.l.ekdahl@gmail.com or amanda.friberg@gmail.com

Abstract

During recent decades society has been striving towards a circular economy where minimisation and prevention of waste is the key objective. An increasing world population coupled with subsequent increasing waste volumes and diminishing raw materials is primarily driving the movement from a linear towards a circular economy. Further, it is widely acknowledged that municipalities have a significant role to play in the development of future waste management systems. Municipalities also have an obligation to implement EU waste directives aimed at developing circular economies within each EU member state. Based on these factors coupled with the gap in literature regarding the municipalities' role in developing regional waste management systems, we chose to focus our study around the role of municipalities in accelerating the development of a regional waste management system. This was achieved by conducting a study at Göteborgsregionens Kommunalförbund (GR), that include 13 municipalities. Our research question explored "What role can Swedish municipalities take to accelerate development in waste management towards a zero waste society?"

Our empirical findings, outlined from three key actors perspectives (municipalities, waste firms and researcher organisations) explored the current waste management system in the region as well as various trends and barriers influencing the development of the system. Our findings also highlight how the current situation, trends and barriers differ between three specific problematic waste fractions: plastic, plaster and textile.

Based on this analysis, we were able to develop four key roles we believe municipalities are able to adopt in order to accelerate regional development of a waste management system towards a zero waste society. The municipal roles recommended are: Co-ordinator, Pioneer, Legislator and Financer. We believe municipalities have an important role to play in removing barriers to allow for the natural development towards a circular economy to unfold. We believe that the four roles we have proposed are key to succeeding with this. Further, we were able to suggest specific changes for GR to enable implementation of circular economy in their region. Finally, since the barriers and trends identified in the region are aligned with international literature to a great extent, we have reason to believe that our findings and proposed municipal roles can be generalised to other regions in Sweden, or even other countries with a similar level of development.

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1 Introduction

The Introduction section aims to provide the reader with background material of the subject of interest, which is the municipal waste management system in Sweden. Further, the section will introduce the organisation to which this study is aimed for, which is Göteborgs Regionens Kommunalförbund (GR) and its future challenges within waste management. This will subsequently lead to our objective and research question.

1.1 Background

The ability and need to develop waste management system is more important in today's globalising and urbanising environment than ever before. Waste management is a key challenge of today since the demand for natural resources is increasing, despite the availability of many materials decreasing simultaneously (McWilliams & Siegel, 2000). During decades many economists, politicians, environmentalists, sociologists and philosophers have searched for a new wave of development that is sustainable given the limits of the planet. More recent literature addresses the concept of circular economy and how it contributes to a sustainable society by utilising resources. According to EU Directives countries should strive towards a circular economy to overcome these environmental challenges. The main argument for circular economy is that it contributes to the design of a zero waste society where products are designed and optimised for a cycle of reuse (the product is being used again just as it is) and recycling of products (the material is treated and reused in a new product cycle) (MacArthur foundation, 2014). Circular waste management systems are inherently the core of the circular economy. This is because the waste management system includes all steps from product creation to product disposal, therefore waste management is naturally a key aspect to develop to move the society towards a circular economy with a zero waste strategy.

Actors within waste management need to collaborate to find the best solutions to develop waste management towards a zero waste society. This argument is further strengthened by the fact that by 2050 as many people will live in cities as the population of the world in 2000. This migration of people to cities will furthermore add challenges to waste management processes. This is because the intensifying concentration of people in cities means that more waste is generated in a smaller geographical area, which means waste management needs to be streamlined and strategies for waste prevention need to be developed. This leads to that citizens and corporations will need to take on more responsibility such as product design and

waste sorting to enable waste firms to treat the products in a sustainable way (Hoornweg & Bhada-Tata, 2012).

1.2 Problem Setting

It is critical for municipalities to take action with regards to the development of waste management since there are new directives from EU that require individual member states to implement circular economy and improve recycling rates. EU proposed a motion regarding rates on minimizing waste and increasing the circulation of material through legalisation. However, the motion was withdrawn in January 2015. EU are now working towards a new motion with a focus on market solutions, strategies and eco-design to reach a circular economy, instead of legalisation. Thus, changes must occur upstream starting with new processes for producers, rather than downstream starting with legislative demands on waste firms (Miljö Online, 2015).

Even though significant improvements can be seen in waste management during the past 20 years, there is still large potential for minimising the environmental impact of waste management in Sweden. However, scenario calculations show that waste quantities will double by 2030 if nothing is done (Naturvårdsverket, 2012). Improvement is crucial since increased waste volumes will increase the environmental impact further if waste management is not streamlined (Ekvall & Malmheden, 2012).

Thus, the need for improvement in national waste management systems is evident, however it is up to each country and region to make these changes. While previous literature covers some broad aspects of how to go about these improvements, there is still a significant gap with regards to the role of municipalities in facilitating development.

1.2.1 GR

Göteborgsregionens Kommunalförbund (GR) have decided that the 13 municipalities[1] that form part of the Gothenburg region need to collaborate with regards to their waste management system to achieve the directives from EU. The purpose of this is to combine the waste volumes of all municipalities in order to achieve synergies in waste management both from an environmental and cost effectiveness perspective. GR are interested in exploring if these combined waste volumes would create incentives for regional waste management firms

[1] Ale, Alingsås, Göteborg, Härryda, Kungsbacka, Kungälv, Lerum, Lilla Edet, Mölndal, Partille, Stenugnsund, Tjörn, Öckerö

to collaborate and invest in more environmentally friendly waste treatment methods, perhaps through setting up a local treatment facility (to avoid exporting or transporting the region's waste to other parts of the country for treatment).

Further, GR lacks knowledge of how the regional waste management system looks today, for instance what are the annual waste volumes, flows, actors, treatment methods and so forth. Plastic, plaster and textiles are three particularly problematic materials that GR are interested in investigating to improve waste management for. These fractions are problematic for GR since these fractions do not have sustainable waste solutions today as well as municipalities lack knowledge of the waste management of these fractions. A study was therefore carried out to gain a holistic view of the waste management system today as well as trends and barriers hindering development towards a zero waste society, with a focus on the three problematic fractions. Based on these findings future municipal roles emerged to improve the regional waste management system. These findings were then presented to the waste managers in the GR municipalities in the hope that the results could improve future decision-making within waste issues in the region.

GR requested that the focus lie on waste collected at recycling stations, since this is the waste municipalities are responsible for. Therefore, all waste directly collected from households, industries and other sources have been excluded for this study.

1.2.2 The Waste Industry

The waste industry in Sweden consists of a number of key actors. These include municipalities, waste firms and research organisations. These actors are present in every region in Sweden and govern the regional waste practices. Directives from EU emphasise that member states need to improve their waste management towards a circular economy. These EU Directives influence the waste management systems in every region. Thus municipalities, waste firms and research organisations are continuously working to develop regional waste practices to fit with EU regulations.

1.3 Objective

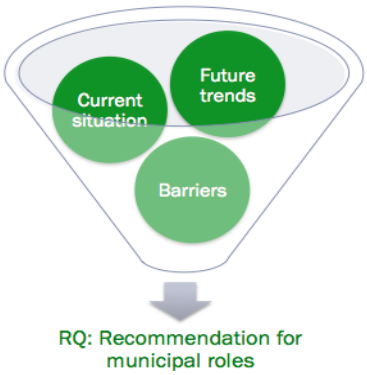
This study will investigate the Swedish waste management system in the Gothenburg region and identify related trends and barriers to development. Based on these findings the study will thereafter investigate what role the municipality can take to accelerate the development of

waste management towards a zero waste society in the region. The target audience for our study is managers at municipalities, actively working with waste management issues.

1.4 Research Question

What role can Swedish municipalities take to accelerate development in waste management towards a zero waste society?

1. What is the current waste management situation in GR?
2. What are future trends within waste management?
3. What are barriers hindering development within waste management?



The research question and its three sub questions will be answered by exploring three perspectives of the key actors in the waste industry, i.e. municipalities, research organisations and waste firms. Further, the study will focus on three waste fractions; plastic, plaster and textile. By answering the three sub questions based on the three waste fractions and the three actors' perspectives we were able to find similarities as well as differences with regards to current situation, barriers and trends. The similarities highlight findings that can be generalised to the regional waste system, while the differences highlight the complexities within the system given the multitude of actors and fractions. A summery of the problem settings that lead to the research objective is outlined below in figure 1.

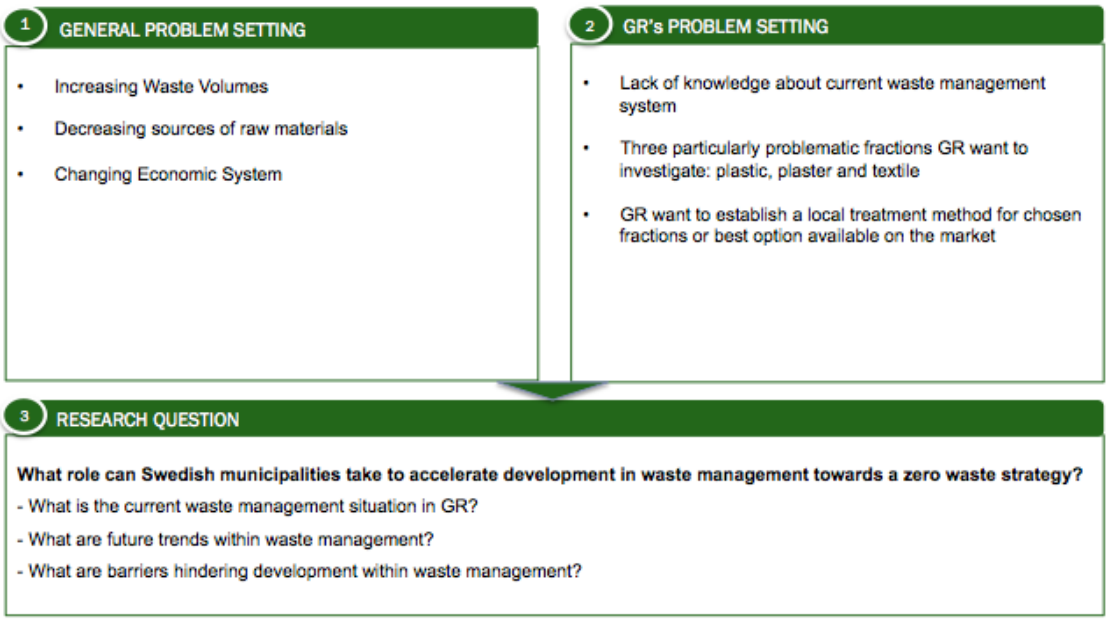


Figure 1: Problem setting and research question

1.5 Disposition

This study will start off with a literature review covering relevant previous research within waste management, for instance a definitional framework of waste management including waste hierarchy and circular economy as a concept. Thereafter, the study will continue with an outline of the applied methodology used to answer the research question. Subsequently, the findings are presented, followed by the analysis of the municipal roles and recommendations to GR. A conclusion and suggestions for future research completes the study. Figure 2 summarises our thesis outline and the relevant content for each chapter.

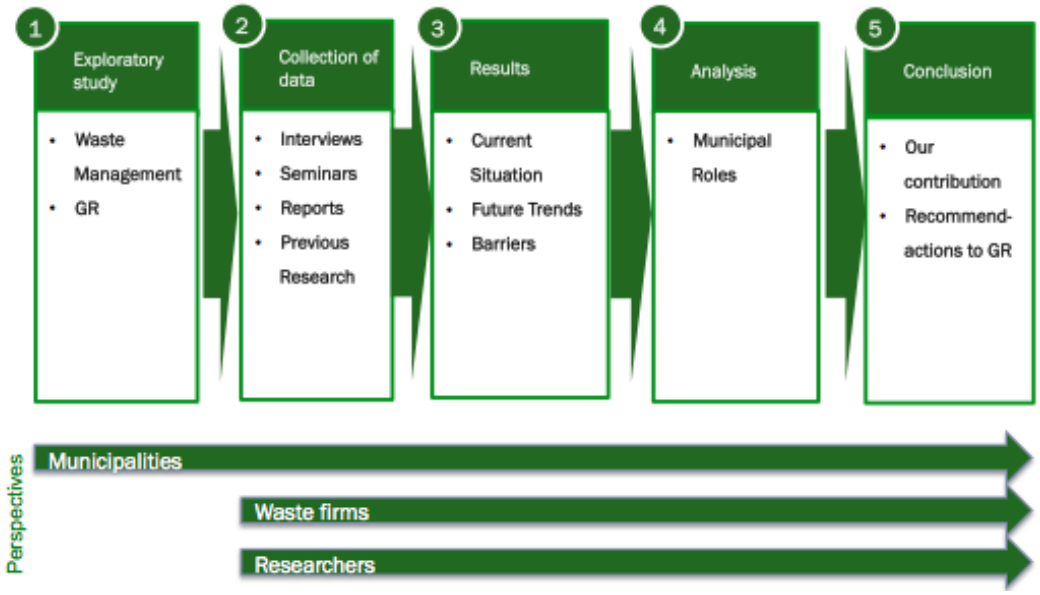


Figure 2: Disposition of study

2 Literature Review

Conducting a systematic literature review on the issue of waste management has resulted in the identification of certain building blocks of waste management necessary to answer our research question. This section will start with an overview of what waste management is; including relevant actors and concepts. Thereafter, previous literature regarding future trends will be presented followed by barriers hindering development of waste management. All parts will be focusing on Sweden.

- What is waste management
  - Waste hierarchy
  - Circular economy
- Actors within waste management
  - Producers
  - Municipalities
  - Waste firms
- Future trends in waste management
- Barriers in waste management
- Research gaps in previous literature

2.1 What is Waste Management

Every municipality is responsible for providing its residents with waste management services to ensure proper handling of waste materials (Hoornweg & Bhada-Tata, 2012). It involves everything from the collection, transportation and disposal of waste products. These aspects require input from legal, economic, political, administrative, and environmental players. The management structure and function is site-specific and depends on socio-economic, behavioural, cultural, institutional, and political frameworks. These actors need to interact and collaborate for the management system to achieve its targets (Letcher & Vallero, 2011).

According to Soltani et al (2015) waste treatment is the core mean to reach the waste management objectives within a municipality. There are several different treatment options for waste management. However, choosing the best available option usually involves decisions on technology, location and capacity of treatment plant. Furthermore, these decisions are often made by considering various criteria such as the trade-off between environmental benefits, costs, political and social factors (Soltani et al, 2015).

Municipal waste is managed by public authorities, which often in turn contract private companies to carry out the waste management services in a region. However, in some cases municipalities decide to manage their own waste services. The waste is collected from households and businesses and then sorted into fractions. Municipal solid waste management deals with waste generation, transport, transformation (treatment) and storage (Lederer, 2009). A general system illustrating the processes for municipal waste management can be seen in the figure below.

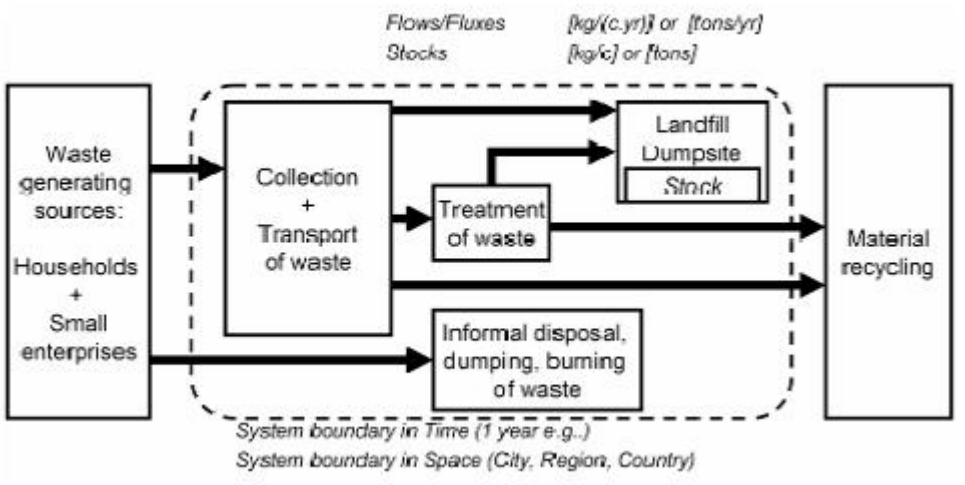


Figure 3: General system definition municipal solid waste management (Source: Lederer, 2009)

A sustainable waste management system is naturally a core aspect involved in creating a circular economy since waste needs to be disassembled in order to be recycled and fed back into production. Ultimately, products will hopefully be designed to enable more efficient disassembly and reuse (Jansson & Sundqvist, 2014). Brunner and Rechberger (2004) explain that ”the common objectives of waste management are the protection of human beings and the environment, the conservation of resources and pre-treatment of wastes in order to reduce aftercare after final storage to zero”. In addition to these objectives, different solid waste management frameworks have been developed and one of these is the *Waste Hierarchy*.

2.2 Waste Hierarchy

The waste hierarchy is widely used by governments and industry as a guiding tool in waste policy (Fig 4). The waste hierarchy framework ranks the treatment methods based on their environmental impact. In the waste hierarchy waste reduction is naturally on the top, thereafter re-use, recycling, and if these options are not possible waste should be transformed to energy (through incineration) and the last option is landfilling (Luks & Hammer, 2003).

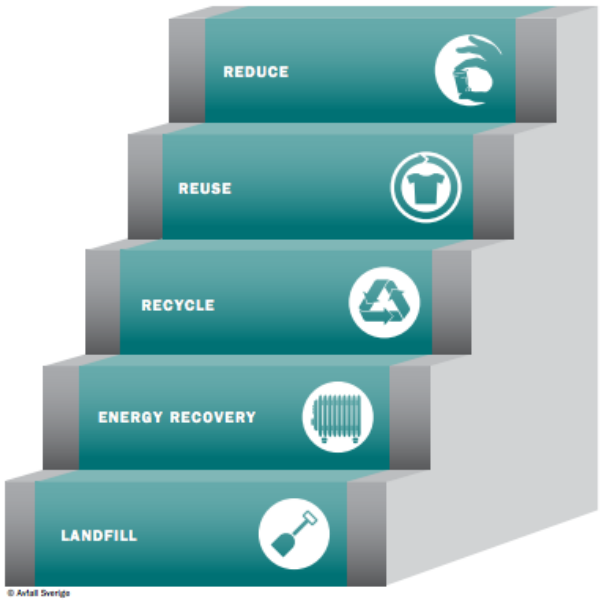


Figure 4: The Waste Hierarchy (Source: Avfall Sverige, 2013)

The three highest levels of the waste hierarchy should be prioritised to achieve a circular economy with a zero waste strategy (MacArthur foundation, 2014).

2.3 Circular Economy

The circular economy business model is highlighted for this study due to the directives from EU to implement the theoretical concept. However, this is only one of many sustainable business models used today, with its own set of limitations.

A circular economy is achieved if the three highest levels in the hierarchy are reached. This is in contrast to the current linear economy model, predominantly driven by "take, make, dispose" of large quantities of resources and energy. The linear economy is based on extraction, production and consumption of resources without replacing the resources utilised. In the beginning of the 21st century clear signs started showing that this system was reaching its limit, for instance raw materials becoming scarcer, evident through increasing/fluctuating prices for raw materials (Jansson et al, 2014, Gertsakis & Lewis, 2013).

A circular economy is a system that is restorative or regenerative by both intention and design (MacArthur foundation, 2014). A circular economy aims to design a zero waste society: products are designed and optimized for a cycle of disassembly and reuse. A circular economy seeks to rebuild capital, whether this is financial, manufactured, human, social or natural. This ensures enhanced flows of goods and services and the products are designed for

reuse (MacArthur foundation, 2014). The figure below illustrates how the inherent design of a linear economy differs from a circular economy.

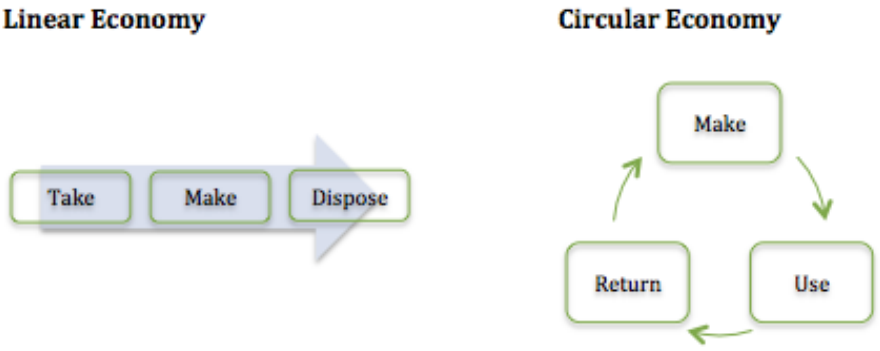


Figure 5: Linear versus circular economy flows (Source: Ellen MacArthur Foundation, 2014)

While circular economy thinking can be applied on a global scale and involves legislations and product designs, industrial symbiosis is a local solution for preventing waste from existing processes through linking local actors with one another.

2.3.1 Industrial Symbiosis

Industrial symbiosis (IS) has been introduced as a strategic tool for economic development regarding circular economy, green growth, innovation and resource efficiency (Lombardi et al, 2012). IS intends to focus on long-term collaborations between local and regional actors enabling more effective use of material, energy, water and other resources both from environmental and cost effective stand point. The goal is optimised resource flows where waste from one process feeds into another. IS is linked to circular economy as it means various local actors work together to link each others in and outflows and make use of each others waste (Jansson et al, 2014).

The symbiosis network itself builds on the concept that synergies are created as new business opportunities arise within the network and create job opportunities as well as environmental benefits through waste prevention. The symbiosis network is made up of four key areas, illustrated below.

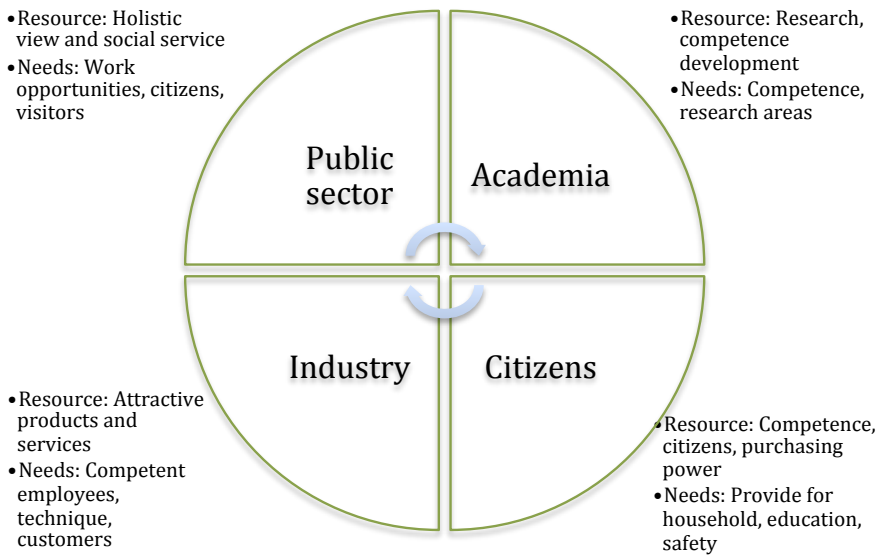


Figure 6: Actors involved in industrial symbiosis projects (Source: Miljö Online)

There have been several successful projects that have achieved industrial symbiosis. One of the most commonly used reference projects of industrial symbiosis in the industrial ecology literature is the example from Denmark in Kalundborg. The industrial symbiosis in Kalundborg was developed through a number of independent by-product exchanges among five co-located companies and the local municipality (Ehrenfeld and Gertler 1997; Ehrenfeld and Chertow 2002). The companies involved in industrial symbiosis include a power plant (Asnæs), an oil refinery (Statoil A/S), a biotech and pharmaceutical company (Novo Group), a producer of plasterboard (Gyproc Nordic East), and a soil remediation company (Soilrem A/S). The various material flows among the companies are based either on water, solid waste, or energy exchanges. The industrial symbiosis in Kalundborg has managed to achieve a combination of operational, economic and environmental benefits (Jacobsen, 2006). To develop waste management towards circular economy several actors need to collaborate as seen in the example from industrial symbiosis. The main actors within waste management will be presented in next section.

2.4 Future Trends of Waste Management

Increased waste volumes and complexity

In a report from the World Bank in 2012, there were about 1.3 billion tonnes of waste per year in the world. A volume that is expected to increase by 2025 to 2.2 billion tonnes. Further, waste management costs are expected to increase from today's annual $205.4 billion to about $375.5 billion in 2025 (Hoornweg & Bhada-Tat, 2012). In recent years, research into the

question of municipal waste management has come to the forefront due to the increasing amount of volume and complexity of this service (Bel and Mur, 2009; Benito-López et al., 2011). The complexity lies in the challenge of integrating new infrastructure into waste management systems while reducing waste volumes and minimising landfill. This transformation of the current waste management may require greater public engagement within the political, institutional and social decision-making (Defra, 2007, Garnett & Cooper, 2014).

Increased municipal involvement

Increasing municipal involvement in situations of conflict, between actors in waste management, allow policy makers to understand and explore opposing perspectives and resolve issues by finding common ground or developing novel solutions where some decisions will require greater levels of municipal involvement than others. For instance, in cases where there is low trust between actors, there will need to be higher levels of involvement from municipalities to be able to encourage social interaction around a waste problem (Garnett & Cooper, 2014). Further, waste management has become increasingly complex for municipalities faced with the challenge of integrating new infrastructure into waste management systems while reducing waste volumes and minimising landfill. This change may require greater public engagement within the political, institutional and social arenas in which decisions are made (Garnett & Cooper, 2014). Subsequently, Petts (2004) suggests that municipalities need to manage greater regulatory and funding support to be able to further develop the waste management system.

Producers take more responsibility

Braungart & McDonough (2013) argues that we must innovate to overcome the limitation of today's system and by for instance designing products in the right way we can start working together with nature rather than against it. Crocker & Lehmann (2013) are researchers that argue that the world's recycling performance is not improving and seems to have reached a ceiling because of the continuously growing supply of low cost products. They suggest that improvement can only be achieved through changes in product designs in the form of incremental improvements (Crocker & Lehmann, 2013). Connett (2013) agrees with the need for producers to be more involved and states "If we can't reuse it, recycle it, or compost, industry shouldn't be making it".

Zero Waste Strategy

Researchers believe that by shifting our thinking towards circular economy thinking, we will find new ways of preventing waste, rather than just minimising it. Moreover, Leonard, Hawken and Jackson, leading environmentalists, explain that people are increasingly aware of the negative impact of waste on the climate and thus are keener to contribute to zero waste solutions (Crocker & Lehmann, 2013). Researchers also state that the most effective ways to promote recycling in the future will be information sharing and collaborative community programmes.

In Europe, waste prevention (zero waste strategy) has been a key trend of waste management during the last years. In 2008, it was integrated in the legislation, waste framework directive 2008/98/EC, and stated that prevention is the first priority of waste management. The legislation had a requirement from European member states to produce waste prevention plans (Gentil et al, 2011).

2.5 Barriers to development of Waste Management

Government policies and public mistrust of authority

Troschinetz and Mihelcic (2009) explain that the lack of governmental policies, incentives and implementation is a key barrier to improving recycling. Further, Bulkeley and Gregson (2009) also stated that a related barrier is a possible mistrust between public and authorities, where the public suspects that waste management programs only benefit the government. Betchel et al (2013) also state that the discrepancies between international regulations and the rigid nature of these can mean barriers to transforming waste management systems.

Lack of communication between industry and policy makers

Nicholls (2014) state that a barrier for circular economy (the ultimate goal when improving waste management systems), is knowledge from both science and technology is needed in the same place and usually these areas are isolated from each other. Further, there is a lack of communication between industry actors and policy makers, which mean the parties, do not know how to help each other achieve better systems.

Expense of waste minimization and diversion

O'Connell (2011) explain that "municipalities often subsidise municipal solid waste recycling programs in the US, Japan and some European countries" to avoid the social cost of simply dumping it. Often the conclusion from such programs is that the costs for labour and transportation outweigh the revenue collected from selling recyclable material. This suggests

that municipal recycling initiatives are not economically feasible on their own, perhaps the solution is to involve more actors in the movement towards a circular economy.

Another financial barrier to develop waste management system is that firms are struggling to find funding for investments to develop new business models that allow for more circular processes, e.g. designing products for secondary markets, or transforming the firm's waste to suit another producer's needs. This is because investors are unfamiliar with the concept of circular economy and lack information about financial risk. Often investors associate it with corporate social responsibility and believe investments with lower returns, when in fact circular economy can introduce profitable business opportunities (Nicholls, 2014). Nicholls (2014) also explains that new business models, centred on leasing or using materials from secondary markets, will require new service obligations and updated legal frameworks, which will take time since it will be unfamiliar.

Habits

Nicholls (2014) state that a barrier to improving waste management systems is changing the behaviours of mass consumers to fit circular economies (purchase, consume, reuse) rather than the linear economy we have today (purchase, consume, dispose). Lehmann (2015) highlight that media often emphasises recycling rates rather than criticising consumption behaviour, waste generation and systems. The focus must lie on changing consumption and products. Nicholls (2014) suggest that producers must innovate in order for consumers to feel that they do not need to drastically change behaviour. Graham (2015) explains that this will require more extensive relationships between actors in the value chain, which could mean that waste firms will also be suppliers of raw materials. The goal is to remove the idea that an old product is lesser than a new product. Betchel et al (2013) and Corporate Citizenship (2014) state similarly that a barrier is the reluctance to recognise that the current behaviour is not sustainable and that a new long-term perspective is needed.

Practical barriers in production

A barrier that has developed since our economy has shifted towards a circular model is how to develop materials for production that are recyclable and how to develop efficient reverse logistics, i.e. the process of fetching used products must be as efficient as delivering new products to customers. Graham (2015) emphasises the opportunities of this barrier: "there is great scope for the global supply chains that dominate today's resource-based economy to be

redesigned into global supply cycles". Further, a related barrier highlighted by Bechtel et al (2013) is that producers may struggle to produce recyclable materials since it requires specific technologies and processes that they will need to adopt first. Corporate Citizenship (2014) states similarly, that development of design and material standards is needed to help producers develop recyclable products.

2.6 Research Gaps in Previous Literature

Since there will be increased waste volumes in the future, advocates of circular theory argue it is vital to develop the waste management system to reach the upper levels in the waste hierarchy. However, there are several barriers hindering the development such as habits, mistrust, costs and so forth. Several researchers have stated that the municipality needs to be more involved in the change process to enable development of the waste management system to reach the goal of a zero waste society. Below we outline to what extent the chosen literature answers each research question and thereby highlight the gaps in previous research.

What is the current waste management situation in GR?

There is a general overview in previous literature of the municipalities' role in the system and the waste management process, which also can be applied to GR. However, there is a gap in previous literature regarding how different actors interact in the waste management system. Moreover, research investigates the waste management system "objectively", without including any of the difference perspectives from actors within the waste system.

What are future trends within waste management?

Future trends within the waste management system are many. However, it is hard to predict which one of the trends that will occur in the future. Previous literature, included in this study, does not investigate which one of the trends that is most likely to happen. Consequently, there is limited previous research that compares these potential trends against each other for a deeper analysis. Therefore the lack of analysis of future trends has been identified as a gap in previous literature.

What are barriers hindering development within waste management?

Literature highlights some general barriers hindering development of a circular economy, however we found no literature on specific barriers in waste management hindering development of circular economy. Thus, this is a further gap in previous research.

What role can Swedish municipalities take to accelerate development in waste management towards a zero waste strategy?

There is limited previous research on what municipalities can do to accelerate the development within waste management system towards a zero waste society. However, there have been several examples of different projects where municipalities have taken an active role in a successful way, which could be an inspiration for other municipalities to adopt. Nevertheless, there is limited theories' exploring specific municipal roles in waste management.

3 Setting the Scene for Swedish Waste Management

3.1 Actors within Waste Management

All actors within the waste management system need to corporate to fulfil the goals of circular economy. Three of the main actors within waste management are presented below; producers, municipalities and waste firms.

3.1.1 Producers

In parallel to circular economy and zero waste strategy being implemented in the society, the role of the producers is drastically growing within waste management. The producers' role to make recyclable and reusable products through eco-design is of great importance in a zero waste society. Eco-design involves creating a product with special consideration for the environmental impacts of the product during its entire lifecycle. Material selection plays an important role as one of the first and most binding choices of the product development. Since this is where the development is heading towards, the producers' role is of vital importance. The producer should create products with materials that are reusable and recyclable. This is arguably a new responsibility that producers must undertake for the society to achieve zero waste society (Serafini et al, 2015).

3.1.2 Municipalities

Waste management is almost always the responsibility of municipalities and is often their single largest budget item, particular in developing countries (Hoornweg & Bhada-Tata, 2012). Municipalities have a crucial role to play in the effort to reach environmental goals for the society. The sustainable development agenda has gained ground, which has led municipalities to increase waste disposal costs, stricter environmental regulations and a growing awareness of the potential profits from by-product and waste utilization (Lombardi et al, 2012). The complexity of municipal waste management decision-making has increased in recent years. This complexity reflects a socio-technical framing of the risks and social impacts associated with selecting technologies and sites for waste treatment and disposal facilities to divert waste from landfill (Garnett & Cooper, 2014). To handle waste management, municipalities need competences in procurement, contract management, labour management and on-going expertise in capital and operating budgeting and finance (Hoornweg & Bhada-Tata, 2012). The role of the municipal government is commonly to be responsible for implementing municipal waste management facilities and systems within their region. A key decision involves deciding whether the municipality itself should be involved in waste

management activities or if waste management firms should be contracted to manage waste within the region. The municipality is ultimately responsible for making sure proper waste management is conducted, measured and reported (UNEP, 2005). Municipalities can contract other actors to carry out the waste services, such as municipal enterprises, municipal associations, self-administration, joint boards, independently or jointly with other municipalities. Alternatively, some municipalities can also collaborate in joint procurements in order to achieve cost effectiveness and optimise environmental benefit. Further, from a procurement standpoint the public sector's significant purchasing power means they have the opportunity to positively influence producers to ensure that more environmentally adapted and energy effective products are commercialised. By imposing stricter environmental demands on procured services, municipalities together with other public procurers create a more sustainable development (Avfall Sverige, 2011). Milou (2010) highlight key benefits of greener procurement, besides environmental benefits. These benefits include tax revenues being used wisely, effectively and for the long-term in matters of procurements. Secondly, municipalities would lead by example and positively influence citizens and companies. Thirdly, environmental technology business would be strengthened (e.g. waste firms' ability to develop better techniques) if municipalities demanding more environmentally adapted and energy effective services.

3.1.3 Waste Firms

Two of the principles of the circular economy model are to design products that minimize waste and that generated waste should be an asset rather than a burden. The actors responsible for how the waste is treated are the waste firms, which need to adapt to the rapidly changing market conditions stemming from the implementation of circular economy. Making the transition to a circular economy will be complex, as it requires both system-level redesign and a pressing need for new skills leading to a wider behavioural change. Waste firms therefore have to innovate efficiently to be able to recycle material at higher rates than today. In sum, the growing amounts of waste contribute to the destruction of local environment, the use of finite natural resources and global warming. Subsequently, it is vital for waste firms to innovate in their processes to become more environmental friendly and recycle more (Fack, 2013).

3.2 Regulations guiding Swedish Waste Management

Regulatory frameworks for European waste management are set on EU level. Thereafter, Swedish Parliament bases the Swedish waste management structure on this framework.

Sweden has always set high goals for more environmentally friendly waste practices, where municipalities have had a significant role to play in driving this forward. Around 73% of Swedish municipalities decide to outsource waste management to external private companies, while the rest offer it as a public service (Avfall Sverige, 2013). Furthermore, there is a strong political agenda for environmentally adapted public procurement processes in Sweden. In 2010 a new directive for public procurement states that environmental and social demands are not only allowed but now should be included in public procurement processes (Avfall Sverige, Naturvårdsverket, Miljöinstitutet, 2011).

The framework "waste hierarchy" is used to measure where Sweden lies in the development of waste management and how they strive to achieve higher levels in the hierarchy towards a zero waste society. To be able to understand how waste management can develop it is important to understand what is done today, using waste hierarchy as a measurement.

3.2.1 Waste Hierarchy in Sweden

The CEO of Waste Sweden (Avfall Sverige, 2014) stated that all levels in the waste hierarchy are needed and will always be needed. Even though the current debate centres on recycling and prevention of waste, there is still large potential for developing material- and energy recycling as well as disposal. The need to replace disposal with recycling continues to be emphasised, however the issue is that the increased volume of waste in Sweden has reduced the profits from increased recycling and thus the step towards prevention is still far away (Avfall Sverige, 2014). The figures below illustrate the development of waste management in Sweden, in the waste hierarchy. It shows that incineration (waste-to-energy) was the most used treatment method in Sweden at the end of 2012 and is increasing in usage. Recycling follows a similar trend and is the second most common method, while landfilling has continuously fallen in usage due stricter regulations prohibiting landfilling (Bourasa, 2013).

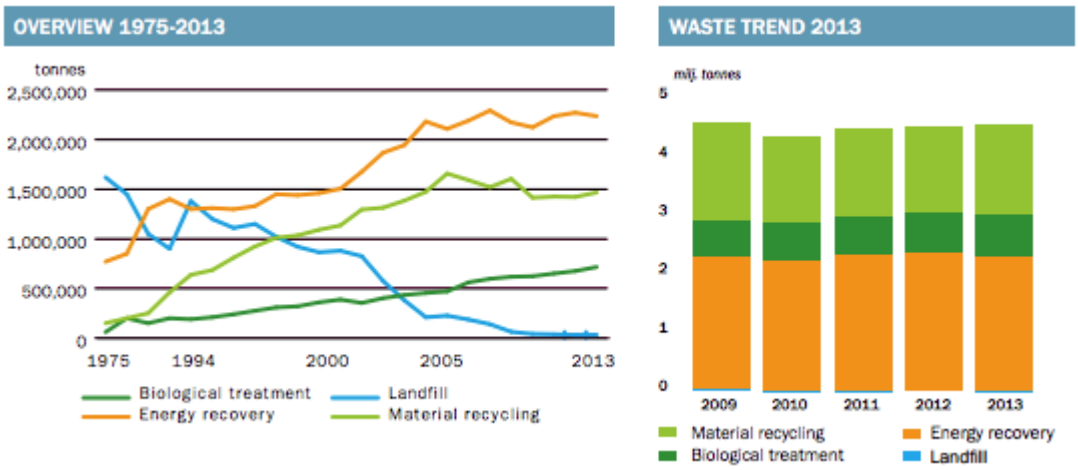


Figure 7: Comparing the use of different treatment options in Sweden (Source: Avfall Sverige, 2014)

The most favourable treatment option (highest in the waste hierarchy) is **"Prevention".** Firms have recognised the benefits of minimising waste, since they need to pay for their waste to be taken care of. Producers have a significant role to play in moving towards a circular economy since industry generates several times more waste than private households. This means that producers need to create products that can easily be recycled. EU has a long-term vision of "zero waste". Bourasa (2013) emphasises that municipalities have a key role to play as the leaders of change and of long-term sustainable waste management.

The second best option in the hierarchy is **"Re-use**" and in Sweden it is increasingly common for charity organisations to collaborate with municipalities on reuse at recycling stations. Avfall Sverige (2014) state that 43% of recycling stations receive clothes and furniture for reuse, and it is an increasing trend. Avfall Sverige (2014) also state that they hope to receive governmental funds towards re-usage organisations where funds would cover the running of the recycling stations, planning and administration.

The third highest level in the waste hierarchy is "**Recycle"** and is defined as transforming waste into a new or similar type of product. The environmental impact is significantly reduced by material recycling as well as it saves energy and utilises resources more cost effectively (Avfall Sverige, 2013).

The fourth step in the hierarchy (second to worst option) is "**extract energy through incineration"** and even though this treatment technique is highly developed to ensure that it generates minimal pollution, regulations are continuously becoming stricter regarding

incineration. The end products from incineration are heating and electricity and are often used when recycling is not possible. Incineration plants are advanced and widespread in Sweden, and this type of waste treatment is the most widely used, to a much greater extent than other countries in Europe (Eurostat, 2013, see appendix 9.2 for country comparisons). Sweden belongs to those countries that recover the most energy from incineration plants. This is largely due to advanced heating plants, so it is easy to utilise the heating generated (Eurostat, 2013).

Finally, **"landfilling"** is the last and worst step in the hierarchy and is meant for waste that cannot be treated in another step in the hierarchy. Further, there is a trend towards land-mining where materials are extracted from landfills to be recycled. However, methods for this are still underdeveloped. The majority of landfill sites in Sweden will be capped (closed) by 2030 due to new regulations introduced in 2008 (Avfall Sverige, 2014).

Today, all levels in the hierarchy are used to treat waste. However, to reach the goal of circular economy the top three levels in the hierarchy (prevention, reuse and recycling) need to be prioritised.

3.3 Swedish initiatives aimed at reusing waste

There are a number of municipal initiatives that have been taken in Sweden recently to move towards a circular economy where the higher levels in the waste hierarchy are prioritized, these are outlines below.

"Circular Waste Parks" (Kretsloppsparker)

In Alelyckan in Gothenburg a "circular waste park" has been set up with the aim of improving reusing rates from household waste. Compared to recycling stations, individuals are first met by second hand stores that accept furniture, clothes, bicycles, construction material and electronics. Thereafter the individual passes through a sorting station where they are asked if they want to donate anything to second hand stores. This waste is then sold in the stores on site. Thereafter you can drive onto the recycling station where you can dump your actual waste in containers. The park also sells recycled construction material to smaller construction firms. The park accepts 500 tons of waste per year whereof 360 tons is reused. If all the Swedish recycling stations where transformed into circular waste parks then 5% of all household waste could be prevented annually (Avfall Sverige, 2011). Such parks are organised and operated by municipalities.

An analysis of the environmental benefits of the park shows that the benefits are higher when old products are reused rather than recycled or incinerated to recover energy. Thus, the environmental benefit of recycling cannot compensate for the environmental impact from production of new products. The figure below illustrates the difference in environmental impact of (1) donating old products to the park and (2) purchase new products and give old ones to recycling/energy recovery. The figure shows that reused plastic waste minimises environmental impact significantly while recycled plastic waste contributes to increased environmental impact. Reused and recycled textiles have similar environmental impact. Plaster, which falls under construction waste, has quite an insignificant environmental impact either way but reused material minimises impact to a slightly greater extent.

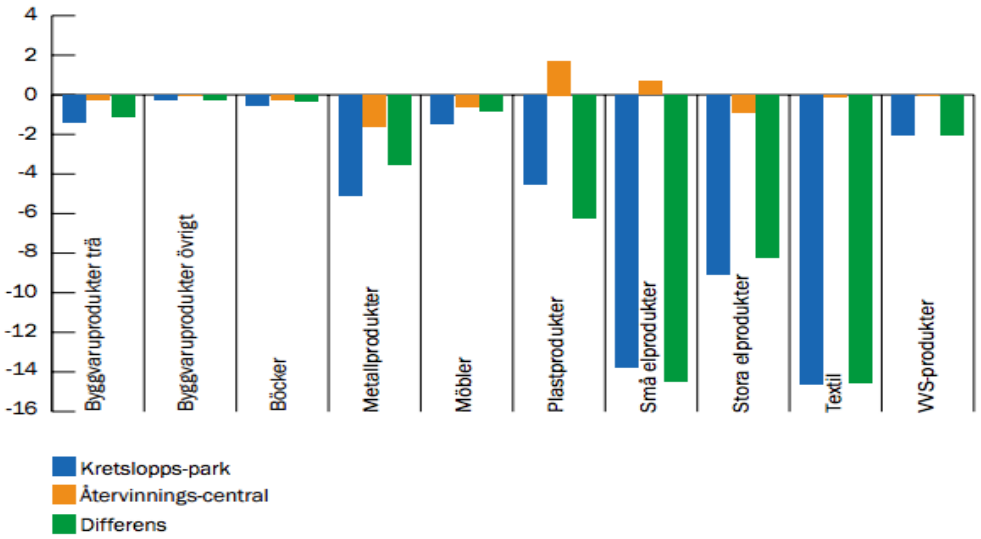


Fig 8: Potential reduction of environmental impact for a Circular park (Kretslopps-park) compared to a Recycling station (Återvinnings-central) (Source: Avfall Sverige, 2011)

Another example of a circular waste park can be seen in Eskilstuna and is called ReTuna where second hand stores and remakers (organisations making new items from old ones) are collected in a "Recycling Mall" where consumers can buy recycled products. A third example of such an initiative is in Växjö where they are developing a "Recycling Village" where similar actors can meet to sell recycled products and where actors can find new collaborations around design (Söderman et al, 2011). These are examples that show how municipalities can achieve the first three levels in the waste hierarchy; prevent, reuse and recycle.

"Clothing library" (Klädbiblioteket)

Another municipal initiative is the "clothing library" where a member pays 400 SEK every six months to borrow maximum three items for three weeks. The idea is that you renew your wardrobe without contributing to increased consumption. The items are donated from designers, City Mission and Myrorna (charity organisation). The concept is based on wider circular thinking aimed at a new form of consumption where people do not need to own things. Some items are reconstructed into new items in the "library". Volunteers work in the "library" but the rent is covered by the municipality (Avfall Sverige, 2011). Finding new solutions for minimising textile waste is highly relevant in Sweden today since textile waste has increased by 40% during the past 10 years, making waste per household amount to 15 kg of clothes and home textiles (Nordon, 2014). This is a great example on how municipalities can take initiative to move to the level of reuse in the waste hierarchy.

Car pool & housing

Car pools are becoming increasingly popular and in Malmö they have taken circular thinking to a new level. Besides from environmentally adapted building techniques, individual measuring of hot water and heating, separated organic waste management and wind power on the roof, a car pool is also included in the rent (Avfall Sverige, 2011). This is another great example on how municipalities can achieve reuse and recycle, that are two levels in the waste hierarchy to be preferred.

4 Methodology

The methodology section will account for the choice of research approach, research design and the procedure of collecting data and the reasons for conducting it in this way.

- Research strategy and design
- Research method
- Research methods for data acquisition
- Limitations of study
- Linking method with research objectives
- Reliability and validity

4.1 Research Strategy and Design

To succeed with our research objectives we carried out qualitative research through interviews with municipalities, waste firms and research organisations. By doing so, we were able to cover different aspects of the phenomenon and achieve a more comprehensive result, compared to previous research that often focuses on one actors' perspective, active within the waste management system.

A case study at the municipalities of GR was conducted as we sought to exemplify our findings in a specific context. In order to understand the concept of waste management, a thorough analysis covering different areas of the concept was needed. We have therefore carried out an analysis of the current waste management system in the Gothenburg region. Secondly, we have investigated what future trends can be seen with regards to development in the regional waste management system. Thirdly, we identify barriers hindering development within the regional waste management system. As a result of these findings we evaluate and propose four key roles municipalities can adopt to overcome barriers to ultimately contribute to the development of the regional waste management system.

4.1.1 Choice of Topic

We would like to contribute to the existing knowledge of waste management to enable the development of the system towards a zero waste society. This was accomplished by working with the municipalities in the Gothenburg region (GR), with the ambition of generalising findings to other Swedish municipalities striving to develop their waste management system. GR was chosen as our target audience/area since the region is in the middle of the process of

developing their waste management and therefore made a good fit for this research objective. This study has therefore contributed to previous research by not only analysing how the regional waste management system looks today but also evaluating key barriers hindering development, future trends and ultimately recommending strategic roles for municipalities to overcome said barriers, bearing in mind current situation and industry trends in the future.

4.1.2 Choice of Actors

Three actors within waste management are chosen for our study. These actors are municipalities, waste firms and research organisations. These perspectives were chosen to get a holistic view of the waste management system within a region. All three actors within waste management play a crucial role in influencing the waste management system and were therefore chosen for our study. Municipalities have the power over the regional procurement contracts which dictate which waste firm should carry out what waste services. Further, waste firms were chosen since they are the actors that carry out the waste services and research organisations were chosen since they investigate possible future solutions for waste management systems.

4.1.3 Choice of Waste fractions

Three waste fractions, plastic, plaster and textile, were selected for this study. We chose to investigate these three fractions to exemplify our findings and show the complexity of a waste management system. This complexity stems from fractions needing different treatments and different waste management systems. Furthermore, these fractions were chosen since they are seen as problematic fractions, with no sustainable waste management solution today.

4.2 Research Method

Due to the choice of research strategy, we applied a mix between the exploratory and the descriptive approach to the relationship between theory and research. This means that we focused on the understanding of the subject and to a certain extent on the testing of theories, by suggesting potential future roles that municipalities can undertake to accelerate the development of waste management system towards a zero waste society. This is also why we made use of grounded theory in our qualitative analysis since it allowed us to move back and forth between theory and data.

4.2.1 Qualitative Research

Qualitative research in its most basic form involves the analysis of any unstructured data, including: open-ended interviews, literature reviews, videos, social media and web pages (Bryman & Bell, 2011), which all are used in our study. To gain an understanding of the

waste management market within GR. Various municipalities, waste firms and researchers were interviewed to explore different treatment methods, barriers and future trends for our chosen fractions plastic, plaster and textile.

4.2.2 Exploratory Study

The objective of exploratory research is to gather preliminary information that will help define problems and suggest hypotheses. Exploratory research often relies on both secondary data, such as reviewing available literature and data, or primary data such as both informal and formal interviews. This can be made through a focus group, case studies or pilot studies (Shields & Rangarjan, 2013). To understand the complexity of waste management we needed to explore the waste management system of today to be able to suggest future roles for the municipalities to take on. To explore the system of waste management, GR was chosen to allow the study to focus on a limited geographical area. This in due to that GR is a network of 13 different municipalities that were willing to improve their existing waste management system and might therefore find value in the findings of this study.

4.2.3 Descriptive Study

The objective of descriptive research is to describe things, such as the market potential for a product or the demographics and attitudes of consumers who buy the product (Shields & Rangarjan, 2013). Descriptive research generally precedes exploratory research and both approaches are used for our study to explore and define new phenomena in the waste management system. For this purpose, the Swedish waste management system needed to be observed. Data was collected from the 13 different municipalities from a few selected municipal representatives, included in GR, to be able to answer the research questions. Furthermore, data was collected from the six largest waste firms and three research organisations. We also attended a seminar regarding circular economy and the role of the municipality to collect information regarding the waste management system, barriers for development in waste management and future trends.

4.3 Research Methods for Data Acquisition

Scientific research is based on collecting primary and secondary data. Both methods have been used for this study. In order to reach the research objective, the primary data involved qualitative research. A qualitative methodology was primarily used since it gave us flexibility to adjust for changes after new findings were collected (Bryman & Bell, 2011).

4.3.1 Primary Data

For this study the primary data is based on qualitative in-depth interviews and emailing with municipalities, waste firms, environmental consultancy firm and research organisations. The chosen method for interviews is semi-structured, which opens up for flexibility balanced by the structure to reach a good qualitative outcome (Gillham, 2008).

4.3.2 Secondary Data

For this study secondary data has been used mainly through literature research. The purpose is to understand the waste management industry and future options for a more sustainable society by investigating previous research. In this study the sources of secondary data are research journals, seminars, desk research and industry reports.

4.3.3 Data Collection and Sampling

To test current practice against previous research with the aim of answering our research question, we gathered primary data from municipalities, waste firms and researchers operating in the region of Gothenburg. We had face-to-face interviews with everyone as a first step. If supplementary information was needed we contacted the interviewees through email, due to time restrictions. The waste firms chosen were the six largest waste firms in the region of Gothenburg. Table 1 below presents an overview of the semi-structured interviews conducted and their settings. The interview guideline used is provided in Appendix 9.1.

Secondary data was accessed initially from the university library, primarily using information databases such as "EBSCO Business Source Premier", "GUNDA", "JSTOR", "ECON Lit" and "Google Scholar". Different keywords that were used, by themselves and in combination with each other were "Waste management", "Innovation in waste techniques", "Industrial Symbiosis", "Circular economy", "CSR", "Sustainable development", "Swedish municipal waste management", "Resource effectiveness", "Waste indicators", "Trends in waste", "Socio-economic analysis" and "Preventative waste initiatives".

No	Company	Organisation Type	Respondent Position	Type	Location	Duration	Date
1	GR	Municipality	Municipal project group for waste management	Face-to-face	Gothenburg	60 min	18-02-2015
2	Renova	Waste firm	Environment & Quality department	Face-to-face, field study	Gothenburg	3,5 hrs	14-04-2015
3	IL Recycling	Waste firm	Key account manager	Face-to-face	Gothenburg	40 min	04-03-2015

4	Stena Recycling	Waste firm	Product manager, production waste	Face-to-face	Gothenburg	40 min	02-03-2015
5	Stena Recycling	Waste firm	Product manager, plastic	Face-to-face	Gothenburg	45 min	20-02-2015
6	Suez Environment	Waste firm	Construction manager & sales manager	Face-to-face	Gothenburg	80 min	18-03-2015
7	Hans Andersson	Waste firm	Marketing manager & Operative manager	Face-to-face	Gothenburg	45 min	24-03-2015
8	Ragn-Sells	Waste firm	Plant manager	Face-to-face	Gothenburg	60 min	09-04-2015
9	SP Technical Research Institute	Research organisation	Researcher	Face-to-face	Borås	70 min	01-04-2015
10	Textilhögskolan Borås	Research organisation	Professor	Face-to-face	Borås	40 min	01-04-2015
11	CircularEconomy.se	Research organisation	Intern	Face-to-face	Gothenburg	50 min	12-04-2015
12	Hifab	Consultancy firm	Project leader industrial symbiosis	Face-to-face	Gothenburg	70 min	25-02-2015
13	Ekocentrum	Research organisation	Lecturer	Face-to-face, seminar	Gothenburg	3 hrs	21-04-2015

Table 1: Overview of the semi-structured interviews conducted

4.4 Limitations of Study

Ideally, collected data from municipalities, waste firms and research organisations would include information from all actors in the region. However, due to time restrictions there was no possibility to achieve that. Therefore we have chosen to interview the six largest waste management firms that collect waste in the investigated region today. Regarding municipalities included in GR we did not have time to meet every waste manager in the 13 municipalities. However, a group of selected waste managers from GR's 13 municipalities was put together to form a project group for this case study and these managers will represent GR. For our research we chose to leave out the producers that is an actor in the waste management system, since they differ slightly from the other actors. This is due to that municipalities, research organisations and waste firm manage pure waste while producers' role in the waste management system is to simplify the management of waste (before the product becomes a waste) by making recyclable products, so-called eco-design.

A limitation regarding data collection from interviews is that these firms may not be willing to share all facts about their treatment techniques or future innovation projects due to being afraid of sharing company secrets. Further, our market analysis is limited to three waste

fractions: plastic, plaster and textiles. This limitation has been made due to that these are the materials that our case organisation GR need to improve and there is no treatment for these materials today in the region. These materials are seen as "problematic" for GR since they lack knowledge of the fractions and acknowledge that there are opportunities to improve. Further, with regards to the trend analysis of future treatment methods, we will primarily consider how internal factors within waste management firms may influence this, however external factors such as technological or political aspects will also be considered. Such external industry factors will be identified through reports and interviews with selected researchers and firms, which means our trend analysis may not consider all trends possible, as it will be limited to the data we collect.

The hope is that our findings will be somewhat generalisable to other regions in Sweden aiming to develop waste management processes, or other countries with similar level of development. However, findings from a qualitative study are not conclusive and cannot be used to make generalisations about the population of interest (Atlas, 2015) Thus, we acknowledge that certain results will be specific to the region and not adaptable to other areas.

We are aware of that circular economy is one of many theories regarding sustainability with both pros and cons, just as every other theory. However, we have chosen to leave out the criticism regarding the concept of circular economy since that would be a study in itself. We are aware of that this is a limitation in our study. However, since EU directives state that member countries should implement circular economy we therefor have chosen to focus on *how* circular economy could be best implemented, excluding *if* it should be implemented.

4.5 Linking Method with Research Objectives

The data analysis will end up in three sections: analysis or current system, future trends within waste management and finally barriers for development. These sections will provide sufficient material to propose different roles that municipalities can undertake to accelerate the development of regional waste management. Ultimately, by providing a deeper understanding of the waste management system in the region and proposing future municipal roles, this study will provide a sound base for further municipal decision making.

Our study has three sub-questions to be able to answer the research question effectively. Our three sub-questions cover (1) the current waste management system, (2) future trends within waste management system and (3) barriers for further development within the waste

management system. Together these sub-questions help us answer the research question regarding what role the municipalities can take on to accelerate development of the regional waste management system. We want to contribute to previous research with three different perspectives on waste management system to enable a holistic view for the reader.

4.6 Reliability and Validity

Our findings with regards to current waste management system, future trends and barriers are all specific to the Gothenburg region. Thus, results do not necessarily concur with other regions or countries. However, since most of the waste firms that were interviewed are present nationally, the results could arguably be somewhat generalised to other parts of Sweden. If the same study was carried out in other regions in Sweden, there is a good chance of reaching similar findings. Further, with regards to the proposed roles for municipalities, it is uncertain if another study would reach the same recommendations since this was based on our own reasoning. However, our recommended roles are based on our findings and we have seen other municipalities taking on these roles before. Further, our study is also highly time limited, i.e. the results are only valid for a certain time period due to the changing nature of waste management systems. Therefore the reliability of our study is arguably strong if carried out in the near future.

Our findings are based on interviews with a selection of waste firms, research organisations and municipal representatives. This means that our interviewees do not represent all actors involved in the regional waste management system and thus results are limited to their point of view and knowledge. Another factor to bear in mind is that we as interviewers underwent our own learning curve during the data collection phase, which means we gained a deeper understanding of the subject as more interviews were completed. Since we conducted semi-structured interviews we had key questions to focus on but allowed the interview to develop into varying areas depending on what the interviewee felt was important to discuss. Thus, for every interview we were able to ask more qualified questions and possibly unconsciously influence the direction of the interview. This means that our latter interviews may have been more heavily influenced by our previous findings than our earlier interviews. Nevertheless, our study arguably has high degree of validity due to the study focusing on a narrow geographical scope and the extensive amount of data collected from three key perspectives (municipalities, waste firms and research organisations). After the empirical findings and analysis were completed, the parts referring to individual interviewees were sent back the interviewees to confirm the accuracy of the findings, which further strengthens the validity of

our study. This means that the study effectively measures what it is purported to measure, giving the study relatively strong validity.

In sum, the validity of the study is a bit stronger than the reliability, since the study successfully measures what it intends to measure, but is only reliable if a similar study is carried out in the Gothenburg region or other regions in Sweden, close in time to this study due to the continuously changing circumstances.

5 Empirical Findings: Interviews

Our empirical data was collected from interviews with municipalities, waste firms, a consultant firm and research organisations to enable a holistic result. This section aims to present the collected empirical data in a transparent way to enable a well-rounded analysis and discussion. The findings have been divided into three topics, which represent our three sub-questions to our research question: current waste management system, future trends and lastly barriers to development. Each sub-question is answered from different actors, i.e. from a municipal, waste firm and researcher perspective. Information from each actor is in turn divided into general, plastic, plaster and textile.

- Current situation of waste management system
- Future trends in waste management system
- Barriers for development in waste management system
- Suggestions for municipal roles
- Summary of empirical findings

5.1 Current Situation of Waste Management System

Today there are six major waste firms that dominate waste management in the region and their key activities involve all steps prior to treatment. There is a complexity within each waste fraction, which requires advanced sorting and treatment techniques. As a result waste services are often divided among actors and often include actors abroad. The three different actors perspectives on today's current waste management system are summarised below. Besides outlining the general current situation, the different waste factions have also been addressed. More detailed information on activities per waste firm can be found in appendix 9.8.

Municipality	A lack of knowledge was found regarding how the current waste management system is composed in general and with regards to plastic, plaster and textile. GR wanted to know which waste firm that could handle one, or more, of the three fractions in the most environmental friendly way. Their aim was to find a waste firm with a local treatment facility to shorten transportation of waste.
Waste firms	**General** The regional waste management system is fragmented with six major players (5 private, 1 public): Ragn-Sells, Suez Environment, Hans Andersson, IL Recycling, Stena Recycling and the public firm Renova. Only two firms manage all steps in the waste process, from collection to treatment at own facilities. However, the most common is for waste firms to manage collection, sorting and pre-treatment (crushing & baling) and thereafter either export abroad

for treatment (depending on the attractiveness of prices on the global waste trading market) or transport for treatment at a facility in another part of Sweden. The customers of the waste firms often decide the treatment technique used, i.e. a customer may choose incineration over recycling due to lower cost and then waste firms must incinerate it even though waste firms know it is not the highest level in the waste hierarchy.

Plastic

Plastic from recycling stations is a problematic material due to several different plastic fractions. Today there is no solution of sorting all these different fractions within plastic and most of it therefore goes to incineration. Plastic involves mixed fractions, poor quality, small volumes and low weight, which means that plastic waste gives low payoffs and is rather unattractive for waste firms to handle. The plastic waste at recycling stations is all plastic besides packaging, e.g larger plastic garden furniture, plastic garbage bins or pots. Plastic from recycling stations is owned by whichever waste firm the municipality has procured at that particular time.

The plastic that is recycled is the waste from curbside collection*. Plastic from curbside collection is owned by Förpackning och Tidningsförbundet (The Packaging and Newspaper Group). This plastic is often locally collected, sorted and pre-treated through crushing and baling. After a waste firm has pre-treated the plastic, it is sometimes sent to their own treatment facility for incineration/recycling but usually it is sent to Swerec, a treatment facility specialised in plastic package recycling for both industry and households, serving the whole of Sweden. If Swerec is operating at full capacity and cannot accept more plastic, the waste firms will arrange for the waste to be exported for a reasonable price to Germany or sometimes Holland or China, some of the plastic also goes to incineration.

*Curbside collection plastic is all plastic packaging from households garbage rooms, whereas recycling station plastic is all other plastic waste that private persons have to dump at recycling stations located within municipalities.

Plaster

Waste firms collect the plaster and thereafter sort and pre-treat the fraction. A small portion is directly reused and the rest is sent for treatment domestically, otherwise exported to Kalundborg, a recycling plant in Denmark or another country. If exported, it is always recycled and if treated domestically it can be recycled, incinerated or even sent to landfill in some instances. Many waste firms find it expensive to recycle plaster into new plaster. Only pure plaster waste can be transformed into new plaster for the plaster industry. However, this comes in small volumes and involves an expensive process. The market for recycled plaster is small due to Sweden's strict quality regulations. Not much recycled plaster is accepted into new production. However, pure plaster that is not accepted for secondary market and contaminated plaster, i.e. plaster with nails, paper or paint, can be purified enough to be used as fertilizers for farmers, used in the foundry industry or become part of cement production. Some waste firms interviewed have developed their own treatment technique for recycling contaminated plaster. The problem is that most private waste firms do not have the necessary annual volumes of plaster and so cannot operate these techniques. Renova has the largest public procurement contract for plaster waste in the Gothenburg region and accepts around 6000 tons annually, which means that Renova is seen as the "plaster expert" in the region. Waste firms in the Gothenburg region transport plaster to Renova, which carry out sorting of plaster, and then transport it to Ragn-Sells where it is recycled. Due to Renova gaining these volumes, this has meant that other firms

	have small volumes of plaster that are insufficient for operating a recycling process profitably. Two waste firms stated they would need 10-30,000 tonnes annually to operate their plaster recycling techniques profitably. If they received these volumes, they would be able to recycle 85-90% of plaster.
	Textile The majority of textile waste in the region is household waste (since most textile producers are now located abroad). Private households donate textile waste in containers at their households or recycling stations. This waste is then collected by waste firms, municipalities and charities (some is stolen, e.g. 800 tons/year in Sweden). The waste collected by municipalities and waste firms are sold to second hand organisations that are responsible for sorting out materials for reuse and materials for treatment domestically or export. If exported, the textile waste is usually sent to Holland or Germany where the textiles are either incinerated or broken down into fibres (mechanical recycling) and reused in other industries such as car insulation or shoe production. If treated domestically, the waste is reused or incinerated. Thus, no regional recycling treatment of textiles today. Textile waste management is a hot topic within the industry at the moment since it is a rather underdeveloped fraction and will most likely be the next fraction that private households will sort themselves. A number of smaller innovative firms such as *Re:newcell*, are starting to develop niche treatment techniques for textile waste based on techniques used in paper recycling. One of the interviewed firms are developing a recycling technique for textiles, however do not have the necessary volumes today to use it. Textile waste involves small and inconsistent flows of textile waste. This means it is hard to develop a stable partnership with producers interested in purchasing recycled textiles since it is hard to predict the supply of secondary textiles. Nevertheless, one of the waste firms have attempted to stabilise textile waste flows by collaborating closely with large textile producers.
Research organisations	During interviews with researchers we were focusing on future trends and the current situation was therefore not prioritised during the interviews.

5.1.1 Current Waste Flows for each Fraction

Plastic

The figure below was developed to illustrate the general flow of plastic waste in the Gothenburg region. The majority of plastic waste is industrial, while the minority of waste comes from households and divided into plastic from curbside collection and from recycling station. All plastic waste is collected by a range of waste firms and then sorted and pre-treated at these waste firms. A small part of this is directly reused and the rest is sent on for treatment abroad or domestically. If it is treated domestically, waste is often sent to Swerec for recycling or sometimes treated by the waste firm's own domestic recycling or incineration plants. If these options are not possible, e.g. if Swerec is operating with maximum volumes then the waste is exported, often to Germany where recycling methods are more advanced and can cater for larger volumes. China and Holland are also key countries for plastic recycling.

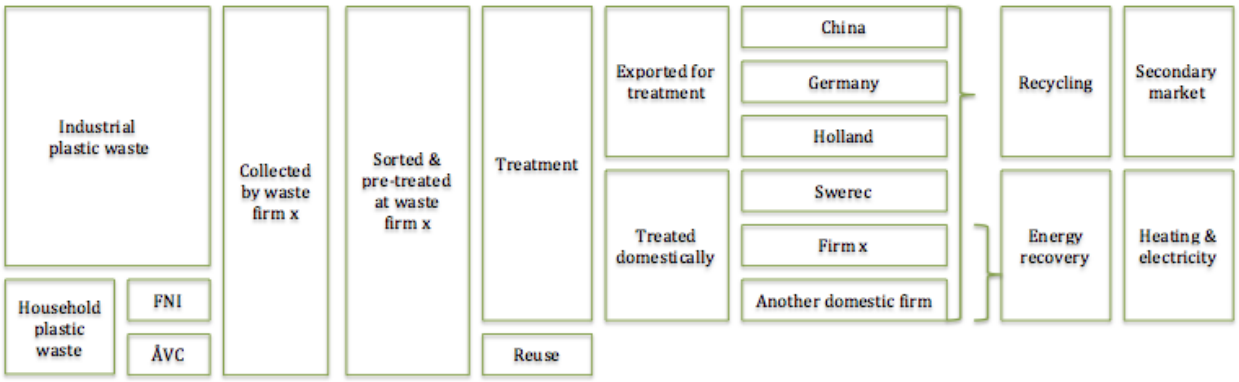


Figure 9: Process map illustrating the steps in the regional waste management system for plastic

Plaster

The majority of plaster waste is industrial, while a minority stems from households. Waste firms collect the waste and thereafter sort and pre-treat. A small portion is directly reused and the rest is sent for treatment domestically at one or two waste firms, otherwise exported to Kalundborg, a recycling plant in Denmark or another country. If exported it is always recycled and if treated domestically it can be recycled, incinerated or even sent to landfill in some instances.

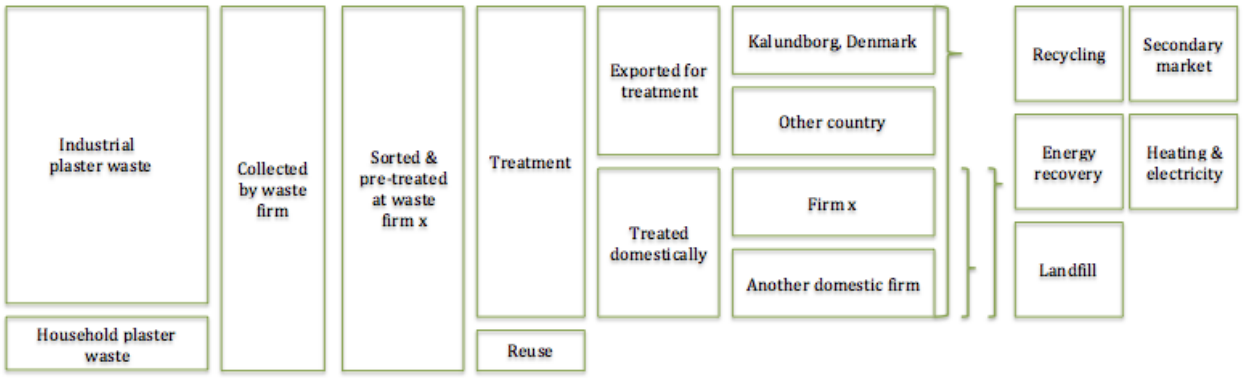


Figure 10: Process map illustrating the steps in the regional waste management system for plaster

Textile

The majority of textile waste in the region is household waste (since most textile producers are now located abroad). Private households donate textile waste in containers at their households or at recycling stations. Municipalities, waste firms or charities own these containers. This waste is then collected by waste firms, municipalities and charities (some is stolen, e.g. 800 tons/year). The waste collected by municipalities and waste firms is given to

charities that are responsible for sorting out materials for reuse and materials for treatment domestically or export. If exported, the textile waste is either recycled or reused. If treated domestically, the waste is reused or incinerated.

Figure 11: Process map illustrating the steps in the regional waste management system for textile

5.2 Future Trends in Waste Management System

Opinions regarding future trends within waste management system are many. We found several different future trends during our interviews. The three different perspectives (municipalities, waste firms and research organisations) of different future trends are explained in the table below. The table explains both general future trends and thereafter future trends within the three specific fractions that are investigated in our study. More detailed information from our trend findings can be found in appendix 9.3 and 9.4.

Future trends	
Municipality	A lack of knowledge was found regarding trends in general waste management systems and trends in the three fractions plastic, plaster and textile. However, GR wanted to find a waste firm that wanted to invest in a local treatment facility since treating waste locally is to be prioritised since it will decrease the environmental impact of transportation, according to GR.
Waste firms	**General** There are several different findings for future trends. Most important is that waste firms start to have closer collaborations with producers, which is needed to enable standardisation of fractions and develop eco-designs. This will simplify for waste firms to recycle the products when they are disposed of as waste. All waste firms believe that circular economy thinking will increase and that we will hopefully see an increase in industrial symbiosis projects in the region. Another finding is increased digitalisation. This means that treatment processes becoming more developed and automated and customers can also use apps and online personalised platforms to gain access to information about the best sorting techniques, track their own progress and easier place orders for pick up. Of the waste firms that we interviewed there was only one that had implemented these kinds of digitalisations. However, the other

	waste firms are closely behind. Procurement contracts are predicted to become more innovative. As an example, Renova's procurement contract gave extra points to firms that had higher recycling rates (making incineration less attractive for the waste industry). Some of the waste firms believe that the secondary market for recycled goods will grow in the future and thus waste will require specialised treatment methods to ensure quality of secondary material. This means that wide generalist waste firms will need to give up treatment responsibilities to smaller innovative firms that specialise in treatments for niche fractions, in order to provide quality. It was therefore suggested that opportunities for today's generalist waste firms in developing the industry lies in effectivising transportation and service. The greatest environmental benefits will come from synergies and cost effective solutions within logistical services in the future. One of the waste firms extends so far as by saying that they think waste firms in the future will only have a logistics role and that the industry itself will own the products and therefore also recycle the products since more products will be leased in the future.
	Plastic Plastic is a highly complex fraction with no perfect treatment method for plastic from recycling station at the moment. The waste firms believe that the treatment and sorting techniques will improve in the future for plastic from recycling stations and then generate a higher profit. This means more waste firms may want to recycle plastic waste and develop treatment methods for this.
	Plaster Few of the interviewed firms recycled plaster. The reason being that Renova has a contract for plaster in the region and other firms cannot compete. However, one of the waste firms explained that techniques for recycling plaster are improving and there is a great secondary market for recycled plaster, which can both be used as fertilisers, in cement or as new plasterboards. Two waste firms expressed that they had a technique for separating plaster from paper, which would enable recycling of plaster at a higher level in the waste hierarchy than is done today. However they did not treat plaster today due to lack of volumes.
	Textile Waste firms have recently started to investigate different treatment methods for textile as an alternative to incineration. One of the waste firms has their own innovation team aiming to find their own treatment method for future textile recycling. Everyone is sure that textile is the next material to be recycled in the future. One firm believes that there will be a great global textile waste market with producers interested in using recycled material, however Sweden is lagging behind. Further, interviewed firms do not believe that large generalist waste firms will be qualified enough to treat textiles. Instead it should be treated by specialised innovative firms such as for example Re:Newsell in Trollhättan where textiles are recycled based on the same process as paper recycling. Wider waste firms will focus on the collection stage only. One interviewee predicted that municipalities may manage sorting of textile waste in the future to help decrease costs for waste firms and therefore simplify the development of treatment methods for textile.
Research organisations	**General** There is a trend in municipalities taking an active role in EU projects aimed at developing waste management system towards a zero waste strategy. Further, a seminar in circular economy explained that EU believes that for the future efforts need to be focused on changing the way products are designed at the producer

	level, rather than regulations for higher recycling rates. A new concept linked to this is upcycling which means that if possible a used product that cannot be reused for the same purpose should be reconstructed into another product of equal or higher quality (as opposed to recycling which creates a new product of lesser quality than the original one). An example is textiles from old bus seats being transformed into shoes. Thus, the idea is that products should be upcycled if possible, otherwise recycled. This is also something that researchers has a strong believe in that we will see more of in the future (see appendix 10.6 for future flow of products model)
	Plastic At the moment there is research about plastic within mechanical recycling, chemical recycling and composting but further research has to be done before techniques can be used (see appendix 9.7). Research within possible treatment methods for the fraction are spread out, difficult to determine which method that will be the "winning one" in the future. Our interviewees believe we will see a future of standardization of plastic fractions that will happen on a global scale.
	Plaster The researchers we interviewed did not have knowledge regarding trends in plaster waste.
	Textile One of the researchers that were interviewed explained that textile fibres can be broken down using similar procedures as plastic but this is an expensive process. There are researchers trying to generate energy from fibres from textile at the moment. The problem is when its time to recycle textile they have been washed a few times and the fibres have become smaller and it is always the length of the fibres that give the materials their quality.

5.3 Barriers for Development in Waste Management System

We found several different barriers hindering development of waste management system, towards a zero waste strategy with treatment methods at a higher level in the waste hierarchy. The three different perspectives (municipalities, waste firms and research organisations) of different barriers are explained in the table below. Besides explaining general barriers, we also include barriers to the development of treatment methods for the three specific waste fractions that have been investigated for our study. More detailed information on barrier findings are summarised in appendix 9.5.

Barriers	
Municipality	A barrier for the Gothenburg Region is the lack of knowledge regarding how the waste management system is composed today.
Waste firms	**General** Sweden has low incineration costs, which hinders development of more environmentally friendly treatment methods (with higher cost) to be prioritized in the waste management system. Consequences are that incineration is a treatment method that is common in Sweden, even if it is the second worst treatment method in the waste hierarchy. Further findings include changing market conditions and innovations in new fractions,

	which constitute a great barrier due to that a treatment method is quickly made redundant in favour of new components in waste fractions that need new treatment methods. Some of the waste firms found the procurement contracts to be a barrier due to that the waste firms with lowest price often gets prioritised, and not the treatment method with a higher level in the waste hierarchy. Treatment methods that are in the higher levels in the waste hierarchy have a higher cost, thus it is difficult to say who should carry the burden of paying more environmental friendly treatment methods, tax payers/firms//producers/municipalities? Further, low volume is one of the greatest barriers for generalist waste firms. Sweden is a small country and to set up a national treatment plant for one specific fraction demands volumes, which is difficult to receive only from Sweden. Most of the waste firms explained that if they are going to develop a treatment facility locally they need Sweden's volume and might even have to collect volume from neighbouring countries. It therefor might be a better option to export waste to countries that have better treatment methods since its been shown that the impact from transport impact does not have a major impact of environment. Another barrier found is the multitude of waste fractions that all need different treatment methods. This means that fractions with great volumes, which are more profitable for waste firms due to economies of scale, are prioritized and other fractions are treated with options lower down in the waste hierarchy.
	Plastic Plastic from recycling stations (such as furniture, sledges and pots) need to be sorted manually due to multitude of different compositions of plastic since they cannot be treated in the same way. This makes this fraction very costly and is therefore hard for waste firms to profit from. Today there are too many fractions that are continuously changing which make the treatment method quickly irrelevant and no one wants to invest in a treatment facility. The technique needs to catch up to the increasing demand for the recycling of it. Due to all these barriers, waste firms do not have incentive to treat the plastic from recycling stations since there is no profit in it.
	Plaster Volume is a great barrier for plaster to be treated at a higher level in the waste hierarchy. This is due to that it is not profitable without economies of scale. For some waste firms, the competitive market was a barrier since other waste firms already established specialisation within this fraction and they did not want to compete with them.
	Textile The greatest barrier to develop waste management within textile is that waste firms do not want to compete with charity and there is no solution today for how to overcome that problem. Further, there is no perfect treatment method for recycling textile today due to several compositions of the material and therefore it is a fraction that is hard to recycle. A further finding is that most fractions have their own specialisation department at a waste firm. However, textile has traditionally not been prioritised and has been included in the department for "miscellaneous waste" at waste firms, which hinders the development of treatment methods for this specific fraction since it is not prioritised as a focus area.
Research organisations	**General** The perspective of researchers is that there is no incentive for small firms or private individuals to sort waste due to a higher cost and it being time consuming. The habits of individuals are therefore a great barrier. Further, researchers emphasise that waste firms always prioritise profits, which hinders innovation in a treatment method with a higher level in the waste hierarchy since they are more expensive than other treatment methods

	lower in the waste hierarchy. Lack of knowledge regarding waste management system was also seen as a great barrier according to the researchers, not only for actors within waste management but also for customers. Once firms understand the goal of a circular economy, they will realise it can lead to new business opportunities and cost savings and then allow waste firms to use better techniques.

5.4 Suggestions for Municipal Roles

During our interviews, it was known to us that waste firms and research organisations had several suggestions regarding how municipalities can act to accelerate development of waste management system and lead the change towards treatment methods higher up in the waste hierarchy to achieve a zero waste society. Municipalities have an important role in the waste management system and could for example rearrange the procurement contract to enable waste firms to treat waste at a higher level in the waste hierarchy. Other suggested actions that municipalities can take to accelerate the development within waste management system are suggested in the table below.

Waste Firms	One of the waste firms specifically mentioned that they saw great potential for development within waste management system if municipalities collaborated more with waste firms. The collaboration would mean communication between these actors to together find the best sorting method for the future. This collaboration is of great importance since the waste firms suggest that municipalities will be the ones who are responsible of sorting waste to decrease costs for waste firms. Then waste firms can focus on more environmentally friendly treatment methods with a higher level in the waste hierarchy. The future trend is that more waste will be recycled and reused than today, and be sold to the secondary market. Some waste firms are certain that municipalities can speed up this process by offering more innovative procurement contracts for waste services to encourage experimentation of new techniques. Otherwise the role of municipalities will lie in coordinating circular economies/industry parks aimed at waste prevention. Waste firms also state that due the political influence municipalities can have, municipalities could contribute to regulations making incineration a less profitable option. The focus for municipalities should therefore not lie in optimising the waste management system but rather on coordinating circular economies aimed at waste prevention. One example of this is a project in Borås Stad, which aims to map the waste market to ultimately develop ideas for more circular economies. For this project the local municipality are responsible for driving this project and collect information regarding current situation of waste volumes in the region.
Research Organisations	A seminar (Miljö Online) with researchers within Circular Economy stated that in the future municipalities must take on the role as a market maker (meaning that they provide facilities and infrastructure solutions enabling symbiosis collaborations), a match maker (coordinating clusters) and a co-creator (acting as incubator for ideas and financer). During the seminar we were introduced to the project in the municipality of Sotenäs, where they engage in an industrial symbiosis project. The symbiotic network in Sotenäs is

that fish guts become biogas and raw material for algae and salmon production (see appendix 9.6 for circular flow thinking behind the Sotenäs project). In the case of Sotenäs municipality, the network gave rise to new business opportunities in form of new jobs and growing tourism activities due to the inflow of new inhabitants. This project shows that industrial symbiosis is possible in practice. Here the municipal taken a role as a co-ordinator, recruiter, communicator and financer (searching for scholarship). Furthermore, the municipality of Sotenäs simplified for the actors involved in the symbiosis to receive a building permit on municipal land. These are further examples of actions that municipalities can take to accelerate development towards a zero waste strategy within their region.

5.5 Summary of Empirical Findings

Current situation

There are six major waste firms that primarily carry out collection, sorting and pre-treatment in the region. The waste is then either exported abroad or treated at another facility in another part of Sweden. Plastic waste in the region comes in small volumes, poor quality and thus low weight, which generates low payoffs. Curbside plastic waste is often collected by whichever waste firm the municipality has procured and then sent to Swerec, Renova or abroad for recycling. Plastic waste from recycling stations is mostly incinerated. Further, pure plaster is recycled into new plaster, whereas contaminated plaster is recycled for use in other secondary markets. Finally, textile waste is collected by municipalities and waste firms, then sold to charities which sort out reusable textiles and export the rest for incineration. A summary of our findings from current situation is found below.

General

- ✓ 6 major waste firms
- ✓ Regional waste firm focused on collection, sorting and pre-treatment
- ✓ Treatment occurs at facilities in other parts of Sweden or exported abroad

Plastic

- ✓ Small volumes, low weight
- ✓ Poor quality
- ✓ Low payoff for waste firms
- ✓ Plastic from recycling stations mostly incinerated within Sweden

Plaster

- ✓ Pure plaster waste recycled into new plaster
- ✓ Contaminated plaster is recycled for other secondary markets: fertilising, foundry, farming, and cement.
- ✓ Non recyclable plaster is sent to landfill

Textile

- ✓ Collected by municipalities and waste firms
- ✓ Sold to charities which sort out reusable textiles and export rest for recycling or sent to domestic incineration

Future trends

Closer collaborations are developing between producers and waste firms regarding eco-designs and standardisation of fractions. Circular economy thinking is spreading and can be seen in increasing business models for leasing and development of regional industrial symbiosis projects. Public procurement contracts are also expected to become more innovative to allow for experimentation of environmental solutions. Secondary markets for recycled materials are also growing due to stricter regulations for producers to use recycled materials in production. This puts pressure on treatment techniques to provide higher quality recycled materials, which is developing niche treatment firms. This means that wider generalist waste firms are expected to increasingly divest their treatment sectors to focus on logistical solutions in the future. A summary of our findings from future trends is seen below.

General

- ✓ Standardisation of fractions
- ✓ Eco-design
- ✓ Stricter recycling EU directives
- ✓ Increased Industrial symbiosis projects
- ✓ Circular economy thinking
- ✓ Business models for leasing
- ✓ Service focus
- ✓ Niched waste firms developing
- ✓ Upcycling
- ✓ Generalist waste firms more logistical focus
- ✓ Growing global waste trading market
- ✓ Municipalities more active roles

Plastic

- ✓ Standardisation of fractions
- ✓ Automated treatment techniques

Plaster

- ✓ Recycling techniques improving
- ✓ Growing secondary market

Textile

- ✓ Increased collaborations with charities
- ✓ Experimentation with treatment techniques
- ✓ Becoming hot topic for global waste trading market
- ✓ Growing secondary market
- ✓ More waste firms active in collection
- ✓ Niched firms taking over treatment
- ✓ Growing producer involvement

Barriers

Municipalities want to contribute to improving regional waste management systems, however a barrier for the Gothenburg region is the lack of knowledge regarding how the system is structured today. Without an understanding of how waste streams flow, key actors, dominant treatment methods or trends it is difficult for municipalities to identify what role they can take to best contribute to developing waste management systems. Thus, the lack of knowledge from the municipal perspective was found to be a key barrier. We have seen that waste firms

and research organisations mention several different barriers hindering the development of waste management system, which are outlined below.

General

- ✓ Lack of Knowledge
- ✓ New components in waste fraction
- ✓ Low incineration fees
- ✓ Procurements prioritise cost
- ✓ Transparency
- ✓ Small volumes
- ✓ Multitude of waste fractions
- ✓ Actors within waste management prioritize profit
- ✓ Habits
- ✓ Issue of who should bear financial responsibility

Plastic

- ✓ High sorting and treatment cost
- ✓ Poor quality of recycled plastic

Plaster

- ✓ High sorting and treatment cost
- ✓ Low volume
- ✓ Competitive market

Textile

- ✓ Do not want to compete with charity
- ✓ Hard to predict volumes
- ✓ Complex and expensive to treat

Municipal Role

Municipalities are important actors in the waste management system. During our interviews and empirical findings we have seen many examples of roles that municipalities can take on to accelerate the development of waste management system towards a zero waste society. Through our interviews we also found new suggestions of general actions (not specifically actions for the three fractions) that municipalities can carry out to further enable development in regional waste management. These actions are outlined below.

General

- ✓ Collaborate with waste firms
- ✓ Take responsibility for improving communication between actors
- ✓ Responsibility for sorting waste
- ✓ Offer more innovative procurement contracts
- ✓ Coordinate circular economy projects, e.g. industrial symbiosis
- ✓ Make incineration treatment less profitable
- ✓ Market Maker (provide facilities and infrastructure for symbiosis projects)
- ✓ Match maker (create opportunities for regional actors to meet

6 Analysis

This section will analyse our research question based on our results regarding: the current situation, future trends, barriers hindering development of the waste management system and suggestions for municipal role. Our empirical data is based on three actors' perspectives (municipalities, waste firms and researchers) that will emerge into an analysis of possible roles for municipalities to take to accelerate development of waste management system towards a zero waste society.

- Role of Swedish municipalities
  - Co-ordinator
  - Pioneer
  - Legislator
  - Financer
  - Summary of roles
- Recommendations to GR

6.1 Role of Swedish Municipalities

Our results highlight a number of barriers and trends influencing the current waste management system in the region. It became clear that municipalities can contribute to help overcome some of these barriers and contribute to some of the positive trends identified. The figures below illustrate where municipalities can influence the development in the context of all future trends identified.

The future trends within waste treatment are outlined below in chronological order. The box with bold outline is where municipalities have a chance to influence the development. We were able to create this figure when assembling the information from both previous research and our own findings. The future trends that were found exemplify future initiatives for how the municipality can engage to accelerate the development of a zero waste society. Our findings show that their main responsibility should be in making public procurement contracts more innovative, i.e. not only focusing on costs. Hence, the figure below sets the role of municipalities in context of future trends within waste treatment.

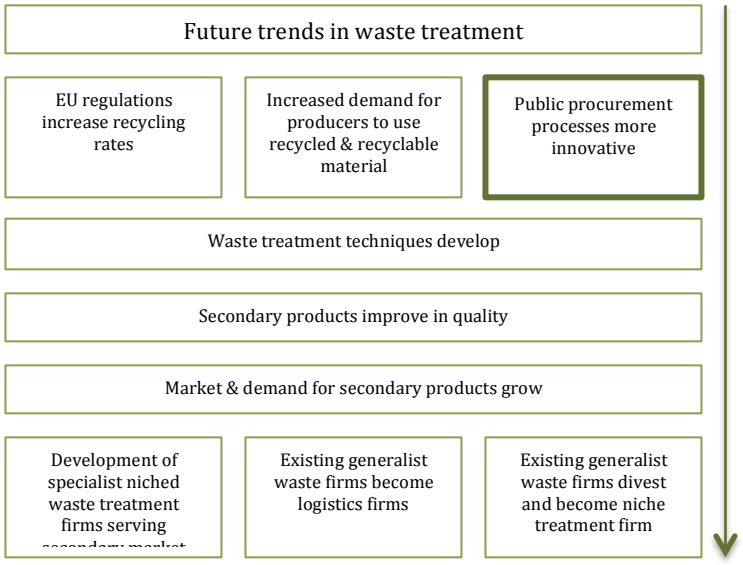


Figure 12: Future trends in waste treatment techniques (bold = potential municipal role)

The next figure outlines the trends towards waste prevention (towards zero waste) and the darker boxes highlight where municipalities can influence the development of future trends. Similar to the figure above, we were able to create this figure when assembling our findings.

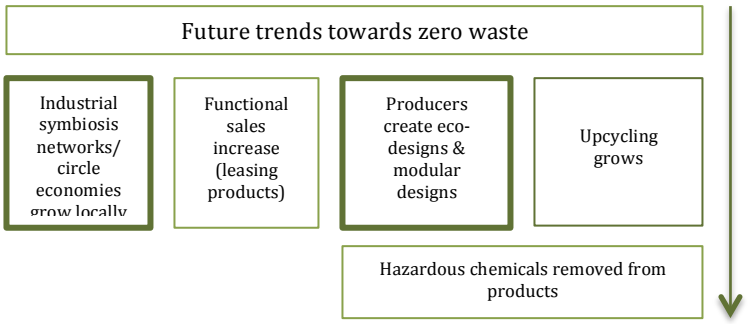


Figure 13: Future trends in waste prevention (bold = potential municipal role)

Based on our findings we were able to collect information regarding different ways municipalities are engaging in circular economy projects. We were also able to collect information, mainly from waste firms, on how they believe municipalities can contribute to overcome current barriers for development within waste management system towards a zero waste society. The interviews and previous literature gave several examples of what some municipalities have already done and suggestions of other activities that can be performed by the municipalities. This information led to four key roles that we believe municipalities should take to accelerate the development within waste management system, which is aligned with Lombardi et al (2012) stating that municipalities have a crucial role to play in the effort

to reach environmental goals. Each role is supported by our findings from current situation, future trends and barriers, as well as previous literature. We believe that the key roles for municipalities to undertake to accelerate the development of the waste management system are Co-ordinator, Pioneer, Legislator and Financer. These roles will now be discussed.

6.1.1 Co-ordinator

Both previous research and our own findings show that integration between different actors within waste management has to increase to achieve the goal of circular economy. We therefor propose the role as a co-ordinator for the municipal to undertake which is supported from previous examples of activities municipalities successfully engaged in.

In the literature we highlighted a number of examples of how municipal initiatives as a coordinating role have recently increased in Sweden to move towards a circular economy where the higher levels in the waste hierarchy are prioritised. Our findings from interviews show that municipalities are engaging more actively in projects for circular economy, such as the symbiosis project in Sotenäs (Miljö Online, 2015). Moreover, the MacArthur Foundation (2014) state that circular economy thinking can be applied on a global scale but can only be achieved if legislations, product designs and industrial symbiosis occurs between local actors. Our results show that there are small signs of local actors in Swedish municipalities collaborating with regards to these specific areas. Through our findings we see a positive development of municipalities being more engaged in these kinds of projects where they have taken a co-ordinator role.

Our findings show that a barrier is “lack of communication” and this is aligned with previous research stating that there is a lack of communication between industry actors and policy makers which leads to different actors not knowing how to help each other to achieve a better waste management system (Nicholls, 2014). Our own findings show clearly that actors have different perspectives on how waste management should be composed. By interviewing actors from academia, waste firms, management consultant firm and municipalities, it became clear that there is a lack of communication between these actors and everyone has different ideas. The different actors do not speak the same language, which makes the development slower since the different knowledge needed does not exist in the same place. The fact that knowledge is spread out between actors was highlighted by Nicholls (2014) as a key barrier to circular economy development, which our results prove to be the case in the region. This has led to a lack of holistic view of waste management and therefore it is of great importance that

producers and waste firms collaborate with municipalities to push the development in the right direction. This is aligned with the theory of Morrissey and Brown (2004) that argue that waste practices can only be improved by formulating the right problem, which they state might not be the treatment technique but rather the lack of integration of actors in the waste system.

Furthermore, as we have seen in previous research, one of the greatest barriers to developing waste management towards zero waste management, where reuse and recycle is prioritised, is changing the attitudes and behaviours of the mass consumers (Nicholls, 2014). It is difficult to shift old habits. As we can see both from our findings and previous research, it is not only the industry that needs to change habits to adapt to circular economy but also the habits amongst customers have to change in that they need to get used to renting and leasing products rather than owning them. Taking a co-ordinating role where being responsible for communication within the cluster will influence both on an organisational and individual level to change habits towards circular thinking.

There are several actions for municipal to execute by taking the role as a co-ordinator. For instance, municipalities can organise face-to-face meetings where different actors meet for discussions. At the circular economy seminar there were representatives from academia, industry and municipalities. Everyone appreciated that different actors were meeting to discuss the issue of implementing circular economy and everyone agreed that more face-to-face meetings like this are necessary. We believe that the frustration found among waste firms, might be reduced if municipalities organise these types of meetings between the actors, which might help accelerate the development towards a circular waste management system. This is aligned with the suggestion from Miljö Online (2015), that municipalities should be a matchmaker, managing organisation of clusters for actors to meet for discussions.

A further action for municipalities could be involvement in industrial symbiosis projects. Miljö Online (2015) suggests that municipalities should act as a ”market maker”, meaning that they provide facilities and infrastructure solutions enabling symbiosis collaborations. Examples from this have already been seen in the industrial symbiosis project in Kalundborg and the one in Sotenäs municipality.

Ultimately our findings show that municipalities can overcome barriers of lack of knowledge, habits, transparency and lack of communication by taking on the role as a co-ordinator to

accelerate the development of waste management. Municipalities will then keep pace with future trends and current situation of projects identified. The basis for recommending this type of municipal role is not only found in our own findings regarding previous action taken by some municipalities but also previous research, as for example from Garnett & Cooper (2014) that explain that higher levels of involvement from municipalities is needed to encourage social interaction between actors to solve waste issues, especially if there is mistrust between the actors.

→ **Challenges for municipality taking communicator/coordinator role:** The difficulty with this role would be for the municipalities to make actors within waste management system value attending these kinds of meetings and understand the need for change. Further challenge could be that municipality need to invest in resources (i.e. employees) that are continuously updating and informing other actors regarding new activities and research within waste management systems.

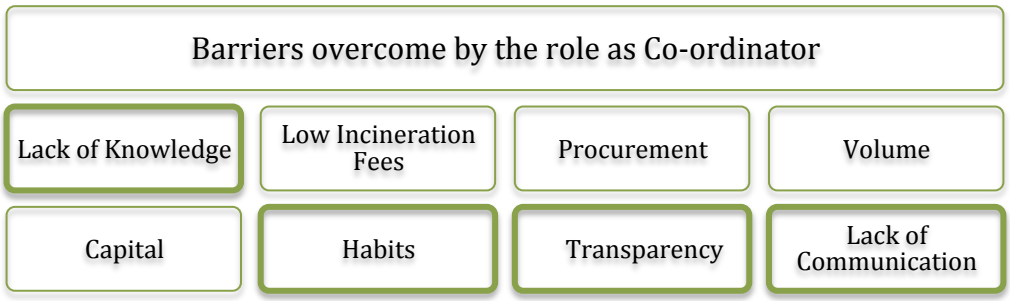


Figure 14: Barriers overcome by the Co-ordinator role

6.1.2 Pioneer

Through our findings and previous research we understood that most theories are only theories and have never been tried out in practice. Due to this, it is important for the municipality, being an authority, to become a pioneer and lead the way. There are several different actions that the municipality can take to overcome barriers and we have already seen great examples from municipalities.

Our findings from interviews with research organisations strengthen the argument that the way to move towards "zero waste" is to collect multiple actors in close proximity to close the loop and create a symbiotic network where no waste leaves the system. The symbiotic network in Sotenäs municipality, where fish guts became both biogas and raw material for salmon production, showed that industrial symbiosis is possible in practice. This is aligned

with the theory of Jelinski et al (1992) and Graedel & Allenby (1995) stating that ecological systems are cyclic and that waste and energy is cascading. Further, interestingly Morrisey and Brown (2004) explained that there was no current model for how to include all stakeholders (government, authorities, experts, community) and that future research must focus on stakeholder involvement. In the case of Sotenäs municipality, the network gave rise to new business opportunities in form of new jobs and growing tourism activities due to the inflow of new inhabitants. This fits with the theory of Jansson et al (2014) that argued that symbiosis could stimulate innovation and increase business benefits both locally and regionally. Further, Lombardi et al (2012) argued that industrial symbiosis could be a strategic tool for circular economy development and resource efficiency. This trend is an interesting find since it is aligned with circular flow thinking and highlights a key municipal role for the future, i.e. pioneering these types of projects by taking a lead in co-ordinating actors and activities.

Further, through our findings of future trends within circular economy we explained that wide generalist waste firms might need to give up treatment responsibilities to smaller innovative firms that specialise in treatments for niche fractions. This would mean that existing generalist waste firms would become more focused on distribution solutions. This trend suggests that municipalities must not be afraid of include new and smaller specialist treatment firms for the most environmental solutions to specific fractions.

Researchers highlighted that there are increasing business models for leasing, i.e. a producer owns the product and leases it to a customer while the producer has the responsibility to recycle the product after use. The trend towards business models based on leasing of products was primarily highlighted in the interviews with researchers. This trend could provide municipalities with an incentive to lead-by-example by leasing all products municipalities utilise and spreading awareness of leasing businesses in the region. If the municipalities can be the pioneer in changing habits, they could encourage other actors to the same. We believe this is of great importance since the municipalities are the ones who set up directives for every actor within a municipality. It would be misleading if they were not acting in the same way as they want others to act. This can be done if municipalities start to lease rather than buy their products to a greater extent than what is done today. This is aligned with our future trend findings highlighting that customers will increasingly lease products instead of owning them. Potential actions the municipal can take are leasing clothes for employees, leasing furniture to their facilities, among other suggestions. Another possible suggestion could be to try out a

pilot project of having a “circular school”. A school with a zero waste strategy. These zero waste strategy will be able to change habits of people at young age, in an effort towards a circular economy.

Based on our findings, we strongly suggest that municipalities should take on a role as a pioneer. By doing so they might be able to influence people’s habits and at the same time broaden the knowledge and communication within waste management, thereby contribute to the movement towards a zero waste society.

→ **Challenges for municipalities taking the pioneer role:** The difficulty in taking the role as a pioneer is to get people to engage in these kinds of projects, considering that many ideas remain in theory compared to practice. Changing peoples’ habits is not easy and it needs to evolve during long-term which can be frustrating. For example, difficulties in setting up a circular school is of course getting the school board and other school authorities to accept the idea and collectively develop an action plan to source products and materials from second hand organisations and collaborate with producers to only purchase recyclable products.

Since municipalities have little influence over waste treatment techniques or where waste is transported (their power is limited to the flexibility in their procurement contracts), we believe it is evident that municipalities should focus on activities where they can make a difference. The challenge of this role is that it requires significant planning and administration, which may require staff, assigned to developing new concepts contributing to circular flow thinking.

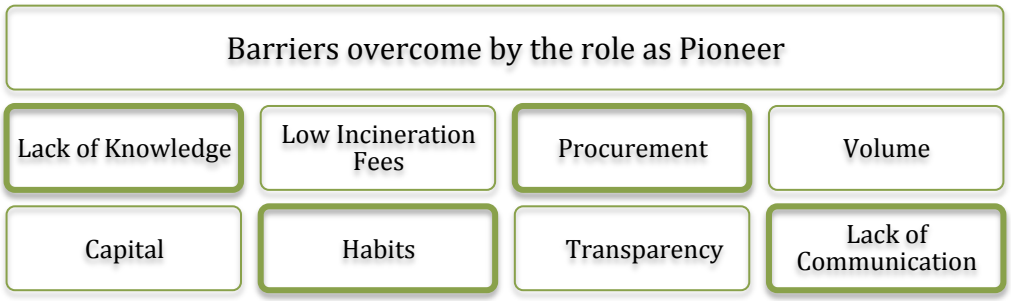


Figure 15: Barriers overcome by the Pioneer role

6.1.3 Legislator

Our analysis has highlighted that a key barrier to improving the regional waste management system is that municipalities only procure waste services from the waste firm offering the lowest price. The interviewed waste firms explain that a consequence of this is that it hinders waste firms from developing their treatment techniques since that would require investments and lead to more expensive solutions for the municipality. Thus, this barrier highlights the crucial role of procurement contracts with regards to the development of local waste management systems. However, we also found that a trend linked with this barrier is the introduction of innovative procurement contracts in Sweden. These contracts allow waste firms to propose new solutions for waste management and gain points for treatments with a higher level in the waste hierarchy. Both waste firms and researchers emphasised the importance of municipalities changing their procurement contracts in favour of innovative solutions.

This suggestion is strengthened by the study by Milou (2010), that highlighted that greener public procurements mean that municipalities can significantly influence citizens and firms positively, environmental technology business grows and tax revenues are more effectively and sustainably allocated. The basis for recommending this role is further strengthened by the study by Troschinetz and Mihelcic (2009) explaining that the lack of governmental policies, incentives and implementation is a key barrier to improving recycling. Further, it was highlighted by Bulkeley and Gregson (2009) that a barrier to development could be mistrust between public and authorities, where the public suspects that authorities make decisions that only benefit themselves. Our results somewhat strengthen Bulkeley and Gregson's statement since we found that regional waste firms feel that municipalities' procurement contracts only benefit the municipal budget but not the environment or the profitability of waste firms. Thus, one aspect of the legislator role could involve municipalities speeding up development by offering more innovative procurement contracts, which would provide incentives for firms to develop treatment methods, with a higher level in the waste hierarchy, even if they are more costly.

Moreover, a barrier highlighted by waste firms is the low incineration fees in Sweden which mean that firms are more inclined to allocate waste to the incineration container rather than sorting and then putting into the recycling container. The literature showed that the most widely used treatment method in Sweden at the end of 2012 was incineration, whereas

recycling came in second place (Bourasa, 2013). The reason for this is the large number of heating plants in Sweden requiring energy recovered from waste. GR aims to find environmentally friendly waste management solutions in the region. However, we found that GR are actually counter productive in this regard by owning incineration plants which is great barrier hindering the development of other treatment methods. Thus, another aspect of the legislator role could involve municipalities somehow increasing prices or lobbying for added tax on incineration. This could shift more waste towards recycling. Naturally, the issue with that will be that abundant number of heating plants in Sweden may not have sufficient fuel to operate but a solution might have to be importing of waste, as already is done today, for the heating plants or close down some (some plants are not even operating at full capacity and require imported waste to operate efficiently).

A related trend identified, explained by research organisations, is that more industries are required to have certain rates of recyclable materials and thus their demand for sourcing secondary materials increases. This is arguably aligned with theories of circular economy and Braungart's theory (2013) suggesting that the only sustainable way waste can develop is if we take after nature's approach and their natural cycles. This trend is positive from an environmental standpoint and thus another aspect of the legislator role could involve municipalities contributing to this trend by imposing stricter recycling rates for producers in the region, or at least lobby for stricter regulations on a national level.

Based on these findings, we firstly propose that municipalities must focus on influencing the nature of procurement contracts and carry out a new procurement process. Secondly, they should influence incineration fees. Thirdly, we propose that municipalities should hop on the trend towards standardising fractions and designs by imposing stricter demand on producers in the region to develop products that are recycle friendly. In essence, municipalities should take on a more legislative role to ultimately contribute to an improved waste management system.

→ Challenges for municipalities taking the legislator role:

The legislator role involves municipalities influencing the standardisation of product designs. Even though regulations regarding standardisations and recycling rates are often set on EU level, each municipality can contribute by for instance ensuring that such EU regulations are imposed in their region.

With regards to innovative contracts, this is something that is regulated by the public procurement laws (LOU), however municipalities have significant potential power to influence the structure of such contracts. Even though there may be risks of changing the contracts to favour more environmental solutions, it is a change that needs to happen since it such a significant barrier for waste firms. The problem is of course the difficulty of finding financing to cover higher costs. If municipalities are not able to reallocate funds sufficiently, perhaps the contracts do not need to focus on more expensive solutions but rather providing more firms with a smaller volume each to allow for them to experiment with techniques and possibly find a cost effective solution for the future. Alternatively funding could be sourced from state subsidies or EU projects.

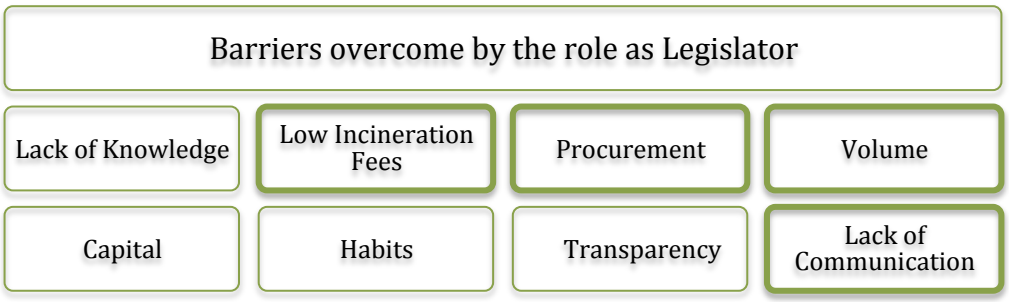


Figure 16: Barriers overcome by the Legislator role

6.1.4 Financer

A key barrier to improvement is the issue of who should pay for the initial investments required to build a more circular economy and develop improved treatment techniques (reaching higher levels in hierarchy). We found that waste firms are naturally focused on profit making, while municipalities are focused on minimising costs. This means that no one is taking on the financial responsibility of developing the waste management system. If waste firms increase their prices for waste services, municipalities will need to pay more and thus might need to reallocate more resources for waste management in order to avoid increasing taxes. A trend linked to this barrier is the introduction of the regional industrial symbiosis networks, e.g. in Sotenäs, where the municipality took on a co-ordinating and financing role in order to set up a functioning system of actors. A related barrier highlighted in the literature review was that investors were unwilling to invest in circular economy business models for firms since the concept is unknown (Nicholls, 2014). However, if municipalities could finance and put together industrial symbiosis networks, firms would easier be able to engage

in local circular economies and thereby municipalities can influence the business models of local producers.

The need for municipalities to organise funding for investments and projects regarding circular economy is strengthened by previous research by Petts (2004) suggesting that municipalities need to manage greater regulatory and funding support to be able to further develop the waste management system. Previous research shows that corporations that use circular economy business models currently struggle to raise investment because of a lack of information about financial risk and because investors are generally unfamiliar with the concept of the circular economy (Nicholls, 2014). Further, Nicholls (2014) argues that financial responsibility can be an issue in development of waste systems. It seems that our results fit with previous literature stating that assigning financial responsibility is a key barrier.

Due to these findings, we propose that municipalities in the region take on more financing responsibility (by for instance leading systematic search for EU scholarships, investors and state subsidies) to both contribute to better waste treatment techniques as well as contribute to creating industrial symbiosis networks locally, as seen in the industrial symbiosis in Sotenäs. This will both help minimise negative effects of waste as well as prevent waste generation.

→ Challenges for municipalities taking the financer role:

This role involves municipalities taking financial responsibility for industrial symbiosis projects, which could mean that they set up a building in the area that carries out co-ordinating activities of the local symbiosis project and taking the lead in actively searching for investors or EU funding for the projects. The difficulties may be finding municipal staff that is suitable and willing to work on these activities. Further challenges could be that the municipality takes on a burden too heavy to manage. If municipalities fail to find investors for projects there will be an issue of who should be responsible for funding. Moreover, one of the waste firms is doubtful that tax payers will be willing to pay extra for waste management to invest in innovation for a more sustainable society. It may lead to potential irritation amongst citizens if they have to pay higher taxes or if they have to cut down on investments in other areas within the municipalities. Some of the waste firms emphasise that more sorting at an individual level might solve the problem of expensive sorting techniques. However, it will be

a cost issue regarding time since more sorting has to be done from a private perspective which is time consuming and might therefor not be the ideal solution.

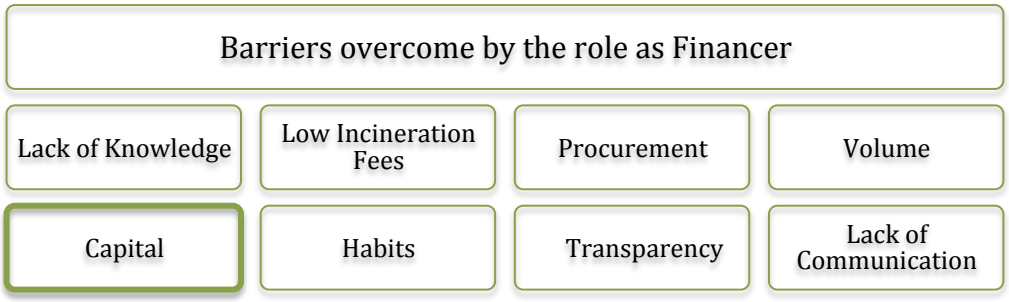


Figure 17: Barriers overcome by the Financer role

6.1.5 Summary of municipal roles

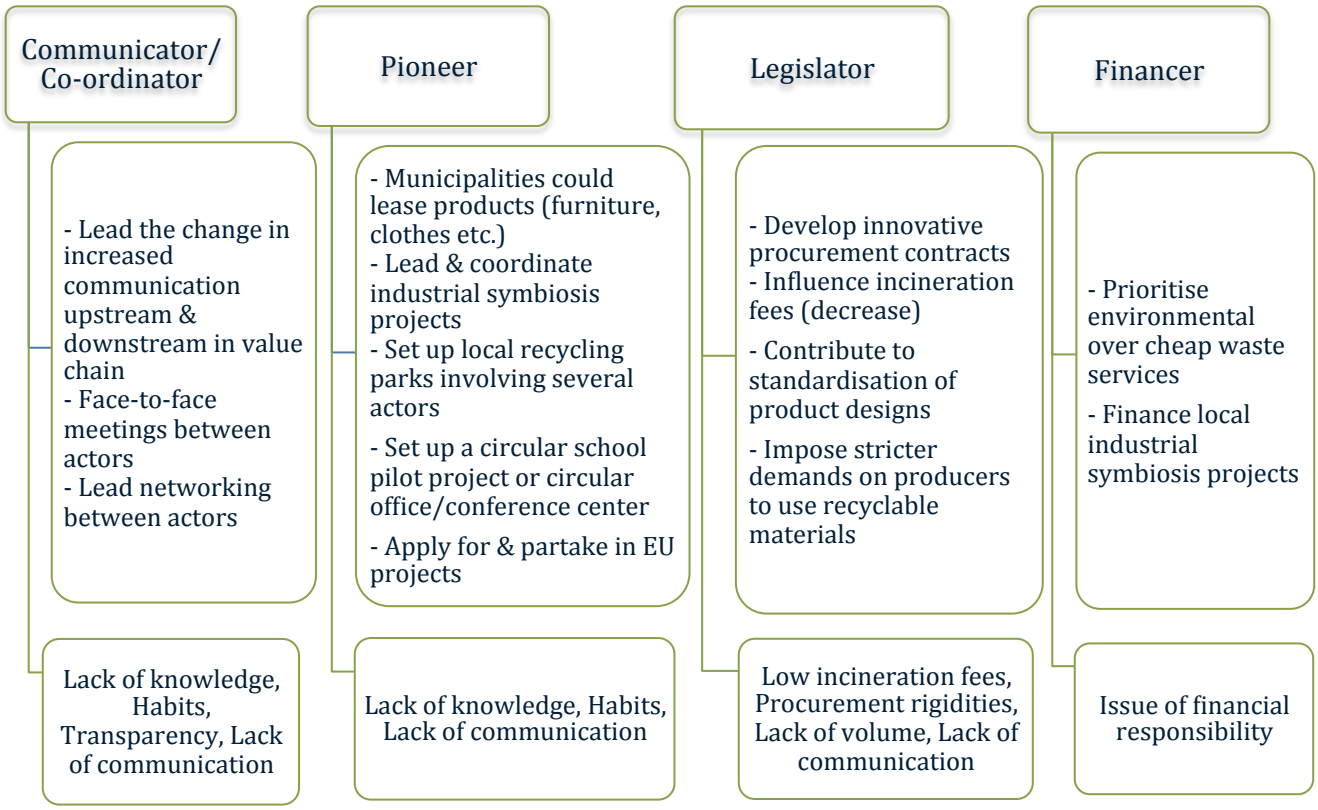
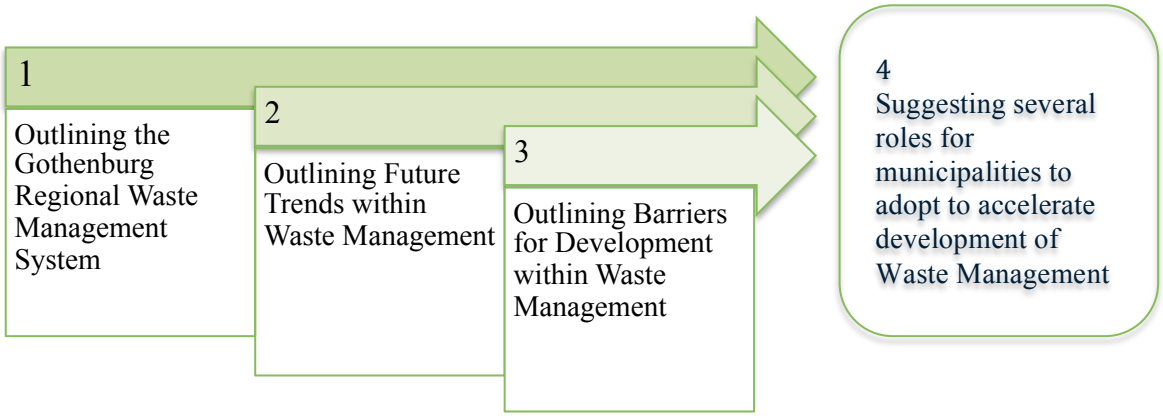


Figure 18: Suggestions for municipal roles

We have contributed to research by outlining the Gothenburg region's waste management system in general and for three specific fractions. Further, we have outlined regional barriers and trends within the waste management system and found that many findings are aligned with previous studies and can arguably be generalised to other regions in Sweden, or countries of similar level of development. Furthermore, we also found some new findings

through our interviews. By assembling previous research with our new findings we were able to propose four roles we believe that GR municipalities need to take in order to effectively contribute to the new wave of development within waste management system currently unfolding in the region towards a zero waste strategy. The contribution of this study are summarised below.



6.2 Recommendations to GR

Our study outlined several implications for municipalities that should be taken into account in their approach to waste management. In this section we will, based on GR's specific demands and situation, provide them with a recommendation, in addition to the already suggested municipal roles.

Our findings show that a local treatment facility for waste, as GR was hoping for, is not necessarily the best solution to improve their regional waste management. This in due to that the benefits from advanced treatment techniques abroad outweigh the additional emissions from transportation. Such advanced treatment techniques require economies of scale, which can only be achieved through large waste volumes, not available in Sweden. Synergies between the municipalities within GR might rather focus on logistical solutions to find collaborations within waste transportation that is more environmentally friendly and cost efficient than it is today when the municipalities in GR are isolated.

Furthermore, our findings clarify the waste management system and different actors within it. The initial goal was thereafter to be able to recommend which waste firm has the most developed waste treatment methods, given a specific fraction. We were given three different materials to investigate; plastic, plaster and textile. However, our findings show that there is no perfect solution today, at the upper levels in the waste hierarchy, for either of the materials but some fractions have more developed treatment methods than others.

Our recommendation to GR is to start prioritise plaster. This in due to that there is already new treatment techniques available but not currently used since there is a lack of volume to make it profitable. GR therefor might need to collaborate with other municipalities as well to be able to provide sufficient volumes to waste firms regarding plaster.
Thereafter textile is a key fraction to focus on since it is a fraction with great potential for improvement and a hot topic within waste management. There are innovation teams currently working on the next recycling treatment method for textile. Municipalities can help co-ordinate a secondary market, i.e. link together producers, charity organisations and households in industrial symbiosis networks or other collaborative relationships.
Lastly, plastic is the fraction where the main improvements in plastic treatment can only be made profitable if the fraction is standardised and sorting techniques further developed. Thus, plastic could be a difficult fraction for municipalities to influence at the moment.

According to research organisations and several waste firms, the most beneficial option, from both environmental and cost perspective, is often to export the waste for treatment abroad. Even though there may not be any optimal waste treatments for these fractions today we were able rank the waste firms according to which firm offered the most environmental friendly solutions today (or with greatest potential for the future).
When carrying out this analysis we firstly identified where in the waste hierarchy the waste treatment was, for each firm and fraction. We further investigated if waste firms owned their own treatment methods and if they currently were innovating in development of treatment methods for the specific fraction. Through our findings we found that Ragn-Sells should be used for plaster, IL Recycling for textile and Hans Andersson for plastic. See appendix 9.8 for more detailed information regarding every waste firms' treatment of waste for the different fractions.

In general, we would advise GR to attempt to move away from idea of the "local treatment solution" since this might either be the most environmental or cost efficient solution. Our more concrete suggestion is for GR to undertake the roles we suggested in our analysis. The role of a co-ordinator, pioneer, legislator and financer. By doing so, we believe that GR are able to accelerate the development within waste management towards a zero waste strategy. For instance, by adopting a more co-ordinating and financing role, GR can develop local industrial symbiosis networks or recycling parks.

In sum, our four roles; co-ordinator, pioneer, legislator and financer, are roles that arguably will be useful in improving waste management systems for individual fractions as well as the larger regional waste management system. Plaster should be prioritised by GR followed by textile. Plastic can first be prioritised after further development of sorting techniques and further standardisations have been established on a global level. Only then can plastic recycling become profitable for waste firms.

7 Conclusion

Our study started out with a literature review outlining models of waste management systems, changing involvement of actors, global concepts in waste management (such as the waste hierarchy, circular economy and industrial symbiosis) as well as trends and barriers to development identified in previous studies.

Our empirical findings showed that a broad regional trend within waste management is the growing secondary market for recycled materials and products. It seemed that a driving force behind this was stricter regulations for producers requiring them to use more recyclable materials and develop recyclable products. Another related driving force was found to be stricter recycling rates for waste firms. The consequence of this seems to be increased collaborations between waste firms and producers in order to help producers develop eco-designs and improve their internal waste management. Another consequence of this is that waste firms in turn have increased collaborations with secondary markets interested in purchasing recycled materials. Ripple effects of such changes has meant that regional municipalities have started to co-ordinate projects such as local industrial symbiosis networks and recycling parks. Thus, trends found in the region suggest that waste management systems are becoming more circular. We also found that "circular" and improved systems do not necessarily mean that waste management solutions are carried out locally, an ideal waste solution from an environmental perspective can just as well involve actors abroad with a better treatment method with a higher level in the waste hierarchy.

Furthermore, we identified a number of barriers hindering or at least slowing down this natural development. Main barriers include that waste firms experience that the municipal procurement contracts prioritise low cost over environmental solutions which inhibits waste firms from experimenting with more environmental solutions since they need to have large waste volumes for such solutions to be profitable (only possible through winning public procurement contracts). Another barrier found is the issue of the actors not knowing who should bear the financial burden of changing towards more circular solutions, and there seems to be a need for someone to a invest and co-ordinate such projects. Further, the low incineration costs in Sweden also demotivate firms from choosing recycling over incineration, which in turn affects the recycling rates for waste firms collecting waste. A general lack of

knowledge among municipalities was also identified as hindering development since municipalities lack the understanding of how to contribute to improved waste systems. Finally, an ubiquitous barrier is the difficulty in changing habits of producers and municipalities to make them aware of how their roles and responsibilities must change for the regional waste systems to improve in the long-run. Interestingly, many of the concepts, barriers and trends found in literature and international studies seem to match the ones identified in the Gothenburg region, suggesting that the region is representative of a wider global development in waste management systems.

With regards to the waste fractions analysed, treatment methods for plaster is the most developed. Trends include improving treatment techniques, growing secondary market and a continued dominance of few waste firms, while barriers were similar to plastic; lack of volume and high sorting and treatment costs. Textile was found to be a fraction with multiple trends such as increasing collaborations between waste firms and charity organisations, experimentation with treatment techniques, increasingly a hot topic in global trade market, growing secondary markets and development of niche firms focusing on textile treatment for specific secondary markets. Plastic from recycling facilities was found to be the most complex fraction and trends involve standardisation of plastic products and automated sorting techniques, while barriers involve poor quality of plastic waste, lack of volume, high treatment and sorting costs and thereof low payoffs.
Due to very different treatment methods for every specific fraction, this has begun to show its effects on generalist waste firms, which are becoming more of logistical partners to niche treatment firms.

Based on our analysis, we were able to develop four key roles we believe municipalities are able to adopt in order to accelerate regional development of a waste management system towards a zero waste society. Our research question was the following:

What role can Swedish municipalities take to accelerate development in waste management towards a zero waste strategy?

We believe the answer to this question is four roles:

(1) Co-ordinator

(2) Pioneer

(3) Legislator
(4) Financer

By taking on these four roles in the way we propose, the municipalities in the Gothenburg region will overcome multiple barriers specific to the regional waste management system. Based on our findings we believe that the role of municipalities must be focused on facilitating the natural development towards a zero waste strategy and adjusting procurement processes and regulations to enable rather than hinder positive trends in the region. The focus should not be on giving waste firms incentives to develop better treatment techniques, since our findings show that waste firms already have developed innovative solutions but are not able to exercise these due to barriers in the wider waste management system. Focus cannot be too narrow, e.g. how to improve treatment techniques, rather focus must be wider so municipalities understand that there is already a paradigm shift happening and it is their role to help facilitate this. Thus, we believe municipalities have an important role to play in removing barriers to allow for the natural development towards a circular economy to unfold. The four roles we have proposed, we believe are key to succeeding with this. Finally, since the barriers and trends identified in the region are aligned with international literature to a great extent, we have reason to believe that our findings and proposed municipal roles can be generalised to other regions in Sweden, or even other countries with a similar level of development.

8 Suggestions for Future Research

During our study, some observations have been made that call for future research. While our study was limited to the Gothenburg region, and to a certain extent Sweden, it would be interesting to compare with how other countries develop their waste management systems and what strategy is used, and more specifically what role the municipality has taken.

Furthermore, we believe that an additional number of multiple case studies would add value to our findings. By doing so we could explore if there is any difference within municipal waste management system in Sweden or if results are similar to our study we can further confirm our own findings and reach a higher validity and reliability.

Lastly, while our study was limited to the perspective of municipalities, waste firms and researchers it would be interesting to include major producers as additional actors since they will have a significant role in future waste management system due to the upcoming concept of eco-design to enable better rates of recycling and reuse of products.

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10 Appendix

10.1 Interview Protocol

1. Is you firm interested in collaborations in terms of:

   a. Plaster
   b. ÅVC-plastic
   c. FNI-plastic
   d. Textile

2. What waste management services do you offer today? Are you treating plaster, plastics and textile materials today? If yes, how? If no, is it treated in collaboration with other waste management entrepreneurs?

   a. General
   b. Plaster
   c. Plastic
   d. Textile

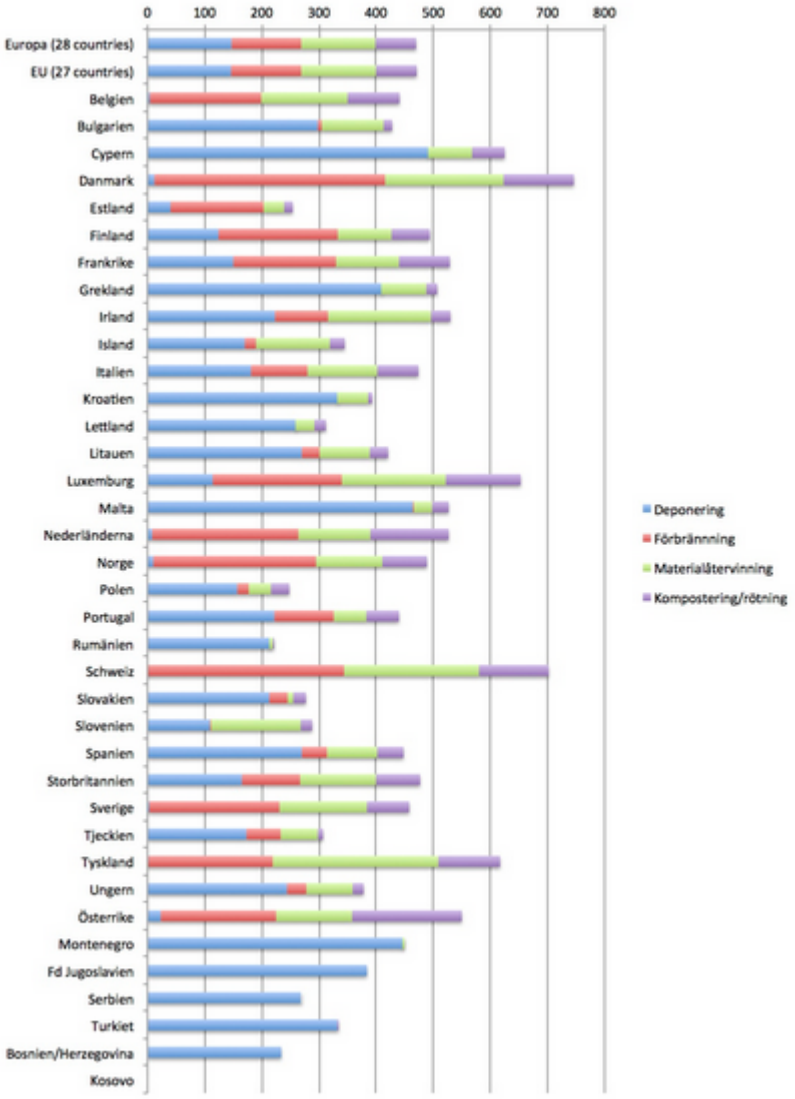
3. Do you have capacity to take care of the volumes from the municipalities of GR?

4. Would you like to be a part of the procurement of these fractions for GR? What are your strengths?

5. What are the obstacles for you to improve your waste management processes?

6. What future trends do you see in the industry? What are your firm's future plans for improving processes?

10.2 Treated amount of waste per inhabitant 2013



Source: Eurostat

Translation of legend:
Deponering = landfill
Förbränning = incineration
Materialåtervinning = recycling
Kompostering/rötning = composting

10.3 Detailed findings: Future trends from three perspectives

Future trends	Municipalities	Waste firms	Researchers
1	Municipalities taking on more co-ordinating roles	Circular economy	Examples of industrial symbiosis increasing
2	Introduction of innovative procurement contracts	Towards global integration	Secondary markets growing
3		Logistics becoming core business	Niche firms arise
4		Towards standardisation & smart designs	New business models for leasing arising
5		Service focus & digitalisation	
6		Plastic treatment & sorting processes developing	
7		Textile waste becoming a global market	
8		Growing secondary markets driving new treatment techniques	

Table: Summary of future trends from the three actors

10.4 Detailed findings: Future trends within fractions

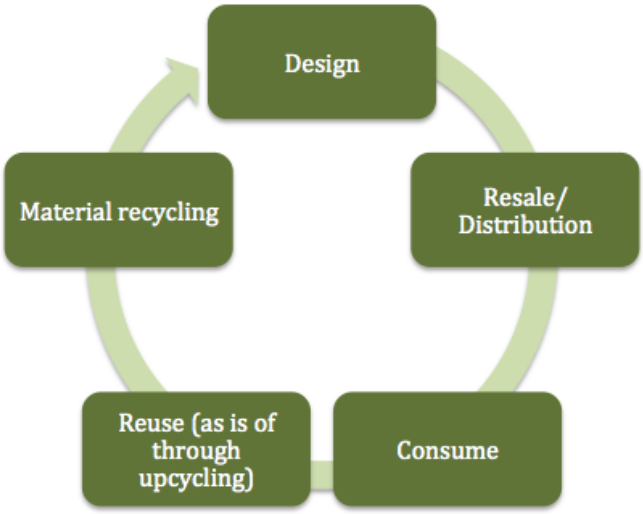
Future trends	General	Plastic	Plaster	Textile
1	Increased global processes (W)	Standardisation of fractions (W)	Treatment improving (W,R)	Increased collaborations with charity organisations (W)
2	Integration of waste (W)	Automated sorting techniques (W)	Growing secondary market (W)	Experimentation with treatment techniques (W)
3	Standardisation of fractions (W)	Increased interest in ÅVC plastic (W)	Continued dominance of few actors (W)	Becoming hot topic for global trade market (W)
4	Eco-designs from producers (W)	Potential future struggle for ownership of FNI plastic (W)		Growing secondary market (W)
5	Stricter recycling directives from EU (R)			More waste firms engage in collection (W)
6	Industrial symbiosis projects (R)			Niche innovative firms taking over treatment (W,R)
7	Circular economy thinking (R,W)			Struggle for ownership of textile waste (W)
8	Innovative procurement contracts increasing (M)			Growing producer involvement (W,R)
9	Increasing focus on service (W)			
10	Digitalisation & automation (W)			
11	Growing secondary markets (W)			

12	Demand for niche treatment methods (W)			
13	Development of upcycling (R)			
14	Generalist waste firms focusing on transport solutions (W)			
15	Global trading of plastic and textile waste (W)			
16	Movement towards leasing (R)			
17	Municipalities taking on more co-ordinating roles (M)			

10.5 Detailed findings: Barriers within fractions

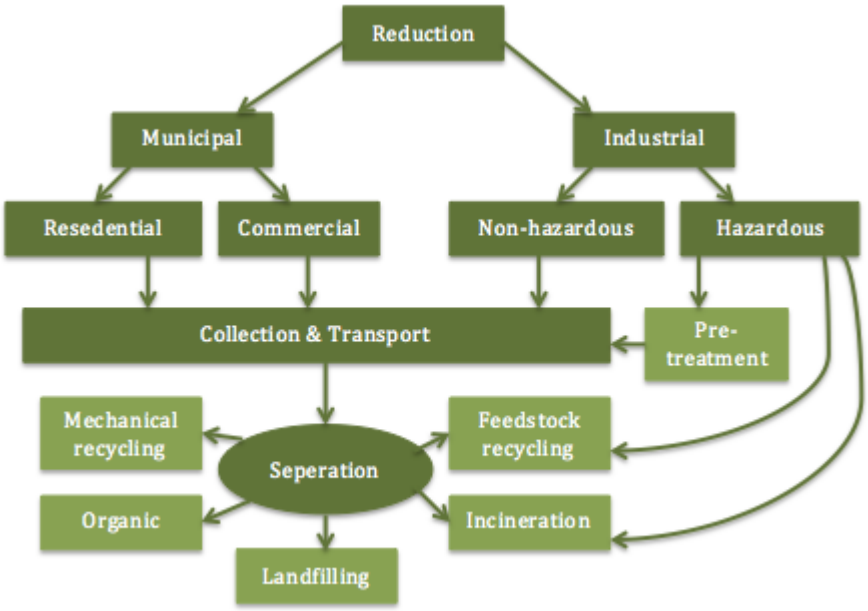
Barriers	General	Plastic	Plaster	Textile
1	Lack of Knowledge	No treatment today	High sorting and treatment cost	Do not want to compete with charity / second - hand
2	Low inceneration fees	High sorting and treatment cost	Low volume	Hard to predict voumes
3	Transparency	Poor quality of recycled plastic		Complex and expensive treatment methods
4	Procurement prioritize cost			
5	Responsibility of capital			
6	Habits			

10.6 Future circular flow of products



Source: Sotenäs municipality, Circular Economy Seminar

10.7 Ideal flow of plastic waste



Source: SP Technical Research Institute

10.8 Detailed findings: Waste services of each waste firm and fraction

Plastic	Collection	Sorting & Pre-treatment	Treatment process	Waste hierarchy
Ragn-Sells	Not interested in ÅVC or FNI plastic today, but can do collection & sorting in the future if given volumes, low payoff			
Hans Andersson	Collect themselves	Pre-treatment (crushing, baling)	Sell to other EU actor for recycling treatment, but recycle pure plastic themselves in Staffanstorp & Rörstånga (then exported), own pilot project in Trollhättan	Recycling
Suez Environment	Collect themselves	Sorting & Pre-treatment (crushing, baling)	Transport to Swerec or exported, depending on the waste producer's preference the waste is either incinerated or recycled	Recycling. ELP (End of life plastics) incinerated
Renova	Collect themselves	Sorting	Incincerate themselves	Incineration*
IL Recycling	Collect themselves	Sorting & Pre-treatment (crushing, baling)	Export abroad for recycling	Recycling
Stena Recycling	Collect themselves	Pre-treatment (crushing, baling)	ÅVC plastic transported to Swerec or exported to other actor. Industrial waste sold or recycled at own facility in Perstorp	Recycling

* according EU directive and the R2 formula, energy efficient waste to energy processes http://ec.europa.eu/environment/waste/framework/pdf/guidance.pdf

Plaster	Collection	Sorting & Pre-treatment	Treatment process	Waste hierarchy
Ragn-Sells	Receive plaster from Renova	Pre-treatment (crushing)	Plaster is recycled, for fertilizer industry, cement industry and calcium sulphate for farmer's fields (strict regulations for recycling plaster into plaster, no market value for recycled plaster)	Recycling
Hans Andersson	Developed a technique for recycling contaminated plaster but lack volumes to operate it (need at least 10000tons/yr)			
Suez Environment	Collect themselves	Pre-treatment (crushing)	Transported to other actor where pure plaster is recycled, small part landfilled	Majority recycled, rest landfill
Renova	Collect themselves	Sorting	Recycling by other company	Recycling
IL Recycling	Collect themselves	Sorting	Transport to other actors for incineration and recycling	Incineration
Stena Recycling	Collect themselves	Pre-treatment (crushing)	Transport to other actor for recycling of pure plaster and Incineration of contaminated plaster	Recycling, Incineration

Textile	Collection	Sorting & Pre-treatment	Treatment process	Waste hierarchy
Ragnsells	Collect FNI textiles themselves	Sell to Myrorna (second-Hand)		Reuse
Hans Andersson	Accept industrial textiles today, not household textiles	Sorting & Pre-treatment themselves	Transport to other domestic actor for treatment (incineration)	Incineration
Suez Environment	Collect themselves (collaboration with large textile producer & containers at recycling stations)	Sorting & Pre-treatment themselves	Export for treatment in Holland or reusage (Collaboration with Björkås, organisation sending textiles for reuse at catastrophic areas)	Reuse, incineration
Renova	Collection together with partner	Sorting	Reuse and recycling by other companies	Recycling
IL Recycling	Collect themselves	Sorting & Pre-treatment themselves	Have new recycling technique under development, need the volumes	Recycling
Stena Recycling	Collect themselves	Sorting & Pre-treatment themselves	Transport to other actor for Incineration	Incineration