Managing Household Plastic Waste

Evaluation of the EU commission's strategy from the perspective of Swedish municipalities

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Abstract

In January of 2018, the EU commission presented a new strategy on how the EU will handle plastics in a circular economy. The strategy raises many of the issues the EU face with plastics and plastic waste today, presents several goals for 2030 in this field - such as a >50% recycling rate of plastic waste - and recommends measures the nations could take to improve their management of plastics and plastic waste. Sweden has for a long time worked closely with the sorting, collecting and recycling of household plastic waste, and is by 2016 already reaching recycling rates of 42.2%, in big part thanks to Sweden's legally demanded extended producer responsibility. The question arose of how much the EU commission's strategy will affect Sweden in its work of sorting and collecting plastic waste. This study approaches this question by attempting to answer instead what the Swedish municipalities have already accomplished without the help of the EU commission's strategy, what actions are being planned in future following this strategy, as well as what other measures had been taken previously when dealing with demands of sorted household waste to see if there are any methods that would be applicable to plastic waste. Additionally, looking beyond what the EU commission's plastic strategy incorporates, it was also of interest to investigate which issues the Swedish municipalities see with bioplastics, as these are expected to take a bigger share of the plastic market in the coming future. Semi-structured qualitative interviews and questionnaires were performed and answered by 4 of Scania's municipalities, and 8 of its waste management companies in order to answer these questions. From the results, Sweden has come far with its sorting and collecting of plastic waste due to implementing convenient measures for its citizen, such as access to household-proximate sorting, and four-compartment bins to single family households where they may sort their waste easily. An underlying motto "easy to do right" have been guiding the household waste sorting and collection thus far, together with information distribution to the citizens. The EU commission's strategy was not deemed to have had an impact on the municipalities' work regarding waste sorting and collecting so far, and was not expected to have a great impact in the future, primarily due to it not presenting any revolutionary demands or measures. The issues with bioplastics were related to biodegradable plastics, as these may contaminate other plastics in recycling due to being difficult to recycle. However, they were also deemed inappropriate to dispose of in nature or among organic waste, as it does not

degrade in these environments either, meaning that there is no good way to dispose of these plastics other than energy recovery. In the future, this issue may be solved by modern second-hand sorting of plastics in sorting facilities, together with second-hand recycling of residual waste, something which is currently not being done in Sweden.

Sammanfattning

I januari 2018 presenterade EU kommissionen en ny strategi om hur EU ska hantera plast i en cirkulär ekonomi. Strategin lyfter många av de problem som EU måste hantera med plast och plastavfall idag, presenterar flera mål till 2030 i detta området - till exempel en >50% återvinningsgrad av plastavfall - och rekommenderar åtgärder som kan införas av nationerna för att förbättra deras hantering av plast och plastavfall. Sverige har under en lång tid arbetat med utsorteringen, insamlingen och återvinningen av plastavfall, och har vid 2016 redan nått en återvinningsgrad av 42.2%, mycket tack vare Sveriges utökade producentansvar. Frågan framkom om hur mycket EU kommissionens plaststrategi kommer att påverka Sverige i dess arbete att utsortera och samla in plastavfall. Denna studie närmar sig denna fråga genom att istället försöka svara på vad Sveriges kommuner redan har gjort utan hjälp av EU kommissionens strategi, vilka åtgärder som planeras utefter strategin, och även vilka åtgärder som utförts tidigare när man hanterade krav på sorterat hushållsavfall för att se ifall det finns metoder som även är relevanta för plastavfall. Dessutom, utöver vad som EU kommissionens strategi innefattar, var det även av intresse att undersöka vilka problem de svenska kommunerna ser med bioplaster, eftersom dessa förväntas ta en större andel av plastmarknaden i den nära framtiden. Semistrukturerade kvalitativa intervjuer och frågeformulär utfördes och besvarades av 4 av Skånes kommuner och 8 av dess renhållningsbolag för att få svar till dessa frågorna. Utifrån resultaten har Sverige kommit långt med utsorteringen och insamlingen av plastavfall tack vare implementeringen av bekväma åtgärder åt dess invånare, till exempel tillgång till hushållsnära insamling och fyrfackskärl till villor där hushållen kan enkelt sortera på fastigheten. Ett underliggande motto av “lätt att göra rätt” har genomsyrat hushållens utsorteringen och insamlingen hittills, tillsammans med informationsutdelning till invånarna. EU kommissionens strategi bedömdes ej ha en större påverkan på kommunernas arbete angående avfallssortering- och insamling hittills, och förväntades inte ha det i framtiden eftersom den inte presenterade några revolutionerande krav eller åtgärder. Problematiken med bioplaster var

relaterade till de nedbrytbara plasterna, eftersom dessa förorenade annan plast i återvinning då de själva är svåra att återvinna. De ansågs även ej passande att slänga dem i naturen eller bland organiskt avfall, eftersom de inte bryts ned i dessa miljöer, vilket leder till att det inte finns något bra sätt att göra sig av med dessa utöver energiåtervinning. I framtiden kan dessa problem lösas av modern andrahandssortering i utsorteringsanläggningar, tillsammans med andrahandssortering av övrigt restavfall, något som inte utförs idag.

Innehållsförteckning

Introduction

In our modern society, you would be hard pressed to spend more than a few minutes without coming into contact with plastics. Due to its robustness, light weight and easiness to manufacture, plastics make an appearance in almost every aspect of our common day life; from our furniture and packaging; our mobile phones, kitchen appliances and cars, to the very clothes and accessories on our bodies, plastics may be found. By itself, "plastics" is a collective term for several synthetic materials consisting primarily of carbon polymers - long molecular chains of carbon atoms - traditionally made from raw material rich in hydrocarbons, such as oil, coal or natural gas (American Chemistry Council). However, due to the same properties that makes plastics a desirable material, plastics have also become a significant environmental problem. In a study used by the EU commission's plastic strategy of 2018, it was estimated that 4.8 to 12.7 million tons of plastic entered the oceans globally in 2010, equal to 1.5-4% of the global plastic production (Jambeck et al. 2015). The dangers of plastic debris to marine fauna is commonly known; however, recent studies are showing that once plastic is released into the environment, it degrades into micro- and nanoplastic particles which distributes globally and may cause additional harm to marine ecosystems (Eerkes-Medrano et al. 2015). Furthermore, there have been studies suggesting that these particles may have an effect on humans through bioaccumulation via the food chain of marine animals (Koelmans et al. 2015). Even when plastics are disposed of more properly, it may still cause issues to the environment. Landfills are a popular alternative for a controlled disposal of plastics, however, these too may contribute to the production of microplastics unless maintained properly, or if exposed to natural disasters (Duis and Coors, 2016). Incineration may be the solution that tackles the issue of microplastics, but then instead it weighs in to the second major problem traditional plastic faces, namely the contribution of anthropogenic CO2 to the atmosphere. Due to its fossil origins, plastics made from petroleum products contributed in 2012 to 400 million tons of CO2 emissions globally (European Commission, 2018), which is comparable to the national yearly emissions of greenhouse gases of many larger European countries, such as Poland, Italy or Spain (Eurostat, 2017).

The EU commission's strategy for plastics

In January of this year, the EU commission presented a new strategy for handling plastics in a circular economy (European Commission, 2018). The strategy presented a vision of how the EU would handle plastics in the coming future, as well as aims to be fulfilled by 2030. These aims are twofold, concerning both the end-of-life management of plastic waste, as well as the production of new plastic products and materials. Concerning the end-of-life management, the commission presented aims such as making all plastics recyclable, and increasing the amount of plastic waste being recycled (materially recovered and reintroduced into the market) in the EU to more than 50% (in comparison to today's 6%), and decoupling plastic waste from the economic growth. As for the production of new plastics, the focus is mainly on growing the use of sustainable materials such as bioplastics, as well as to increase demand for recycled plastics in new product production. The strategy states that pressure needs to be put on plastic product producers to design their products for recycling; this means, for instance, making larger plastic parts labeled and easier to separate from the product, discouraging design choices that may negatively affect the value of recyclates (e.g. dark colors), and removing or providing information about additive chemicals used in the plastics which may hinder future recycling (e.g. flame retardants). Ensuring a reliable stream of sorted and recyclable plastics with a low risk of contaminants is key in order to increase the demand for recycled plastics, the commission states, as today producers at large are too concerned with the risks related to recycled plastics to commit to the use of them. The commission shares the concerns of the Swedish Government related to the rise of biodegradable and compostable plastics, and states that there is a clear need for a clear regulatory framework and harmonized rules for defining and labeling such plastics in order to avoid such plastics being disposed of incorrectly.

While a large part of the strategy puts responsibility on the EU states at a national level to implement regulatory frameworks, as well as on industries to comply with the design proposals to promote recyclability, regional and local authorities will play an important role as well. Working with waste collection operators, the strategy states that regional and local authorities will have key role of raising public awareness and ensuring high-quality separate collection of plastic waste; together with extended producer responsibility from the plastic manufacturers. The strategy provides a list of measures recommended for national and regional authorities (see Annex 1), however the list does for the most part not give any inclination of *how* to implement these measures. Therefore, it is implied that authorities are to start their own initiatives in order to implement these measures.

Bioplastics

The two major environmental problems traditional plastics face - harming ecosystems through littering and degradation, and the contribution to fossil greenhouse gas emissions - may be solved with bioplastics. Today, bioplastics are missing an internationally accepted definition, and the term differs somewhat between companies and organizations. The most common definition is *plastics which are biobased, biodegradable, or both,* which is the definition used by the European Bioplastics organization (European Bioplastics). Biobased materials are based on renewable materials, most commonly derived from biomass produced by plants, such as sugarcanes or corn. These forms of plastic often mimic, or attempt to be chemically indifferent to traditional fossil plastics allowing them to be used with already established equipment in the plastics industry, which also makes them the most common (European Bioplastics, 2017). Biodegradable on the other hand refers to the material's ability to decompose after it has been disposed of. This means it would convert into naturally occurring substances such as water or CO2, instead of degrading into smaller particles (European Bioplastics). These materials may be found in products sold due to their different properties and more niche applications, such as for compostable food waste bags or soil stabilization in agriculture (Biobag). Combined, these two properties create four categories of plastics, depending on if the material is bio- or fossil based, and if it is biodegradable or not, as shown in figure 1 below.

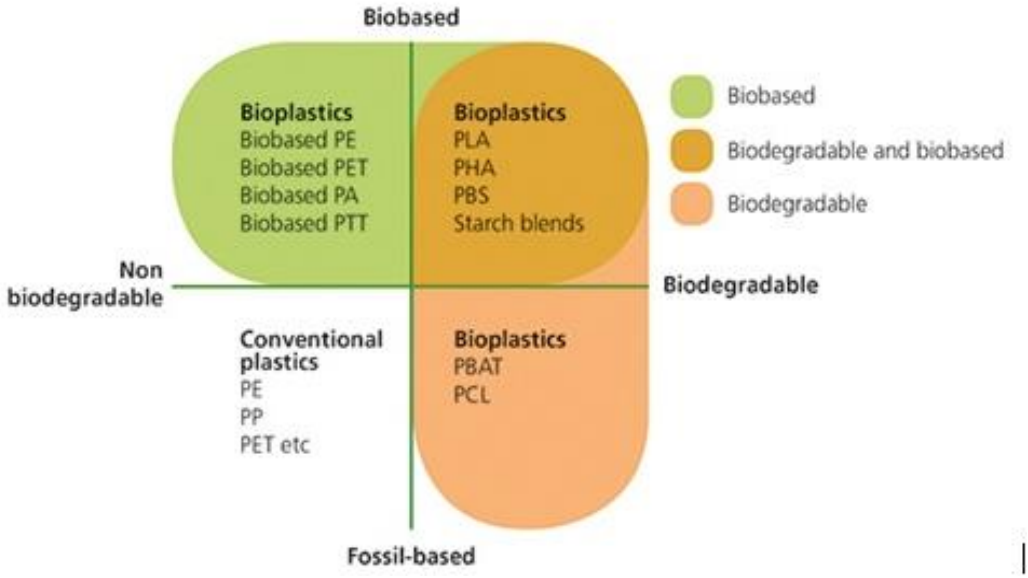

Figure 1:
Matrix displaying the different categories of plastics and bioplastics, as well as examples of each category. Source: Perstorp.

Bioplastics are not entirely without fault however. While studies initially focused on the positive aspects of bioplastics as a renewable material, more recent life cycle analysis have shown that bioplastics may not be as vastly superior to the fossil alternative in terms of climate impact as we previously thought. For instance, a study conducted in Sweden (Røyne & Berlin, 2018) compared the global warming potential (GWP) of an engine component storage box made from fossil-based plastic acrylonitrile butadiene styrene, to two hypothetical alternatives, one made from a blend of polycarbonate and bioplastic polylactic acid (a fossil-based and biobased mix), and another made from biopolyamide (biobased). The study found that the overall climate impact of the biobased and fossil-based products were similar, due to the biobased alternative having a higher GWP than the fossil-based original during production, while as the fossil-based contributed more at the end-of-life incineration. More crucially, the study showed that the deterioration and life-time of the product played a significantly more important role, as a prematurely failing product would require the manufacturing of a new product entirely to serve the same function. Therefore, due to the shorter lifetime expectancy, the study showed that the biobased/fossil-based blend would have a higher GWP than the fossil-based original. The study additionally pointed out the importance of availability of recycling. Since there is currently no market for recycling such plastic blends, the product was made entirely from virgin materials, whereas the fossil-based original may have been made partly from recycled materials. Another study conducted in 2011 (Álvarez-Cháveza et al. 2011) comparing other sustainability aspects related to public health and the environment found that none of the commercially available bioplastics are currently fully sustainable. This is primarily due to the production of bioplastics; industrial methods of agriculture are still used to produce the feedstock needed for bioplastic materials, which may for instance involve the use of pesticides, pollute water and soil, and contribute to the erosion of land and wildlife habitats. Additionally, it raised concerns of land use, as the use of crops to primarily produce bioplastics compete with the production of foods and biofuels. Finally, there is also an issue concerning the biodegradability of some bioplastics. A 2014 press release by Plastics Recyclers Europe claimed that biodegradable plastics reduced the quality of the plastic waste stream, which in turn harmed the recyclability of other plastics (Plastic Recyclers Europe, 2014). There is therefore a need for an infrastructure which may separate biodegradable plastics from the general plastic waste stream, though a recent investigation by the Swedish Government stated that such technology is currently missing (Statens Offentliga Utredningar, 2018). The same investigation also highlighted the problems of biodegradable plastics, as many of these products are only degradable in controlled industrial compost environments, while they perform similarly to conventional plastics in the open or marine environment. Therefore, plastic products marketed as biodegradable may cause an increased littering due to

consumers misunderstanding the term, and disposing the products in the environment. Additionally, the availability of industrial composts in Sweden has been declining in favor of digestion plants that may produce biogas (Statens Offentliga Utredningar, 2018). These plants are unable to degrade many biodegradable plastics due to them lacking the right form of microorganisms which would be present in composts, meaning that the biodegradable plastics pass through the plants mostly unaltered.

Aims of this study

This study seeks to answer how Swedish municipalities are reacting to the Plastic Strategy presented by the EU commission. Of interest are what measures to sorting and collecting plastic waste the Swedish municipalities have already implemented since before the EU commission's strategy was presented, as well as what different measures have been planned as a result of the strategy. Due to the role local authorities play according to the strategy, the focus of this study is going to be on infrastructure developments made to promote the collection of plastic waste, and measures implemented to produce sorted plastic waste streams fit for recycling. It is also of interest to investigate what measures the municipalities have implemented when dealing with previous demands to sorted household waste, as similar methods may be applied when dealing with demands of sorted plastic waste. Additionally, though it is not largely the focus of the EU commission's plastic strategy, it is of interest to investigate what issues or concerns the municipalities may have with bioplastics, as these have the potential to solve many issues of conventional plastics and will most likely see a larger use in the near future. Summarized, this study seeks to answer the following questions:

- What developments have already been made by Swedish municipalities, that fulfill the demands of the EU commission's plastic strategy, since before this strategy was presented?
- Which actions do the Swedish municipalities plan to make going forward to meet the requirements of the EU commission's plastic strategy, related to demands on collection and sorting of plastic waste?
- How have Swedish municipalities worked in the past when developing solutions to similar requirements to their waste management infrastructure?
- What attention has been given to the waste management of biobased and/or biodegradable plastics by Swedish municipalities?

Method

Semi-structured qualitative interviews (Bryman, 2011, s. 413 - 445) were suitable for an explorative study such as this one, as information about such measures and actions that may answer the research questions are not readily available in literature. As such, interviews were conducted with representatives from the municipalities of Scania – the southernmost county of Sweden. Scania was chosen due to several reasons; firstly, the number of municipalities was high enough to get a reasonable representation of how local municipalities work with the questions surrounding plastic waste. Secondly, the municipalities of Scania share the same regional government - The County Administrative Board of Skåne - meaning that the upper-level influence for the municipalities presumably does not vary much. They are also geographically aggregated and closer to the Lund University, which may influence the respondents' willingness to partake in the study. Finally, Scania contains a several municipalities with coastlines which is of particular interest to the EU commission's plastic strategy, due to its concerns of shoreside littering and microplastic particles in the sea, and as such, these municipalities may have taken a special interest to the strategy. The full questionnaire used in the interviews and sent out to the respondents can be seen in annex 2.

All 33 municipalities of Scania were contacted with a request to participate in the study, with two follow-up requests to those that did not respond. 9 regional waste management companies (WMCs) were also contacted as some municipalities had collaborated with neighboring municipalities to create joined WMCs to bear responsibility of the waste management in all municipalities involved. In total, 4 municipalities agreed to partake in interviews for the study, 1 municipality partook through filling in a questionnaire, 8 municipalities redirected the request to their local WMC and the remaining 19 municipalities were not interested or unable to participate. Due to it being the most economically powerful municipality, it is notable that Malmö municipality redirected the request to the local waste management organization VA SYD. Among the WMCs, 5 agreed to participate in interviews, 2 partook through filling out the questionnaire, 1 gave a short descriptive answer of their company's stance on plastic waste, and the last one gave no response to the contact requests. The WMC SYSAV filled in a questionnaire on the behalf of an additional 2 municipalities. In total, 24 of Scania's 33 municipalities are in some way represented in this study, shown in

further detail in table 1 and 2 in the *Results* section. Lastly, an attempt was made to contact Förpacknings- och Tidningsinsamlingen (FTI), a large Swedish company that manage the recycling of plastic waste from many Scanian municipalities, however they refused to partake in the study.

After the interviews had been conducted and transcribed, they were analyzed for responses that may answer the research questions posed earlier in the study. Of particular interest were opinions of measures the municipality or WMC had implemented or were planning to implement which the respondents deemed were especially effective in regards to collecting or producing fractions of sorted waste, but also trends and patterns among the municipalities of proven measures that several municipalities found useful. These answers were then categorized and presented in relation to each of the four research questions. A fifth category of interesting opinions that might not have fit under any specific research question was initially planned, however no such opinions arose. All interviews and questionnaires were conducted in Swedish, meaning that the quotes used for this study have been translated as accurately as possible.

Limitations and sources of error

Limits of the study

Due to the roles the municipalities play, the focus of this study will be on the sorting and the collection of waste specifically; not the recycling or reduction of plastic waste. The responsibility of the plastic waste after collecting was said to be passed to third-party companies owned by producers, primarily FTI, as part of the extended producer responsibility in Sweden, which means that the respondents from the municipalities and WMCs were unable to speak on their behalf. The reduction of plastic waste, while an interesting and certainly important question too, is similarly beyond the scope of this study. This is due to reduction of plastic waste demands vastly different measures than the ones managed by the respondents interviewed in this study, meaning that it would require additional interviews to be conducted with the appropriate people, something which was beyond the time constraints of this study. It is, however, important to note that other actors play a part in the EU commission's strategy that affects the municipalities' management of plastic waste which are not represented in this study. Consumers have a large impact on the municipalities' ability to collect plastic waste, due to the reliance on consumer waste sorting, though this may be influenced through informational campaigns from the municipality. Downstream, the plastic recycling and producer industry are

responsible for ensuring the plastic waste may be turned into recyclates and then enter the market again. As such, the municipalities are limited in the amount of sorted plastic waste they can collect due to the capacity the recycling and producer industry provides. Additional important actors are the higher governmental instances that may provide national regulations or goals the municipalities are expected to abide by, and that conduct governmental investigations highlighting certain issues more than others. Finally, while it is a large part of the EU commission's strategy, this study does not discuss the management of plastic litter in the municipalities, despite there being questions related to this in the interview questionnaire; too many of the respondents were not affiliated with this subject which lead to the answers being too inconclusive.

Sources of error

As comes naturally with a study based on interviews, there are some sources of error. For starters, the results are based on a small subset of respondents from each respective municipality or WMC, and therefore the results will be limited to their knowledge, even if the situation or collective knowledge of the municipality or company may be different. Similarly, is it also possible that primarily knowledgeable municipalities, and municipalities that have come far with these types of waste-related questions, were willing to participate in the study, due to them being the most comfortable with these kinds of interviews as a result. In which case the results would be skewed to be more positive than what they actually should be. The results may be further skewed by the chosen region of interviewed municipalities; while there are many positives of picking one county of Sweden to interview, it may also not be representative of the whole of Sweden. Finally, a large source of error is the questionnaire itself, when given out to respondents that were willing to participate by filling it in themselves. Some of the questions were easily misunderstood outside an interview environment where the questions could be elaborated on as necessary, which only became apparent after the filled-in questionnaires came back.

Results

Respondent overview

The interviews conducted with the municipalities and waste management companies (WMCs) for this study are listed in table 1 and 2 below. The interviewees are referred to by their position at their respective municipality or company, as personal names were deemed unnecessary for this study. Said positions are shown in both Swedish and English to clarify potential mistranslation.

Table 1:
Overview of the representatives from the municipalities interviewed.

Municipality	Interviewee position (Swedish/English)	Interview format
Burlöv	Miljöstrateg/ Environmental Strategist	Interview, telephone
Helsingborg	Miljöstrateg/ Environmental Strategist	Interview, telephone
Vellinge	Avfallsansvarig/ Waste Coordinator	Interview, telephone
Åstorp	Miljöchef/ Environmental Manager	Interview, telephone

Table 2:
Overview of the representatives from the waste management companies interviewed and questioned for this study, together with the respective municipalities each company manages.

Waste Management Company	Interviewee position (Swedish/English)	Interview format	Municipalities managed
Nordvästra Skånes Renhållnings AB (NSR)	Avfallsstrateg/ Waste Strategist	Interview, telephone	Bjuv, Båstad, Helsingborg, Höganäs, Åstorp, Ängelholm
Mellanskånes Renhållnings AB (MERAB)	Avfallsstrateg/ Waste Strategist	Other	Eslöv, Hörby, Höör
Norra Åsbo Renhållnings AB (NÅRAB)	VD/CEO	Interview, telephone	Klippan, Perstorp, Örkelljunga
Östra Göinge Renhållnings AB (ÖGR AB)	VD/CEO	Questionnaire	Osby, Östra Göinge
Landskrona-Svalövs Renhållnings AB (LSR)	Miljövetare/ Environmental Scientist	Questionnaire	Landskrona, Svalöv
SYSAV	Projektledare/ Project Leader	Interview, telephone	Kävlinge, Lomma, Svedala
(organization) VA SYD	Kommunikatör/ Communicator	Interview, telephone	Burlöv, Malmö
Lunds Renhållningsverk (Lund)	Kommunikatör/ Communicator	Interview, telephone	Lund

In addition to the representatives listed above, three municipalities wished to remain anonymous, and a representative from SYSAV (different from the one listed above) answered a questionnaire on the behalf of two of these.

Interview results

Research Question 1: What developments have already been made by Swedish municipalities that fulfill the demands of the EU commission's plastic strategy, since before this strategy was presented?

Household-proximate and four-compartment sorting

> *"The good thing is the household-proximate sorting, we have two bins with a total of eight fractions, and it follows the EU waste hierarchy to sort waste close to the source, at the household. We've received very good results. The residual waste has decreased significantly."* - *Environmental Manager, Åstorp*

> *"What is however gratifying is that the citizen are through the use of four-compartment sorting in middle-Scania excellent sorters of plastics, and the amounts of sorted plastics for recycling is high."* - *Waste Coordinator, MERAB*

The Scanian municipalities have already made efforts to encourage their citizens to sort out their plastic waste separately to their residual waste. A theme that permeated all interviews was an attitude that sorting waste should be simple for the consumer. To accomplish this, all but one of the municipalities questioned said to have implemented or were in the process of evaluating or implementing *household-proximate four-compartment sorting,* meaning that single-family homes were given two bins with four compartments each where they may sort not only the plastic waste, but most types packages and food waste from the residual waste.

> *"We chose early to offer household-proximate collecting, meaning that if you have an estate then you also have two bins with four compartments in each where you may sort your plastics into one of the bins. This household-proximate collection has been A and O to collect waste in a good way."* - *Environmental Strategist, Helsingborg*

This kind of household-proximate waste sorting increased the sorted waste greatly according to all 6 municipalities or WMCs that spoke in further detail about this kind of sorting, when comparing to the previous system of having to take the waste to larger recycling stations. When speaking freely of what they would recommend to other municipalities, 8 respondents recommended household-proximate sorting.

> *"The four-compartment bins have gained much use across the country, and many municipalities have joined in. That is because the results in the actual sorting have been very good and have fulfilled FTI's requirements for purity."* - *Communicator, Lund*

None of the respondents that had introduced four-compartment sorting mentioned how effective the switch had been in exact numbers, however the interviewee from Vellinge, a municipality in the process of evaluating a switch to four-compartment sorting, notes that the total amount of materials sorted with such a system reaches between 80-90%.

The four-compartment sorting, however, is only used for single-family households, not larger apartment buildings with multiple households which is how a significant part of the municipalities' inhabitants live. This is a more difficult problem to handle, explains two of the interviewees, due to the waste sorting and collection being under the responsibility of the landlord*." Plenty of [multi-family] households have household-proximate sorting"* says the interviewee of VA SYD, but goes on to explain that the decision to implement such sorting is ultimately up to the landlord, and some of them decides against it due to the small size or the age of the buildings. In this regard, the municipalities are unable to do much more than provide information and advice to those landlords that want it.

Information

> *"I believe strongly in putting money in ad campaigns and information, and to use different channels, because we have a very wide group. We communicate with everyone that handles waste in the society."* - *Communicator, VA SYD*

> *"I believe the public awareness surrounding waste is very high in Helsingborg. Also, the will to help. Even if we always have to work with this question, because there will always be new generations and new citizen, so it isn't something you stop working with just because it works decently right now."* - *Environmental Strategist, Helsingborg*

Another important factor to succeed in sorted waste collection was giving out information to the citizens of the municipalities. 8 respondents said to have held some form of informational campaign to raise awareness about the sorting and collection of plastics, and an additional 4 said to have held similar campaigns about material sorting and collection in general. When answering freely about what had been most important to succeed in producing sorted waste, 5 respondents claimed information to the citizens was among the most important measures. Lund municipality, for instance, have expressed a public thanks to its citizens, *"Half of the work is done by the Lund-citizen themselves"* comments the interviewee from Lund. Additionally, 3 respondents claimed that when awareness was raised surrounding the sorting and collection of food waste some years ago, an increase in the sorting of packaging materials was observed as well.

> *"We noticed in 2007 when we introduced the sorting of food waste that when people began sorting food waste, we also gained a better sorting of all packaging. So where is the motivation, one wonders. Is the motivation in sorting and recycling at large, or to sort out a specific kind of material? We have worked with the motivation being the recycling at large." - Communicator, Lund*

However, this synergetic effect appears to be limited, as the respondent from VA SYD notes:

> *"I notice when I speak to friends, it is obvious to sort out food waste because we have spoken about it for six years approximately, but they're not so good at sorting out packages, which we have informed about but not had campaigns about."*

Second-hand sorting of residual household waste

> *"We have technology today, so it should work, not only for plastics but for everything else too. Imagine how easy it would be, the people would love us. If we're talking about the big four-compartment bins by the households then we see great quality of what is sorted there, but it's natural that people would think it's great if you could throw everything in one place and it was sorted afterwards." - Waste Coordinator, Vellinge*

> *"More and more technology is coming, it isn't on the agenda right now, but in the future, I see no impossibility in trying to, for example, opening all the bags and running them through a machine that sorts the waste afterwards. They are looking at the industrial waste right now, for instance, the same technology could probably be used to sort residual waste too." - Project Leader, SYSAV*

An area of potential improvement for the Scanian municipalities would be the sorting of residual household waste; the remains after the consumers have sorted their waste. None of the respondents said to do any form of second-hand sorting of the residual waste, instead the majority was sent to energy recovery without any further treatment.

> *"It is difficult to access, due to it being the responsibility of the consumer. If crap comes in, then crap comes out, if it isn't sorted then we don't have any ways to sort it afterwards." - Project Leader, SYSAV*

While there is a lot to gain from second-hand sorting, 30% of packages end up in the residual waste according to the respondent from VA SYD, there are still concerns to address;

> *"It is difficult to second-hand sort, especially the plastics because it has a requirement of purity. When everything is mixed with food waste and 'you name it' there is partly a work- and safety hazard due to the uncertainty of what it in it, but also it would have required a pretty thorough cleaning process" - Project Leader, SYSAV*

Overall, the impression given by the respondents on this subject was that the idea of second-hand sorting of residual waste would be a possible future advancement, however it was not currently looked at or worked with by any municipality or WMC.

On the other hand, while it is not the ultimate responsibility of any of the WMCs, second-hand sorting of plastic waste into different fractions depending on the type of plastic is possible, according to the interviewee from NSR, as they describe the process after the plastic waste has moved on from the WMC;

> *"The plastics go through new technology that uses infrared light which tells you what plastic the product contains so that stream can be treated separately. Soft plastics are blown away, then they use the new technology to identify different types of plastics. After that its granulated and sold as new raw material."*

6 of the other respondents mention that their plastic waste is sent to Förpacknings- och Tidningsinsamlingen (FTI) after collection, though none go into further detail of how the plastic waste is treated there.

Which actions does Swedish municipalities plan to make going forward to meet the requirements of the EU commission's plastic strategy, related to demands on collection and sorting of plastic waste?

> *"There isn't anything new that comes because of the strategy to us, there wasn't anything revolutionary other than it is coming from the EU, and the fact that is it a strategy that everyone shall follow and work towards."* - *Project Leader, SYSAV*

Respondents from two municipalities and six WMCs said to have known about the EU commission's plastic strategy before they were contacted for this study, however none claimed to have taken any actions as a result of the strategy itself. This is likely due to several factors; for one, the strategy is still new and is to be reviewed by higher Swedish governmental instances before decisions are made on how Swedish municipalities as a whole are to work with the strategy. Secondly, the plastic strategy is not legally binding, and so far, lacks enforcing incentives from the EU level. Thirdly, the strategy does not propose any changes that would revolutionize the waste management of plastics in Sweden, and is steering waste management in the same direction many of Scania's municipalities and WMCs were already working towards. Finally, due to the reliance on contractors to manage their waste, many of Scania's municipalities have contracts lasting for several years into the future which prevents them from performing any major changes to their waste management systems in the near future.

As it stands, even though none of the respondents said to have taken any actions as a direct result of the strategy, the universal opinion was that the municipalities and WMCs would have worked to fulfill similar goals to those of the strategy regardless of if the EU commission would have presented the strategy or not. Furthermore, none of the respondents claimed their respective municipality or WMC were currently planning to implement any big and unique changes to the way they collect plastic waste. Instead, those in the process of changing their ways of waste collection were planning to do so by switching to household-proximate sorting, as mentioned previously.

How have Swedish municipalities worked in the past when developing solutions to similar requirements on their waste management infrastructure?

> *"We have one waste management company, and we have given out information and given the accessibility to the citizen to sort as easily as possible."* - *Environmental Manager, Åstorp*

> *"We have 850 newspaper bins placed by the street network in the municipality. We have really good numbers of newspaper collection here in comparison to other Swedish municipalities. It is because it comes close by; that is what I see as the greatest factor of success. That you have something close by. It should be easy to do right."* - *Waste Coordinator, Vellinge*

It was of interest to this study to investigate how the municipalities had handled the sorting and collection of other types of waste too, in order to see if similar methods could be applied to plastics. The most obvious example was the management of food waste, as it was recently enough introduced for it to still be fresh in people's minds, but long ago enough that conclusions could be drawn of which methods worked effectively. A drawback of this correlation may however be that food waste is generally easier to separate from residual waste, and does not share the same demands of cleanliness. Just as previously, a common answer to this question was the importance of information to the citizen, but additionally, 5 respondents referred to the idea of making it easy for the consumer to do right. With this concept comes easy to understand instructions of how to sort waste, and readily available and accessible ways to sort it; which goes together with the household-proximate sorting as described previously. In this regard, plastics face a difficult problem in how it may be difficult for the consumer to properly separate. The interviewee from VA SYD puts it:

> *"The most difficult thing to communicate is actually the plastics, because all the other packaging material can be recycled almost to 100%. Metal, glass, newspapers, paper packages… You can recycle a paper package 6-7 times, that's how long the paper fibers last. But plastics is a bit trickier, because there are so many different kinds of plastics."*

A different idea was brought forth by the interviewee of SYSAV, harkening back to how Sweden managed the issue of landfilling organic waste:

> *"There have been much going on about how you can't landfill freely, for example that you couldn't landfill organic materials. Legal demands have been very effective there, everything was solved over a day, more or less."*

They continue:

> *"Now it's time to take the next step. I think to get really big changes [to the waste management of plastics], a legal demand is probably needed there too, enforcing."*

What attention has been given to the waste management of biobased and/or biodegradable plastics by Swedish municipalities?

> *"That problem has not even been solved by the producers. We can't do anything about that problem until they themselves open up a recycling line for degradable plastics, that is a whole science in itself."* - *Communicator, Lund*

> *"In terms of incineration there is absolutely no issue. There it's just better if it's biobased, since it's carbon neutral, just fire it up. But if we look to the recycling then there is of course a challenge, or potentially a challenge."* - *Project Leader, SYSAV*

> *"As a [waste] collecting company I see no problems, but I see a huge problem with recycling. I think that if they can't solve this, then it will probably kill all plastic recycling."* - *CEO, NÅRAB*

Lastly, the respondents were questioned about biodegradable and biobased plastics; what issues they see and if any measures have been taken to separate these bioplastics from the regular waste stream. None of the respondents claimed to currently be doing anything to separate the bioplastic waste from the fossil-based plastic. In terms of issues, the biobased plastic was deemed fine aside from the possibility that consumers may be confusing it for biodegradable plastics according to one respondent. The biodegradable plastics on the other hand faces several issues; 5 respondents expressed concerns of what the consumer might expect of biodegradable plastics, as they may expect them to degrade naturally if thrown away in nature. Related to this, 5 respondents mentioned issues if these plastics are put into the organic waste management systems, as the digestion

plants that most Scanian municipalities rely on for their organic waste treatment does not degrade biodegradable plastics like an industrial compost would. Lastly, 5 respondents mentioned issues with recycling, as degradable plastics are not fit for traditional recycling and currently contaminates recycling streams. 3 respondents were unaware of any issues with the biodegradable plastics.

Summary of the interview results

- Household-proximate and four-compartment sorting has by far been the most popular method for effective and clean sorting of all household waste from single-family households.
- Accessing the waste of multi-family households is more difficult due to it being the responsibility of the landlord, not the municipality.
- Household-proximate sorting is largely accompanied with ad campaigns and information given out to citizens through different channels to promote household sorting of waste.
- None of the municipalities have implemented measures to sort residual household waste second-hand in order to recover materials that escaped household sorting due to technical limitations, work hazards and financial unviability.
- On the other hand, technologies to separate different types of plastic waste second-hand in to pure fractions fit for recycling is being used to some extent.
- Scanian municipalities appreciate a strategy coming from the EU-level, but have not taken nor expect to be taking any specific actions because of it, due to the municipalities already working closely with sorting, collecting and recycling plastic waste.
- To fulfill previous demands of sorted waste, many municipalities adhere to the idea of "easy to do right", meaning they make it easy for their citizens to sort their waste correctly by providing information and accessible household-proximate sorting.
- Some municipalities see that biodegradable plastics face many issues as it is not currently fit for recycling; additionally, that consumers may mistakenly dispose of such plastic among the organic waste or in nature.

Discussion

Whilst conducting this study, an underlying question of how relevant the EU commission's strategy for plastics in a circular economy really is for Sweden arose, in regard to the sorting, collecting and recycling of plastic waste. Sweden has for many years already worked towards an effective recycling system and is close to the EU commission's plastic recycling goal of >50% by 2030, having already reached 42.2% as of 2016 (FTI, 2017). Several Scanian municipalities in particular appear to be doing well in this regard, being represented by 9 of the 30 municipalities with the highest rate of sorted plastics that were sent to recycling according to FTI collection statistics of 2017 (FTI, 2018a), although some misrepresentation may occur due to certain municipalities not relying on FTI for end-treatment of their plastic waste, such as those managed by NSR in this study. The effectiveness of the four-compartment sorting varies between municipalities and on what you measure. A common measurement is the amount of residual waste before and after implementation of the sorting system, since the assumption is made that the removed waste is instead sorted by material type. ÖGRAB reported in a public message after their first year of using four-compartment sorting that the residual waste had been reduced by over 20% (ÖGRAB, 2017). Similarly, an early study investigating the different municipalities managed by NSR showed results that household-proximate sorting increased the amount of materials separated and left to recycling, however the exact amounts were difficult to determine (Dahlén et. al, 2006) It is, however, important to remember that the municipalities are only responsible for a part of the material recycling process. Improvements the municipalities make in sorting and collection of plastic waste may only be as good as the recycling industry's capacity to then process said waste into recyclates, and for the economic viability to sell this recovered material back to producers.

Another point of interest when considering how Sweden has approached the issue of collecting waste is when comparing its measures to those recommended by the EU commission (Annex 1). The EU commission puts a focus on economic instruments such as taxation, extended producer responsibility and deposit schemes. Sweden in this regard has opted almost entirely on the legal requirement of extended producer responsibility, producers share a legal responsibility to collect and manage plastic waste from packages (FTI) which drives the cost of the end-product up for the consumer, thus acting as an incentive to consume fewer

products, or products that produce less waste. The actual collection and management of waste is however only possible if the consumer does the initial step of sorting their household waste to begin with. The consumers too, have a legal requirement under the extended producer responsibility to sort their household waste (2011:927, 24 a § & 24 b §), however this law may be difficult to enforce in practice, and there are few other incentives, especially economic ones, to encourage the consumer to sort their waste beyond a limited deposit scheme for beverage containers (Pantamera). To tackle this, Scanian municipalities at large introduced informative and "convenience-enhancing" measures beyond what is legally required by the municipalities (2014:1073, 58 §), rather than economic incentives to encourage the consumers to sort their waste. It is possible that these measures have built a social expectation among citizens to sort their waste. This would in turn be enhanced further via the use of household-proximate sorting for single-family households that several municipalities have implemented, due to it becoming very visible to others how much a household sorts their waste, simply by looking in its assigned bins. It may be speculated if these measures incentivized by meeting a social expectation to a household's neighbors are more cost efficient than other more enforced measures, seeing as it cuts out the need for personnel to enforce such measures.

The plastics industry is facing difficult challenges in the coming future. Biodegradable plastics are already an issue when it is mixed in with other recyclable plastic materials, and additional issues were raised concerning how biodegradable plastics will not degrade if thrown away in nature or in digestion facilities among other organic waste. It would therefore seem today that the only suitable way of disposing biodegradable plastics, to those without access to industrial composts, would be to toss it in the residual waste for energy recovery, which arguably defeats the purpose of biodegradable plastics in the first place. In June 2017 the Swedish government appointed an investigation focusing on the negative environmental effects of the production, usage, waste management and material recycling of plastics (Regeringen, 2017). Later, in March 2018 this investigation highlighted the issues of plastic littering and biodegradable plastics disposed of incorrectly (Statens Offentliga Utredningar, 2018). So far, it is still unclear what actions must be taken to tackle these problems, and what role the Swedish municipalities will play. The problem of littering was similarly raised by the EU commission's plastic strategy, and will most likely gain more attention by the municipalities in the future. As for biodegradable plastics the responsibility may fall on the producers of such products, to clearly label and rename their products to easily inform the consumers of how it is to be disposed. However, from the consumers' perspective, an additional issue was raised in the interviews about separating biodegradable plastics from regular plastics. For the consumer to have to stop and read on every plastic package to see if it is biodegradable and then sort their plastic waste accordingly goes against the motto many

municipalities have worked for; “easy to do right”. One respondent expressed the worry that consumers may be “exhausted of packages”, explaining that additional demands for sorted waste on the households may cause unrest among the citizens, and a backlash effect of people simply not bothering to sort anymore may occur. The future is not entirely dark for biodegradable plastics, however. Second-hand sorting may be the solution to get the best of both worlds; pure fractions of separated types of plastics, and quick and easy sorting for the consumers. FTI has announced a new state of the art plastic sorting facility set to be established in the Swedish city of Motala, claiming to be the most modern facility of its kind in Europe by the time it planned to be taken in to full use in 2019 (FTI, 2018b). In a presentation of the facility by FTI they claim the facility will be able to separate different fractions of plastics, highlighting specifically “bioplastics” (Naturvårdsverket). Beyond the capability of sorting and treating plastic waste for the region, this facility may also play an important role as a test project to other nations of the world.

The way forward for Sweden in regard to managing plastic waste may not be obvious. Throughout the interviews in this study, many respondents claimed they did not have specific plans for the coming future, but were always looking for ways to improve their ways of sorting and collecting plastic waste. It may be that in the near future, if facilities such as the one in Motala prove to be effective, the question will not be “how do we manage plastic waste?”, but rather “how do we reduce plastic waste?”, a question that has already gained attention among producers and consumers today. Regardless, based on the results of this limited study it is impossible to answer the question of how relevant the EU commission’s strategy for plastics in a circular economy is to Sweden in regard to sorting, collecting and recycling plastic waste. However due to the success of many of Sweden’s already implemented measures in this area, it would be important to not miss the relevance Sweden might have to the strategy in return; to set examples and to show other nations of the EU tested methods that may work elsewhere too.

It is of my personal opinion that the strategy aims too low to have an impact on Sweden. I think we currently run the risk of underperforming what we would be able to do, if we only aim for a minimum of 50% recycling of plastic packaging considering the FTI statistics of 42.2% already in 2016. It would instead be better to set a significantly higher national goal and run the risk of failing to reach it. The purpose of such a goal is after all to increase and optimize rates of recycling, not celebrate arbitrary numbers. However, for a study designed such as this one, it is important to remain critical of the interview results. It is possible to get a skewed perspective of reality, in this case a too positive one. Due to the specific focus on sorting and collecting plastic waste for recycling, different important issues may not be highlighted. It depends heavily on the design of the interviews,

but also the knowledge and interests of the interviewees, which for many interviewees in this study were primarily the sorting and collecting of waste. For instance, it is possible that further increased recycling is not the most important issue to the municipalities in managing plastic waste. With limited resources, it may be more important to the municipalities to focus on improving the prevention and collection of littered waste, considering the governmental investigation highlighting these issues specifically. This may be especially true for Scanian municipalities as many of these share coastlines that are of special interest to keep free of litter, due to their social values and risk of sea littering.

Conclusion

Sweden has already come far in its work to sort and collect plastic waste, and is well on its way to meet the EU commission's goal of at least 50% plastic waste recycled by 2030 as presented by the EU commission's strategy for plastics in a circular economy. This has come as a result of the Swedish municipalities working actively to implement measures that make it convenient and easy for the consumer to sort their waste, primarily through household-proximate sorting with four-compartment bins where the consumer may sort most kinds of packages based on its material. This is also possible through a well implemented extended producer responsibility system, which helps ensure that there are facilities in place to turn the plastic waste into plastic recyclates fit for sale. Potential areas of improvement lay in second-hand sorting of residual waste, as no such measures are currently implemented. This would allow materials the consumer fails to sort to be turned to recycling instead of energy recovery, without putting additional responsibility on the consumers which would go against the motto of "easy to do right". As it stands, Sweden and the Swedish municipalities will, based on the results of this study, not make any significant changes to its way of sorting and collecting plastic waste as a result of the EU commission's strategy; the measures proposed by the strategy are simply no longer relevant to Sweden at its current state. The Scanian municipalities interviewed have claimed that consumer information, and making it easy for the consumer to do right has been important when tackling previous demands of sorted household waste. Collection of food waste, which may be correlated to plastic waste due to its need for consumer sorting and special recovering facilities, have seen great improvements due to such actions. Though a drawback of this correlation is that food waste may generally be easier to separate from residual waste, and does not share the same need of cleanliness. Regarding bioplastics, the concerns raised have been related to how to handle biodegradable plastics, since they are today not fit for recycling, nor do they biodegrade in nature or in digestion facilities together with other organic waste. Therefore, biodegradable plastics currently need to be separated from other plastic waste, something which goes against the motto of "easy to do right" if demanded of the consumer. However, improvements in technology, and the establishment of a new plastic sorting facility in Motala, may prove to provide a solution to this issue, and furthermore might serve as an example to plastic sorting in other nations going forward.

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Annex 1: List of measures recommended to national authorities and industry by the European Plastic Strategy, cropped to focus on the plastic recycling which is of interest to this study. (Source: European Commission, 2018)

List of measures recommended to national authorities and industry

Key measures to improve the economics and quality of plastics recycling
National and regional authorities are encouraged to: ➢ favour reusable and recycled plastics in public procurement; ➢ make better use of taxation and other economic instruments to: – reward the uptake of recycled plastics and favour reuse and recycling over landfilling and incineration – step up separate collection of plastics waste and improve the way in which this is done ➢ put in place well-designed EPR schemes and/or deposit systems, in consultation with the relevant sectors ➢ make voluntary commitments in support of the strategy's objectives, in particular as regards the uptake of recycled plastics
Industry is encouraged to: ➢ take concrete steps to improve dialogue and cooperation across the value chain, in particular on material and product design aspects ➢ make voluntary commitments in support of the strategy's objectives, in particular as regards the uptake of recycled plastic

Annex 2: Interview questionnaire

1. Hur familjära är ni med EUs nya plast strategi?

Läget idag

1. Hur hanterar kommunen idag insamlingen av plastavfall?
2. Vad händer med plastavfallet efter det samlats in? (Återvinning, sortering?)
3. Hur hanteras hushållsavfall efter det samlats in? (Utsortering av material, etc.)
4. Görs det något speciellt för att sortera ut nedbrytningsbara plaster ur plastavfallet?
5. Gör kommunen något speciellt för att motverka nedskräpning?
6. Har kommunen gått ut med några informationskampanjer angående insamling/sortering eller nedskräpning av plast?

Utefter EU-strategin

1. Har kommunen några planer på att förändra sin plastavfallsinsamling i framtiden? (Hur då i så fall?)
2. *(Beroende på tidigare svar)* Planerar kommunen att införa någon form av sortering av plastavfallet (Vad/varför inte?) / Anses sorteringen av plastavfallet idag vara tillräcklig? Finns det planer på att förbättra den?
3. *(Beroende på tidigare svar)* Planerar kommunen att införa någon form av sortering av hushållsavfall? (Vad/varför inte?) / Anses sorteringen av hushållsavfallet idag vara tillräcklig? Finns det planer på att förbättra den?
4. Finns det planer för att specifikt sortera ut nedbrytningsbar plast från plastavfallet?
5. Förutser några problem med biobaserad plast?
6. Har kommunen planer på hur de ska motverka nedskräpning i naturen?
7. Finns det planer om informationskampanjer till allmänheten angående insamling/sortering eller nedskräpning av plast?

Tidigare åtgärder

1. Hur har kommunen hanterat tidigare krav på in avfallshantering? (Ex. insamlingen av matavfall eller pantburkar)
2. Finns det något kommunen har gjort som ni tycker andra kommuner kan ta lärdom av?