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UNITY

Is it possible to replace all of today's plastic variants with a smaller number?

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Preface

The unique properties of plastic mean that it can play an important role on the way to a more sustainable, circular and resource-efficient future. At the same time, plastic has gained a large global use in society and has come to symbolize the wear and tear of the consumer society as it is often used in short-lived products that are produced in large volumes and then thrown away. The development of various types of plastic has so far been based on desired material properties without thinking about future needs for recycling or reuse.

Material recycling of plastic is low today. The big fundamental problem is that there is a large variety of different plastics, all with different combinations of additives – all to give the specific plastic the desired properties, for example, with regard to hardness, colour, fire propensity and quality. As there are such large quantities of different types of plastic that all have different quality, this leads to several problems with the possibility of material recycling and disposal of recycled raw material.

Starting from design and with a focus on thermoplastics, this project has studied whether it would be possible to replace the large number of different thermoplastic variants with a smaller number that have higher performance and clear specific properties. This also includes studying the problem with coloured plastic. A smaller number of plastic variants, with higher performance and clear characteristics, is assumed to provide several benefits, for example easier logistics and separation, higher volumes of plastic that can be recycled and increased recycling value, which together are expected to provide environmental benefits and economic gains for the actors involved in the recycling.

The project has been carried out by Mattias Lindahl, Ellen Lundin and Erik Sundin, all at Linköping University and Rajni Hatti-Kaul at Lund University. The project is co-financed by Vinnova, the Swedish Environmental Protection Agency and Avfall Sverige, Swedish Waste Management. Mistra REES and STEPS have also participated as collaborative partners.

Malmö in November 2022

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Chairperson Avfall Sverige, Swedish Waste Management , Development Committee

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Abbreviations and explanations of words

	Acrylonitrile-Butadiene-Styrene
Advanced plastics	High-performance plastics or plastics with the best properties
Basic plastics	Plastics that are manufactured in large quantities and that have a wide use in society, for example PE, PP, PET, PS and PVC (SPIF, 2007)
Converters	Plastic processors
EVA	Ethylene-Vinyl-Acetate
EVOH	Ethylene vinyl alcohol
LDPE	Low-density polyethylene
NIR	Near infrared, technology that sorts the plastic so that it can be recycled (Swedish Plastic Recycling, 2022)
PA	Polyamide
PC	Polycarbonate
PE	Polyethylene
PEEK	Polyetheretherketone
PEF	Polyethylene furanoate
PET	Polyethylene terephthalate
POM	Polyoxymethylene
PP	Polypropylene
PPS	Polyphenylene sulfide
PPSU	Polyphenyl sulfone
PS	Polystyrene
PSU	Polysulfone
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
REACH	An ordinance dealing with registration, evaluation, permits and restrictions of chemical substances and requirements for users of chemicals (Kemikalieinspektionen, 2022)
Simple plastic type	Basic plastic or plastic with only a single additive or color
SIS	Styrene-Isoprene-Styrene
SIS	The Swedish Institute for Standards, project leads the Swedish work on developing standards (SIS, 2022)
Thermoplastic	Plastic that melts. Compare with thermoplastics that burn at high temperatures.
Tool	The mold (usually metal) used to form a plastic part by injection molding (the most common method of making plastic parts)

Abstract

The purpose of the Unity project is to investigate the attitude of the players in the plastics industry toward the possibility of reducing the number of variants of thermoplastics. To achieve the aim, literature studies and an interview study with a subsequent workshop have been carried out. Within the interview study, 63 respondents in the plastics industry were interviewed, ranging from manufacturers of thermoplastics and thermoplastic products, buyers, sellers, trade associations, and recycling companies to researchers and experts.

The results from the Unity project show that a reduced number of thermoplastics would result in higher volumes of base plastics for those who recycle plastics, allowing them to sell larger volumes of more consistent, higher-quality recycled plastics at a lower price. This would, in turn, lead to higher-quality recycling, as it should also be easier to collect and sort the plastics. In addition, financial benefits can also be obtained throughout the value chain. Challenges that have been highlighted include that both producers and consumers of thermoplastic products have high expectations for the quality of the thermoplastic. If producers and consumers can accept the quality that future recycled thermoplastics provide, it increases the possibilities for more recycled thermoplastics to be used in society.

The results also show that it is possible to make a natural reduction in the number of thermoplastic variants within the plastics industry, but that this needs to be supplemented with the introduction of new laws and standards to achieve the potential environmental and economic benefits that a reduction in the number of thermoplastics can bring.

Through the interview study and the subsequent workshop with players in the plastics industry, the following action proposals were developed to enable a reduction in the number of variants of thermoplastics:

- Make requirement specifications for plastics less harsh where possible.
- Standardize more industry-wise and product-wise and only allow a certain selection of plastics, especially manufacturers with few suppliers, that are more likely to agree to use a limited number of plastics than manufacturers with many suppliers.
- Manufacturers of plastic products can actively try to cut down on the number of plastics they use; for example, lists such as the EU's Substances of Concern or the Candidate List of REACH can be used as a basis for which plastic variants may be reasonable to phase out.
- Introduce labelling systems that facilitate sorting for individuals.
- Use transparent and recycled plastic where possible.
- Use transparent plastic in combination with labels rather than colouring entire packages.
- Design products that enable recycling.
- Expand producer responsibility for plastic products.
- Expand the deposit systems for plastic products.
- Introduce tariffs on imported plastic.
- Introduce quota obligations on recycled plastic.

The proposed measures can be implemented separately or in combination with each other. A more detailed description of these action proposals can be found in Section 11.6. Within the project, it also emerged that more studies need to be carried out at the product or industry level to investigate which thermoplastics should remain after a reduction in their number and which specific material properties are desirable.

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1 Introduction

1.1 BACKGROUND

Plastic has come to symbolize the wear and tear of consumer society as it is often used in short-lived products that are produced in large volumes and then thrown away. The global use of plastics is constantly increasing, and in 2018, it amounted to almost 360 million tonnes, of which close to 62 were produced in Europe (PlasticsEurope, 2019). The main raw materials in production are crude oil (petroleum) and the condensed form of natural gas, as well as fossil energy, which together make up about 6% of the total use of fossil raw materials but which contribute large quantities of greenhouse gases (equivalent to about 1.8 gigatons of CO_2 equivalents globally 2015) (Hatti-Kaul et al., 2020; Zheng & Suh, 2019). If plastic use continues at the same rate, plastics are expected to account for 20% of total fossil oil consumption, with the associated greenhouse gas emissions rising from 1% to 15% of the global annual CO_2 budget by 2050.

Plastic is a collective name for a relatively large group of semi-synthetic or synthetic materials which, since the middle of the 20th century, have gained a large global use in society. Put simply, plastic mainly consists of one or more polymers mixed with one or more additives (additives). A polymer is a large molecule made up of many small molecules bound together to form a long chain. Plastics can be divided into two main groups, thermoplastics and thermosetting, of which the former is the largest group from the point of view of use. Examples of thermoplastics are acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), polyethylene (PE), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polymethyl methacrylate (PMMA), polypropylene (PP) and polystyrene (PS). Thermoplastics soften when melted and can be reshaped, whereas thermoplastics cannot be melted down without destroying their chemical structure because the plastic is hardened during its manufacture. From a recycling perspective, thermoplastics are therefore more useful materials.

The properties of the plastic can be modified relatively easily by adding additives, and therefore plastics can be created for a large variety of different uses. Examples of additives that are added to give the plastic certain properties are reinforcing materials, fire protection additives, dyes, insulators, plasticizers, antioxidants, stabilizers, and density or volume-changing additives.

The large number of different plastic variants with different additives that are used and mixed in various products causes major problems when waste management wants to recycle the plastic material. It becomes largely impossible to distinguish clear plastic fractions with specific material properties. If you succeed, the individual volumes of each separated plastic fraction will be very small, making it difficult to find an actor who can reuse the plastic as these usually require larger volumes and clearly specified material properties. The consequence is that they instead use virgin plastic raw material, which increases the amount of plastic waste that cannot be recycled and thereby increases CO_2 emissions from both the production of virgin plastic raw material and when waste is incinerated. In order to have a more circular and climate-neutral industry and society, we must bring about a change in this, which is also the starting point of the Unity project. Plastic is not bad in itself, but the problem is how we use this valuable material in our society.

1.2 PLASTICS IN A CIRCULAR ECONOMYI

The circular economy is an economic system that aims to eliminate waste and continuous use of new resources. Circular systems utilize the reuse, sharing, repair, renovation, remanufacturing and recycling of products to create a more closed-loop system, reducing the use of virgin resources and the creation of waste, pollution and CO_2 emissions. The circular economy aims to keep products, equipment and infrastructure in use longer and thus improve the productivity of these resources.

This regenerative approach stands in stark contrast to the traditional linear economy, which is based on a "take-make-dispose" – that is, the "wear-and-throw" society that plastic has come to symbolize.

The unique properties of plastics mean that they can play an important role on the way to a more sustainable, circular and resource-efficient future. Light, versatile and durable plastics can help save important resources such as energy and water in addition to raw materials and leave a lower CO_2 footprint in strategic sectors that include, for example, packaging, buildings and construction, vehicles, renewable energy and healthcare. In addition, plastic applications in packaging can help reduce food waste and maintain sterility. However, to improve the circularity of plastic, it is important to ensure that more plastic material is recycled and does not end up as waste. If the plastic becomes waste, it is recycled as energy, but it is partly of lower environmental benefit than material recycling the plastic, and partly it does not support the waste industry's and municipalities' goals of fossil-free energy recycling. As the world's use of plastic is constantly increasing, it is important to have an efficient material recycling of plastic while constantly trying to make the recycling even more efficient.

The development of plastics has so far focused on desired material properties without considering the need for reuse or recycling. Today, only some types of thermoplastics, about 5-10%, are recycled, and many problems must be overcome to achieve more efficient recycling.

A major fundamental problem, therefore, is that there is a large number of different plastics, all with different combinations of additives, and this leads to several problems in material recycling. On the one hand, there are relatively small volumes of each specific plastic; on the other hand, all the plastics are mixed (which have different properties linked to additives involved) in such a way that it becomes difficult to separate them in material recycling. All in all, this makes it difficult to manufacture a new product based on recycled plastic as it is not possible to determine exactly which type of plastic, as well as which additives the recycled plastic contains and which material properties it has.

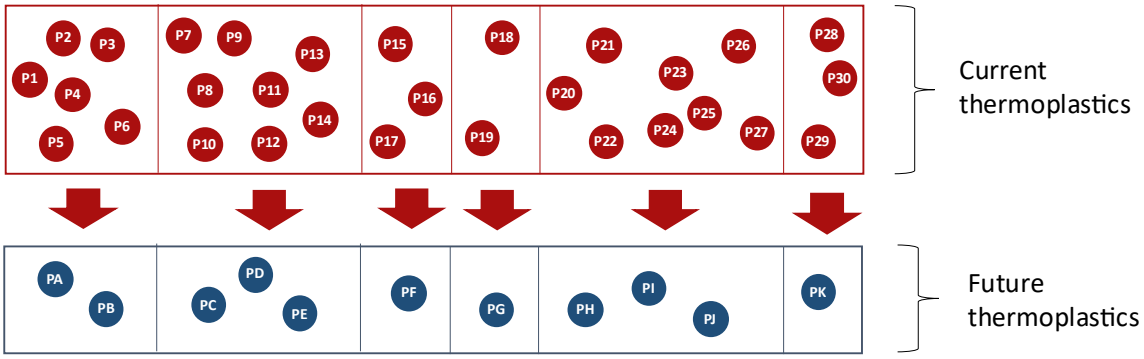
For Sweden, this means that, out of the plastic, with an original value of SEK 10 billion, which is disposed of each year, 84% is recycled or deposited after use (Material Economics, 2018b). Of the 16% that becomes new plastic, only roughly half of the original value is preserved as the quality deteriorates. This means that only 8% of the original total value remains. Instead, large parts of the plastic are recycled for energy, with resulting large CO_2 emissions. The fact that so much plastic is recycled into energy is a problem for the Swedish waste management industry as it wants to achieve freedom from fossil fuels, and this will not be achieved if nothing is done about the current residual management of used plastic.

At the same time, starting work in the waste stage to reduce the amount of plastic that goes into energy recovery is too late in the value chain. In order to deal with the problem that so much plastic is recycled into energy, it is necessary to change the way plastic products are designed, as it is in the design that its future environmental impact is determined (Hatti-Kaul et al., 2020). When designing the product, it is determined which plastics and associated additives will be used, how that product and plastics will be produced and used and for how long, as well as the possibilities of being able to reuse or recycle the product (for example, in that the plastics are easy to access and distinguish). Examples of design measures that can reduce the problem are making the plastics easier to disassemble and sort, marking products for sorting, and, not least, the use of a smaller number of plastic types, which is proposed in this project, which makes it unique.

1.3 PURPOSE AND QUESTIONS

The hypothesis this project is based on is that it is possible to merge the current varieties of thermoplastics with regard to their material properties and replace these with partly new, partly existing varieties of thermoplastics that cover a similar spectrum of material properties but be fewer in number. Figure 1 illustrates how one can, in principle, go from 29 to 11 variants of thermoplastics. The purpose of the Unity project is to investigate, based on the design of products, whether the players in the plastics industry think it is possible to reduce the number of thermoplastics used in the plastics industry.

Figure 1. Illustration of an example of how the current thermoplastics can be grouped according to similar properties to then be replaced by a smaller number of partially new plastics.



A smaller number of plastic variants, with higher performance and clear characteristics, is expected to bring several advantages, for example, simpler logistics and separation, higher volumes and increased recycling value, which in total is expected to provide environmental benefits as well as financial gains for the actors involved in plastic recycling. The environmental benefits are, among other things, reduced use of virgin plastic raw material, which leads to a reduced amount of plastic waste that cannot be recycled and thus reduces CO_2 emissions from both the production of virgin plastic raw material and waste incineration. An economic advantage of recycled plastic with high performance and specified properties in combination with large volumes is that it then becomes more interesting for companies to reuse the plastic in new products. From a socio-economic perspective, there are also several advantages with reduced costs due to the CO_2 problem and littering.

To achieve the purpose of the Unity project, the report highlights the following research questions (RQs):

RQ 1.	What are the largest volumes of thermoplastics in products?
RQ 2.	What are the advantages and challenges of a high-quality reuse of thermoplastics in products?
RQ 3.	What consequences would a smaller number of thermoplastic types have for producers of products with plastic in them and for Swedish waste management, both from an environmental and an economic perspective?
RQ 4.	How could today's large number of thermoplastics be replaced with a smaller number that have high performance and clear specific characteristics with fewer required non-toxic additives and that are easier to recycle?
RQ 5.	What requirements for performance and specific properties should the fewer future thermoplastics have?

2 Methodology

2.1 OVERALL METHOD OF IMPLEMENTATION

To answer the purpose and questions, two literature studies and one interview study have been carried out. In the Unity project, terms such as less complex plastics or more advanced plastics are used. The term less complex plastics refers to, for example, basic plastics or plastics with only a single additive or colour, while the term more advanced plastics denotes high-performance plastics or plastics with the best properties.

2.2 LITERATURE STUDIES

Two literature studies have been carried out to get an overall picture of previous and ongoing research as well as research articles in the field. The literature studies are based on search results from Science Direct, Google and Google Scholar for keywords such as plast, termoplast, cirkularitet, resurseffektivitet, högpresterande plaster, färre plastsorter and more. Corresponding English translations were also used, that is, plastics, circularity, resource efficiency, high performance plastics and fewer plastic types.

2.3 INTERVIEWS

Semi-structured interviews were conducted with respondents in the plastics industry between October 2021 and March 2022. The following types of actors and companies were interviewed:

1. Manufacturers (M): those who manufacture plastic products that consist wholly or partly of plastic. It can be both those who manufacture components or a finished product, for example, building materials, car parts, packaging, plastic raw materials, plastic sheets, plastic boxes and electrical products.
2. Sellers (S): sellers and retailers who purchase products that consist entirely or partly of plastic and resell them to consumers.
3. Purchasers (P): those who purchase products made entirely or partially of plastic and use them themselves in their business, for example, as packaging or in consumer products.
4. Recycling companies (R): those who collect and or recycle plastic products.
5. Trade organizations (T): industry organizations linked to plastics or large-scale use of plastics.
6. Researchers and experts (E): people who are considered to have expertise linked to plastics, recycling or the circular economy.

The six different types of respondents were selected by the Unity project members. During the interviews, the respondents were also allowed to make suggestions about respondents whom they thought should be interviewed. To get a comprehensive picture of the plastics industry, respondents were identified from small to large companies as well as from different industries. The Swedish Plastic Industry Association (SPIF) and its members were used to obtain respondents.

The questions to the respondents vary slightly depending on their role in the plastic system. However, the questions focus on what challenges and opportunities exist with the idea of reducing the number of varieties of thermoplastics. The respondents were not given access to the interview questions in advance. The interview questions asked of the various actors are described in Appendix 1 – Interview questions.

The interview study included 63 anonymized respondents and was conducted via the internet and telephone. On some interview occasions, a number of respondents from the same company participated. Table 1 reports from which industries within the plastics industry the respondents in the interview study come.

Table 1. Account of which industries the respondents operate in and the size of the companies[1]. *M stands for manufacturers, P for purchasers, S for sellers, T for trade associations, R for recycling companies and E for researchers and experts.*

Industry	Respondents	Company size
Agriculture	T5	-
Assorted products	M2	Average
	M5	Small
	M6	Small
	M16	Small
	M17	Small
	M23	Small
	M27	Small
Chemicals	T4	-
Children's toys	M31	Small
Construction industry	M4	Average
	M14	Large
	P3	Large
	P4	Large
	P8	Large
	T1	-
	T2	-
Electronics	M1	Large
	M20	Small
	S1	Large
Food	S2	Large
Hygiene and healthcare	M11	Large
	M13	Average
	P1	Large
	P5	-
	P6	-
Municipality	P2	-
Packaging and storage	M3	Average
	M7	Small
	M8	Average
	M12	Average
	M18	Average
	M19	Small
Plastic raw material	M24	Large
	M25	Small
	M26	Average
Profiles and boards	M9	Small
	M22	Small
	M29	Small
Recycling	R1	
	R2	Large
	R3	Average
	R4	Small
	R5	-
Researchers and experts	E1	-
	E2	-
	E3	-
	E4	-
	E5	-
	E6	-
	E7	-
	E8	-
	E9	-
	E10	-
	E11	-
Traffic	P7	Large
	P9	-
Vehicles	M10	Average
	M15	Small
	M21	Large
	M28	Small
	M30	Small
	S3	Large
	S4	Large
	T3	-
Total number	**63**	

1 The EU definition of small, medium and large companies is used and reads: small companies: companies with fewer than 50 employees and an annual turnover or balance sheet total that does not exceed EUR 10 million; medium-sized companies: companies with fewer than 250 employees and an annual turnover not exceeding EUR 50 million or a balance sheet total not exceeding EUR 43 million; large companies: exceeds the above-stated values.

2.4 WORKSHOP

After the interview study, a workshop was organized to get feedback on the action proposals to which the interview study led. The workshop lasted two hours and had 10 participants whose industries are reported in Table 2 below.

Table 2. Below is shown in which industries the workshop participants work.

Workshop participants' industries with respective interview respondent numbers	
Experts	Nr 4 and 6
Manufacturer	Nr 7, 16 and 24
Purchaser	Nr 7
Recycler	Nr 3 and 5
Seller	none
Trade organizations	Nr 3 and 4
Total	**10**

The structure of the workshop was that the participants first had to introduce themselves to each other and the Unity project was briefly presented. Then followed two longer discussions moderated by one of the representatives from Unity. The first discussion was about whether the conclusions and proposed measures are correct, what challenges exist around them and what may need to be done about these challenges. The points that laid the foundation for the discussion are as follows:

- A reduced number of plastics would lead to higher volumes of the base plastics for those who recycle plastics, whereupon they can sell larger volumes of a higher percentage of recycled plastics with more consistent quality at a lower price. This would, in turn, lead to higher-quality recycling, provided that collection and sorting work well.
- In addition, economic benefits can also be achieved throughout the value chain. Challenges can be that both producers and consumers have unsustainably high expectations for quality. Therefore, a further opportunity to replace today's large number of thermoplastics with a smaller number is if producers and consumers could accept the quality obtained from using recycled plastics.
- Major challenges are also connected to the recycling system and that it may be necessary to introduce legislative changes and standards in combination with the reduction of plastic variants for it to have an effect.
- Is this correct? What challenges are there? What needs to be done?

This was followed by a discussion about what is needed to move forward. The following points formed the basis for the discussion:

- How can we move forward?
- Who should do what?
- How can we collaborate?
- Influence the standardization / Industry?

3

Action plans and results from previous studies of plastics

3.1 SWEDEN'S CURRENT ACTION PLAN FOR PLASTICS

In February 2022, the Swedish government issued an action plan for plastics with 55 measures to make plastic use more circular and have less impact on the climate and the environment (Regeringkansliet, 2022). The action plan presents four different focus areas. The first focus area is called "production and product design of plastics and plastic products" and includes measures such as making it more expensive to put plastic packaging that is difficult to recycle on the market or that standardization is to be used as a tool to make plastic use more circular. The government must also propose global standards for plastic products on an international level, and the government must work for an ambitious product policy framework as well as new requirements for the design of packaging within the EU.

The second focus area is "consumption and use of plastic and plastic products", which includes, for example, that certain plastic products must have information requirements about how the product must be handled when it has become waste and that the Procurement Authority must focus on how information about circular and fossil-free public procurement is disseminated out to companies.

The third focus area is "non-toxic and circular cycles of plastic and plastic products". It includes measures such as a commitment to sustainable plastic management, an improved packaging collection and a ban on burning plastic that has been separately collected to be prepared for either reuse or recycling.

The fourth and final focus area is "a driving force for business and other actors who promote innovation and circular business models for plastics and plastic products". It includes, among other things, research and innovation for plastics or investment in strategic innovation programmes. The government's goals include that Sweden shall become the world's first fossil-free welfare country, lead the way, and show that a fossil-free world is possible.

Furthermore, the Swedish Environmental Protection Agency (2021b) has also developed a roadmap for sustainable plastic use, which was published in May 2021. The roadmap is based on existing legislation, strategies and goals from Sweden, the EU and globally and aims to be used as a basis for decision-makers. There are four focus areas for the roadmap: raw materials and production with minimal environmental impact, smart use of resources, reduced leakage of plastic into nature and greatly increased and high-quality material recycling. For each focus area, the Swedish Environmental Protection Agency describes what the focus area must contribute to, indicators for follow-up and what changes must take place in that particular area. The overall target image for these is that plastic is used in the right place, in resource- and climate-efficient, non-toxic and circular flows with negligible leakage in order to achieve a more sustainable use of plastic. The changes that the Swedish Environmental Protection Agency has identified for each area are described below.

Table 3. Need for change as identified by the Swedish Environmental Protection Agency (2021b) in the roadmap with the current situation in the left column and what it needs to change to in the right column.

Smart use of resources

Current situation	Future situation
Disposable plastics	Reusable in both plastic and other materials.
Linear business models.	Resource-smart business models and design principles.
Unnecessary use and much waste.	The benefit that plastic can provide is used effectively, e.g., by starting from which function is to be achieved and identifying more resource-efficient opportunities to do so, avoiding unnecessary use and waste, increasing the lifespan of products, sharing, etc.
Wear and throw away.	Used products are reused.

Raw material and production with minimal environmental impact

Current situation	Future situation
Almost all plastic is made from fossil raw materials.	Predominantly contain recycled and/or bio-based material in products. High requirements for non-toxicity for recycled as well as virgin raw material. Management towards bio-based raw materials being able to replace fossil raw materials without biodiversity and other ecosystem services being negatively affected.
Primary plastics and product design do not fully bear the costs of negative externalities from a life cycle perspective.	The cost of materials and products also includes the cost of the environmental and climate impact.
Lack of knowledge about content and environmental performance.	Clear and easily accessible information about products' content, origin, environmental impact and how they can be recycled or taken care of.
Lack of design for circularity and minimal environmental impact, including the presence of particularly hazardous substances.	Lack of design for circularity and minimal environmental impact, including the presence of particularly hazardous substances.
Ignorance of the meaning of concepts such as "degradable" and "bio-based".	Good knowledge of which plastics fit where, in terms of opportunities to minimize environmental impact from a life cycle perspective.

Strongly increased and high-quality material recycling

Current situation	Future situation
Plastic is the main cause of greenhouse gas emissions from waste incineration. Less than 10% of plastic used in Sweden is material recycled.	Material recycling of plastic makes a significant contribution to reaching climate goals.
Controls and systems have previously focused on collection volumes and mixed flows.	Focus on enabling material flows for the production of recycled raw material of demanded quality. As part of this, create plastic flows with well-defined composition suitable for material recycling, including control of hazardous substances throughout the value chain.
Lack of logistics solutions.	Well-developed logistics, including smart loops.

Reduced leakage of plastic into nature

Current situation	Future situation
Plastic leaks into and accumulates in the ocean and nature, and a systematic effort to counteract the leakage of plastic globally is lacking.	Established global practices for reducing plastic leakage, including standardized measurement and analysis methods.
Lack of knowledge about flows and effects inhibits the development of control instruments and measures to reduce the leakage of microplastics.	Knowledge base that enables the assessment of risks and cost-effectiveness for measures to reduce the leakage of microplastics.
Many businesses lack knowledge about opportunities to reduce leakage of microplastics	Measures to reduce the leakage of microplastics are implemented.
Collected plastic in some cases leaks into nature or is incinerated/dumped in uncontrolled ways.	Not accepted to litter. Waste crimes are prevented and punished.

In summary, the Swedish Environmental Protection Agency (2021b) writes that significant changes are needed to achieve the development needed in the area of plastics, including increased collaboration for the development of system solutions, that the product design is completely rethought for many products and changes to existing business models, a more resource-smart use and an increased collection for material recycling.

3.2 THE EU'S CURRENT ACTION PLAN FOR PLASTICS

The measures included in the EU's plastics strategy can be divided into four categories (European Commission, 2018). The first category is to improve profitability and quality in plastic recycling. It includes measures that can be divided into the subcategories of measures for better product design, measures to increase the proportion of recycled material and measures for better separate collection of plastic waste. The next category is to limit the generation of waste and litter. It consists of measures to reduce the use of single-use plastics, measures against marine-based sources of marine litter, measures to more effectively monitor and reduce litter at sea and measures for compostable and biodegradable plastics. The third category is steering investments and innovation in the direction of circular solutions. It includes measures to promote investment and innovation in the value chain. The final category is measures to leverage global efforts. This includes measures in special regions, measures to support multilateral plastic initiatives, measures in bilateral cooperation with countries outside the EU and measures relating to international trade.

3.3 PREVIOUS STUDIES

Two literature studies have been carried out. The first literature study deals with the identification of the largest volumes of thermoplastics in products, as well as challenges and advantages in obtaining a high-quality reuse of these for new products. The second literature study examines the possibility of replacing the current large number of thermoplastics with a smaller number that have high performance and clear, specific properties.

3.3.1 Identification of the largest thermoplastic volumes in products

The Environmental Protection Agency's mapping of plastic flows in Sweden shows that the largest plastic flows are, in descending order, from packaging, the construction sector, vehicles,

electronics, deposit bottles, and the agricultural sector (Ljungkvist Nordin et al., 2019). Textiles are, to some extent, included among those flows. However, the largest flow is other plastic products, which, among other things, includes plastics in healthcare items, toys, household items, sporting goods and furniture.

The five plastics are PE, which is mainly used in packaging, plastic film, toys and agricultural plastics; PP, which is mainly used in car parts, caps and packaging; PS in insulation and packaging; PVC in windows, pipes and floors; and PET in bottles and packaging. However, other plastics make up about 26% of the total plastic use, and among them are included products such as furniture, screens, glasses and hubcaps. Material Economics (2017) also states that areas that give rise to large flows of plastic are packaging, the construction sector, vehicles, electronics and other areas.

3.3.2 Advantages of fewer thermoplastics

In a "discussion brief" from Lund University, Nielsen et al. (2018) put forward five different proposals for a more sustainable use of plastics, and one of the proposals is precisely to have fewer plastics. According to Nielsen et al. (2018), the proposal would result in the plastic system becoming significantly less complex, whereupon cleaner plastic flows and an improved recycling and reuse of plastic would be obtained. Having a plastic system consisting of fewer types is also believed to be able to increase the recycling rate as the risk would be reduced that plastics with low recyclability are mixed in flows with plastics with high recyclability.

Material Economics (2017) also believes that higher volumes and an increased recycling value would be obtained from using more of a smaller number of plastic types, as they conclude that recycling the five largest types of plastic in Sweden could preserve at least 40% of the plastic's value in contrast to today's 13%. To implement this, they mention measures such as standardization and prioritization of the right kind of plastic in the right place.

Stenmarck et al. (2018) believe that cleaner flows increase the recycling rate for the plastic in question because if the sorting process turns out to be too expensive, it becomes unprofitable to even try to recycle. In addition, cleaner flows also mean a higher guarantee of quality for the secondary plastic. Furthermore, Stenmarck et al. (2018) brought up the example that PET plastic collected from recycled beverage packaging results in a cleaner flow which will thus retain higher quality and get greater use as secondary plastic than the PET plastic from a more mixed flow would have.

Members of Circular Sweden write that more and more companies see the benefits of developing circular products and services (Ahlvar et al., 2021). The benefits are mainly financial gains for both companies and society through an increased use of recycled material, a reduced material consumption, avoidance of hazardous substances, designing for increased lifespan and designing the products so that they can be easily repaired, upgraded and material recycled.

Material Economics (2018a) describes that most plastics are recyclable, and recycling saves 90% of the CO_2 emissions that would be generated by manufacturing new plastics. Furthermore, Material Economics (2018a) believes that the combination of reuse and recycling could supply 60% of the plastic demand in 2050 and halve CO_2 emissions. To make this economically attractive, the focus needs to be on procuring systems that enable high-quality recycling so that the plastic's value is better preserved when it is recycled.

3.3.3 Challenges with fewer thermoplastics

Critics of the proposal to use fewer types of plastic believe, firstly, that there is a risk that the plastic can no longer be used as advantageously as today and that it would hinder future developments in the area (Nielsen et al., 2018). Second, critics claim that reducing the number of plastics or choosing only one plastic is a naïve approach that would rather likely increase the use of resources in general. Furthermore, critics also believe that the approach involves a material substitution that would not be beneficial because, many times, the advantages of plastic outweigh the disadvantages, for example in some food packaging. Critics also point out the difficulties that exist around who should decide which plastics are allowed and under what conditions this should take place. It should be possible to introduce more deposit systems like for PET to create completely clean, closed loops for more plastics, but at the same time, it is completely dependent on actors agreeing on principles and priorities before it can become a reality.

Mattias Lindahl, program manager for Mistra REES, believes that if plastic is to exist in a circular economy, it is not enough to increase material recycling (Mistra Summerar, 2020). What is required is rather that the number of types of plastic must be reduced, products must be designed for reuse and recycling and plastic must be used where it is really needed and not where other materials are better suited. Since plastic is a long-lived and durable material, it becomes problematic when it is mainly used in short-lived products that are also often contaminated during use, which in turn means that the incentives for material recycling are basically non-existent. Even if the material recycling rate were to increase, plastic would not necessarily be able to be included in a circular economy because the reduced quality during recycling means that new plastic must still be added to each recycling loop in order for it to be used for something new. That particular problem is becoming a big one, partly because plastic is used a lot in short-lived products and partly because there are thousands of types of plastic today that are mixed and make recycling even more difficult.

The market for recycled plastics is uncertain; for example, Material Economics (2017) points out that the manufacturing companies say they cannot get hold of recycled plastics that meet their requirements as the quality, traceability and transparency of recycled plastics decrease. At the same time, producers of secondary plastic claim that there is neither demand for recycled plastic nor willingness to pay for the upgrade that could raise the quality. The situation, combined with the fact that there is no long-term solution for how secondary material markets should be managed, makes the market unreliable for investments in recycling facilities and new technology. According to PACE (2021), the demand for recycled plastics needs to increase first because it is still price and quality that drive customers the most.

3.3.4 Possibilities to replace the current large number of thermoplastics with a smaller number

An example of a possibility is that Material Economics (2017) proposes to create circular flows for the five types of plastic that together make up 70% of Swedish plastic use. Another example is that in 2017, the British retailer Marks & Spencer undertook the Plan A 2025 strategy, which consists of two commitments: firstly, that all their packaging must be 100% recyclable by the year 2022, and secondly that they must develop a strategy for and start using only one type of polymer for all their types of packaging (Packaging News, 2018).

Already in 2017, the packaging in their food range consisted of only three types of plastic, and then they had come to the conclusion that if they were to limit themselves to just one plastic, it either needs to be able to be blow-moulded, extruded or shaped. Currently, there are pilot projects where a type of plastic called PEF, or polyethylene furanoate, is to be used.

A further possibility is when high-flying "moon shot ideas" may be the approach needed, as addressed in a report by the World Economic Forum et al. (2016), as they believe that it may now become relevant to invest in things like finding a "super polymer" that is both cheap, has high performance, has many functions and should work optimally for reuse.

Furthermore, Nielsen et al. (2018) mean that to implement the actual reduction in the number of plastics, special additives that are difficult to recycle should be phased out, it should be marketed to create products from only one kind of material, the number of plastics allowed for specific products should be limited and innovations that contribute to complexity in the plastic system should be ruled out.

The Nature Conservation Society (2021) writes in the report The right plastic in the right place that in Sweden, producer responsibility applies to eight product groups: batteries, cars, tires, electrical and electronic products, packaging, pharmaceuticals, radioactive products and recycled paper. They believe that a potential solution to a more sustainable use of plastic is to extend producer responsibility so that more product groups are included so that the seller is obliged to accept old, used goods and recycle them. It would create incentives to design sustainably right from the start so that the products are easier to both reuse and recycle materials. A further possibility is that the Nature Conservation Association (2021) proposes to label plastic products with a QR code. There would be information about the content of the product, which thus follows all the way from the manufacturer to when the plastic is to be recycled. Then it would be easier to get clean plastic fractions, whereupon recycling is facilitated, and the material does not lose as much value.

Holmberg et al. (2021) investigated Swedish public opinion regarding plastic policies. Their key points for policy-makers include that there is generally strong support for tackling the problems associated with plastics and that regulation of plastics should, therefore, not be abandoned for the sake of it. Furthermore, they believe that it should start with introducing soft policies with very high support but at the same time communicating the vision of a more sustainable use of plastic. They also state that there is clear support among Swedes for both an extended deposit system and a tariff on imported fossil-based plastics.

Katrin Molina-Besch, former assistant university lecturer at the department of packaging logistics at Lund University of Technology, also believes that in order for the food industry to be able to use more recycled plastic, one or more completely closed recycling systems or an improved sorting guarantee that it is precisely food packaging that becomes new food packaging again (Orkla, 2021). In this way, food safety is guaranteed, and with a better recycling system, it is also not necessary to use as much renewable raw material to produce new packaging, but a closed recycling system is created instead, just like for PET packaging.

3.3.5 Focus and questions for new and ongoing studies

The table below shows a selection of ongoing or new projects with different approaches to somehow achieve a more sustainable use of plastic.

Table 4. Selection of new projects linked to sustainable plastic use in Europe.

Project	Country	Brief description and results
Circpack (2017-2020)	Spain	An EU-supported project that strives to develop a more sustainable and efficient plastic value chain that is less dependent on fossil products. This shall be done by working with compostable plastics to facilitate the collection and recycling of multi-layer materials and multi-layer packaging. In the end, the project also wants to work across several sectors so that the vehicle sector is also affected (Circpack, 2022a). Biodegradable plastics with a high proportion of renewable resources have been tested, and several products meet the requirements. They have shown that it is possible to create sustainable multi-layer packaging for detergents or plastic trays. A new method has also been developed to increase the recycling of plastic (Circpack, 2022b).
CIRCULAR FoodPack (2021-2024)	Germany	The project aims to create closed loops for food packaging. The project investigates recently developed sorting techniques (Tracer-based and Sensor-Based), focusing on different types of dry goods (CIRCULAR FoodPack, 2022). Based on the sorting techniques, they can produce high-quality PE from recycled material (Circular Economy, 2022).
CREAToR (2019-2023)	Germany	A project that focuses on removing dangerous, already banned flame retardants from waste streams from mainly the construction industry and electronics in order to more easily reuse the plastic (CREAToR, 2020). Collects plastics from the construction sector and electronics, removes the flame retardant and recycles the material (CREAToR, 2022).
Economic transition from virgin fossil plastics (-2021)	Sweden	The goal is to get a better picture of the potential for change in companies and what role a means of control, e.g., investment support, can have in realizing that potential. The goal is also to get proposals for the design of control measures that reduce the use of virgin fossil plastics, e.g., controls suitable for combination and how they would look or controls that should not be combined (Naturvårdsverket, 2022). Based on the interviews held, it emerged that the needs in the market today are that there is a need for more facilities for recycling, an increased demand for recycled material, support for product development, increased access to recycled and bio-based raw materials and traceability of the material (Naturvårdsverket, 2021a).
MANDALA (2019-2022)	Spain	Aims to develop a new adhesive that should have both barrier properties and be easy to dissolve in order to create multi-layer packaging that is easier to recycle (European Commission, 2022).
MERLIN Project (2021-2024)	Spain	The project aims to design innovative solutions for all processes required to increase the quality and rate of recycling of multilayer packaging. The plan is for the sorting, separation of the layer, recycling and validation of the quality to be improved (Merlin, 2022).
MIX-UP (2020-2023)	EU, China	MIX-UP is short for “mixed plastics biodegradation and upcycling using microbial communities” and wants to use it to achieve circular plastic handling with bioplastics (MIX-UP, 2022).

Project	Country	Brief description and results
Multicycle (2018-2020)	Spain	The project aims to increase the recycling rate and the value of recycled plastic by creating a pilot facility for the recycling of multi-layer packaging of both fossil and bio-based plastics and composites with fibre reinforcement. The process must use a new solvent that has not been used before (Multicycle, 2022b). Halfway through the project, small-scale pilot experimentation has begun, plastics and composites have been recovered from waste and processed to be reused in packaging and cars later in the project, and a photonics-based system for classifying waste is under validation. The pilot plant was planned to be in use in autumn 2020 (MultiCycle, 2022a).
PlastiCircle (2017-2021)	Spain, Netherlands	Twenty European organizations have joined together to develop innovations around waste collection, transport, sorting and recycling of plastic packaging, and among other things, they develop new packaging, more cost-effective transport systems and sorting systems (PlastiCircle, 2022). The recommendations from the project are to introduce an incentive to use recycled plastics, but not in packaging, to allow non-packaging industries to use collected packaging that is not otherwise recycled and to legislate to favor recycled plastics or to limit the use of virgin plastics (PlastiCircle , 2021).
PolyCE (2017-2021)	Germany	PolyCE stands for "post-consumer high-tech recycled polymers for a circular economy" and is a project supported by the European Commission which consists of 20 organisations. With a focus on electronics applications, the project wants to, among other things, demonstrate a possible circular model for such plastics, develop a rating system for recycled plastics to serve as guidelines when designing new electronic products, and develop sustainable materials and additives suitable for reuse and recycling. (PolyCE) Has developed 31 guidelines for plastic parts in electronic products to create an easy access to them and to remove hazardous substances in the components (PolyCE, 2021).
STEPS	Sweden	Shall facilitate the transition to a more sustainable use of plastics by sharing knowledge between academia, industry and society (Mistra Steps, 2022).
TRANSFORM-CE (2019-2023)	UK, Belgium, Netherlands, Germany	A project that involves creating new products from used disposable plastic through additive manufacturing and intrusion-extrusion moulding to create a more circular economy (Interreg North-West Europe, 2022).
UPLIFT (2021-2025)	Denmark	Aims to convert packaging waste into more renewable polymers that should be easy to use again with the help of depolymerization (UPLIFT, 2022).

Based on the plastics research projects that have been identified and which are briefly reported in Table 4, it can be stated that there is a lot of research on plastics with a focus on, for example, the production of bioplastics and improved plastic recycling. However, there are no ongoing studies concerning the Unity project's hypothesis of reducing the number of variants of thermoplastics. In addition to the research projects, research articles have also been identified on studies connected to sustainable plastic use in Europe; see Table 5.

Table 5. Selection of research articles on studies related to sustainable plastic use in Europe.

Title	Author	Brief description and results
Bioplastics for a circular economy	Rosenboom et al. (2022)	Explores the benefits and challenges of using bioplastics to transition to a circular economy. Advantages and challenges are discussed. They believe that identification standards and guidelines need to be revised and become more homogeneous. In addition, more regulation is needed, and financial incentives are still necessary to increase the use of bioplastics.
A review of the plastic value chain from a circular economy perspective	Mathilde Rosenberg Johansen et al. (2022)	Examines the current scientific literature linked to the entire plastics value chain to create an overview of the current research associated with moving to a more circular model, as well as to see where gaps exist in the research. A high percentage of the literature focuses solely on waste management, which indicates that other life cycle phases do not receive as much attention. Future research needs a holistic approach to move to a more circular system through careful mapping of implications and stakeholders and their engagement. Future research needs a holistic approach to move to a more circular system through careful mapping of implications and stakeholders and their engagement.
Promising Developments in Bio-Based Products as Alternatives to Conventional Plastics to Enable Circular Economy in Ukraine	Shevchenko et al. (2022)	Aims to present current trends and challenges with bioplastics and bio-based materials as sustainable alternatives to plastic. The results showed the potential of bio-based plastics to facilitate the transition to a circular economy in Ukraine. This can be done, for example, by using innovative solutions that have not yet received much attention, or by increasing the discussion and bridging the knowledge gap between developers, academics and the plastics industry, or by identifying the main challenges and future perspectives for further research.
Drivers and Barriers to the Circular Economy Transition: the Case of Recycled Plastics in the Automotive Sector in the European Union	Baldassarre et al. (2022)	Focuses on drivers and barriers to using more recycled plastics in the automotive sector within the EU, more specifically with regard to the ongoing assessment of the End-of-Life Vehicle Directive (ELV Directive). Through analysis of literature and in-depth interviews with the entire plastic value chain (including vehicle manufacturers, suppliers, recyclers, experts and trade associations), drivers and barriers to recycling have been identified. The results contribute to how circularity can be increased in the automotive sector within the EU, and the results can serve as a template for how similar barriers and driving forces can be identified in other sectors to cover the knowledge gap. A follow-up with more specific results will take place.
Plastics in a circular economy: Mitigating the ambiguity of widely-used terms from stakeholders consultation	Aubin et al. (2022)	Aims to strengthen measures to develop new strategies to replace oil-based plastics by examining the definitions of the terms “bio-based plastics”, “bioplastics”, “biodegradable plastics” and “plastic recycling” to reduce the ambiguity of the concepts. The conclusions are that more discussion is needed to clarify the meaning of the words as they advise against using, for example, “bioplastic” for the general public as it is perceived as confusing.

Title	Author	Brief description and results
Agri-Food Wastes for Bioplastics: European Prospective on Possible Applications in Their Second Life for a Circular Economy	Visco et al. (2022)	Focuses on opportunities to use food waste from agriculture to produce either building blocks for bioplastic manufacturing or biofillers that can be mixed with other bioplastics. The high number of EU-funded projects for the recovery of agricultural waste and good European practice show that there is a growing interest in reducing pollution. However, there are problems, such as the correct labelling of bioplastics and how they should be separated from the fossil ones.
Romania's Perspectives on the Transition to the Circular Economy in an EU Context	Dobre-Baron et al. (2022)	Aims to emphasize Romania's perspective on the transition to a circular economy with regard to EU tendencies. Indicators are produced in agreement with EU guidelines: generation of waste excluding major mineral waste per consumption of household materials; recycling rate of municipal waste; the degree of use of circular material; gross investment in material goods – percent of GDP. Analyses of the data show that there are good conditions for Romania to be able to improve its circularity in the long run.
Transition from waste management to circular economy: the European Union roadmap	Chioatto and Sospiro (2022)	Analyses EU members' road maps to sustainable waste management and circular economy. France, Germany, Italy and the Netherlands are examined with regard to criteria, methods, policies, implementation and outcomes for sustainable waste management at the national level. In order for the countries to be able to close the loops, they conclude that a greater amount of secondary material needs to be taken back to the manufacturers, and for that, measures are needed that do not only concern waste management.
The road to sustainable use and waste management of plastics in Portugal	Prata et al. (2022)	It has been investigated how Portugal can create a better waste management of plastic. The current recycling rate of plastic packaging needs to increase to reach the EU average. In addition to increased recycling, pyrolysis and gasification could provide short-term alternatives to producing new products from plastic waste.
Why pledges alone will not get plastics recycled: Comparing recyclate production and anticipated demand	Kahlert and Bening (2022)	Analyzes the current flow of PET from production to recycling in the EU and shows that the promised volume of recycled PET to be used in the EU in 2025 requires the annual recycling rate to double in the coming years compared to 2014-2018. They also believe that the introduction of a deposit system for bottles is not enough, especially when increasing demand from other industries pushes the price to more than packaging manufacturers are willing to pay. Significant investments and regulations are needed.
Technical and environmental performances of alternative treatments for challenging plastics waste	Arena and Ardolino (2022)	The article describes new techniques for recycling, for example, flows of mixed plastics, multilayer materials or composites with fibre, and compares their environmental impact. A life cycle analysis has been performed focusing on new treatments for dissolution/precipitation, supercritical fluid extraction, catalytic pyrolysis and waste-to-energy combined with CCS. In particular, recycling with dissolution/precipitation seems to have good potential.
Reusability and recyclability of plastic cosmetic packaging: A life cycle assessment	Gatt and Refalo (2022)	Investigates the environmental impact of plastic packaging for cosmetics and examines whether it is more sustainable to design an extremely durable product that can be reused multiple times or to utilize dematerialization.

4

Results from interviews with manufacturers of plastics and plastic products

4.1 MOST USED THERMOPLASTICS

A clear majority of manufacturers mainly use between one and five types of plastic. Including additives and colours, the majority believe that their total number is between 10 and 100 variants. A few use less than ten variants in total, and a few use over a hundred variants. The varieties most used are PP, ABS, PE and PA.

4.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF A SMALLER NUMBER OF THERMOPLASTICS

4.2.1 A higher-quality reuse of thermoplastics in products

M25 claims that the process of recycling itself is expensive. If standard plastics were to increase among recyclers, combined with a better design for recycling, M25 believes that recyclers would be able to sell more recycled at a cheaper price. The manufacturers also relatively agree that the reduction would lead to lower prices for the plastic because the manufacturers would then be able to buy larger volumes of each type of plastic. However, M9 believes that if the reduction would lead to an increased price for the plastic, there is a risk that if the customers do not accept it, they might switch to aluminium or some similar material instead.

4.2.2 Challenges with the transition

M1, from a large company that manufactures products, believes that their products last so long that there is really no incentive to change plastics. In addition, it is difficult to make such a change only in Sweden because they and many others are multinational companies, which is pointed out in many interviews. M2 believes that it may be a challenge to get an acceptance for lower requirements. They believe that customers would like to manage themselves but that the cost issue is often too great. M8 also believes that customers are the bottleneck because they are conservative, and neither buyers nor engineers want to change something that already works. Furthermore, M8 believes that cost is a challenge as they have looked at alternatives to PP that could cover three out of four plastics they use, but that the price is too high.

Furthermore, M8 believes that a further challenge is that the industry is looking for new materials because there is a demand. M27 also believes that companies like to be cautious about taking risks and that they want their secrets to be more competitive. M25 also points out that some industries may not have an alternative to the plastic they currently use. Several manufacturers influence the challenge of producing the right type of plastic so that it works for many.

4.2.3 Consequences for manufacturers

Positive potential effects often mentioned are lower costs for manufacturers because larger volumes of the same plastic can be purchased instead of small volumes of many different ones and that a smaller supply would lead to lower inventory costs. Several manufacturers also believe that it would lead to lower set-up times, but also a higher capacity in the factory and less waste as it can be more profitable to recycle the plastic internally. Furthermore, the machines can be made more efficient if they only use one plastic because they can then optimize the process according to that particular material. It would also be significantly easier to choose which plastic a customer should use if there were fewer variants. A further argument is that fewer variants mean that the employees do not have to learn different specific runs so that all employees can be equally good at the laying on of hands required in the manufacturing process, as opposed to having only one employee who is particularly good at a more complicated process.

Negative effects could be that different manufacturing processes require different viscosities, and therefore M22 points out that there is a risk that fewer types of plastic may mean that something will still need to be added so that the plastic has the right fluidity for the manufacturing process. A further challenge with a reduction could be that customers get fewer choices, which could lead to them switching manufacturers. A smaller supply could also lead to increased competition among manufacturers so that they either need to completely change their direction or are forced to shut down. In addition, it can take several years to develop the products again if a different material than the one used today is to be used instead. If the cycle time increases, more new machines are also needed to manufacture more products at a time to keep efficiency up. In addition, one manufacturer believes that one of the reasons for wanting a certain variety is that sometimes when manufacturing plastic products, the geometry is not quite right when it solidifies. Then this may need to be compensated for by changing to another similar type of plastic and seeing if it gets better. If there are not enough similar plastics available, the alternative may be to make new tools, which takes time and is costly, both for the manufacturer and their customers.

4.2.4 Consequences for the market

M3 states that the extreme case is that only one type of plastic is used everywhere, which would result in no competitive advantage, and the only manufacturer that survives is the one that can produce it the fastest. In the same way, M23 believes that a smaller number of plastic types can provide market advantages, as it is then rather in the interest of the granule producers to manufacture faster than to manufacture new types in order to sell more. If the rate of production increases in Sweden, M23 believes that it is more likely that the plastic granules can be produced in Sweden rather than imported, which thus provides environmental benefits.

M24 from the major manufacturer and M16, on the other hand, believe that because there are so many different manufacturers, some would disappear from the market as they are not needed if the number of plastics is reduced. M18 believes that Borealis, the only polyethylene manufacturer in Sweden, has no vested interest in manufacturing something they do not sell, and suppliers only manufacture what customers want, so the problem rather lies with the manufacturers and that the market would self-adjust to them.

4.3 POSSIBILITIES TO REPLACE TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

4.3.1 Requirements specifications should be able to be lowered

Just over 60% of the manufacturers who were asked the question believe that the products they manufacture themselves have higher requirements than what is actually necessary for their function and that the product could probably be manufactured from simpler plastics. Several manufacturers believe that some of their customers are afraid that their products will break or have quality defects that could affect them negatively, but that the customers are probably mostly aware that the products are somewhat overspecified. Several manufacturers believe that the reason for this is that the customers do not always have knowledge about the plastic materials, while other manufacturers believe that the reason is rather that it is easier, cheaper and faster to overspecify compared to testing to find which type of plastic is good enough. M24 from the large manufacturer also points out that the production cost could be reduced by, for example, making thinner goods or using a softer and, thus, perhaps also cheaper plastic.

Something that several manufacturers often consider to be overspecified is outer packaging. For example, M7 believes that such a thing should be made from a pure type of plastic, and several point out that one possibility is to make all outer packaging that goes in transparent plastic.

4.3.2 Manufacturers think they can get by with fewer plastics

21 out of 31 manufacturers think it should be possible for them to reduce the number of plastics they use. The majority of them think it should go but don't know by how much; four think they could phase out a particular variety, three think they could reduce the number by between 20-30% and the remaining three think they could halve the number they use, provided customers agree.

Manufacturers were asked if they have already reduced the number of plastics they use, and many responded that they have. For example, M2 says that one reason was that they wanted to avoid having so many different suppliers. M3 used to have 20 different variations on the top sheet, a packaging part, but today only has two. M13 claims that they have deliberately worked to have few varieties from the beginning. M28 has phased out a lot of additives and, in some cases, was able to use some plastic they already use a lot of as the requirements specifications of different customers do not differ that much. M22 believes that they would rather have large volumes of fewer numbers but that this is not always easy to achieve.

M23 adds that many plastics are basically identical but have different company names or brands. M30 also states that in the last 20 years, there have been many new plastics that have very similar properties and that therefore from the manufacturer's perspective it should be possible to reduce.

4.3.3 Manufacturing processes work with similar plastics

Several manufacturers believe that their manufacturing processes are flexible and work for more than one material; all that is needed is a trial run process to re-optimize the machine. Several manufacturers configure the machines so that they can handle several different plastics and can therefore manufacture products from different types of plastic in the same machine. All that is needed is a trial run process to re-optimize the machine between runs of different plastics. They point out that the process consists of the same steps; what differs between different types of plastic are only settings around parameters such as temperature and time.

According to M13 and M17, the machines are relatively general, but the moulds are made for a particular plastic, and therefore the mould may need to be adjusted if another plastic shrinks differently. Two manufacturers, in addition to M13 and M17, also point out the problem with mould casting and that the mould is made depending on the plastic used. Injection moulding means M4, on the other hand, works the same for a larger number of variants.

Several manufacturers believe that it is the viscosity and heat resistance that determine the processability. M9 explains, for example, that more expensive plastics usually withstand higher heat, and then other machines may be needed. M18 points out, however, that if the optimal process for each material is desired, a tool is needed for each material, but probably the optimal one is not always needed. What the manufacturers seem to agree on is that as long as the material does not change significantly, the manufacturing processes should still work without too much change.

4.3.4 Legislative changes that may be needed

Regarding which regulations are needed to promote a high-quality recycling of plastic, M22 believes that there needs to be someone who checks how much companies send to incineration because it does not need to be reported at the moment. M27 believes that recycled plastic needs to be food-approved in some way or to a certain extent. M7 believes that some legislation has hampered recycling, for example, because a company that made bags from recycled plastic went bankrupt when the plastic tax was introduced, even though the company did not use any new plastic raw material. Therefore, he rather believes that the tax should be placed on things that are actually made of fossil plastics. M16 believes that EU regulatory requirements and REACH regulations may be needed. M29 adds that voluntariness does not work, but regulations are needed. Several manufacturers also propose deposit systems for specific packaging.

4.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THESE THERMOPLASTICS SHOULD HAVE

The properties most often cited as important are impact strength, chemical resistance, processability, transparency, heat resistance and price. In general, the important properties are linked to the manufacturing processes working. Many manufacturers emphasize that which features are most important depends entirely on the product in question, and therefore it is impossible to answer which features are most important.

4.5 DISCUSSION

Manufacturers are the largest group of actors among the categories that have been interviewed, a total of 15 out of a total of 31 respondents. The result is judged to be relatively general, considering the variation among manufacturers' size and industries. Although the manufacturers have experience working in production and know what works in practice, it should be taken into account that the manufacturers are not necessarily experts in plastics.

According to the manufacturers, PP, ABS, PE and PA are the most common types of plastic. Worth noting is that all manufacturers indicate different numbers as the varieties they use most and that the manufacturers belong to very different industries. According to Material Economics (2017), PE, PP, PS, PVC and PET accounted for 70% of plastic use in 2015, and thus two varieties of the five have been identified as common varieties even by manufacturers. This shows that the respondent selection is large enough because the results for the most common types of plastic are relatively consistent with what previous studies have found.

One of the two manufacturers that produce new plastic from recycled plastic points out that a major advantage of reducing the number of types of plastic is that it would increase the volumes of base plastic they have. They further believe that, in combination with a better design for recycling, it could mean that they can sell more recycled plastic at a cheaper price. Because they work with both recycling and production of plastic raw material, that is, precisely where the consequences of reducing the number of plastics can have major effects, their opinions are considered to carry weight.

Something that is often highlighted is that the reason for today's large variance of thermoplastics is conservative customers and that buyers and technicians prefer not to change something that already works. Even if that is possibly true to some extent, it can also be interpreted as the manufacturers disclaiming responsibility for today's large variance of plastic types.

Regarding the possibilities for replacing today's large number of thermoplastics with a smaller number, many manufacturers seem to be positive that they could reduce the number they use since their customers have unnecessarily strict requirements specifications. The reason why unnecessarily hard requirements specifications arise seems to be because it is easier and cheaper to do so than to test yourself and make a new prototype for each test. That, combined with the fact that manufacturers believe they can get by with fewer plastics and that manufacturing processes still work with similar plastics, indicates that it is possible to make a reduction from the manufacturer's perspective.

Since all manufacturers work in different industries and have different requirements for the manufacturing processes to work, and because which properties of the plastic are most important depends entirely on the product in question, it is not possible to draw any conclusions about which properties would be most important. In general, however, it can be stated that as important aspects, the manufacturers mainly list material-specific properties, requirements needed for the material to function in their manufacturing processes and price.

Several manufacturers believe that, in the extreme case, for one or a few plastics to be able to function in all application areas, it needs to be an extremely versatile plastic. Such a reduction would probably not happen because it is not feasible for obvious reasons such as the cost issue or the challenge of producing a plastic with the right properties. It is, therefore, more likely that a reduction would begin with the removal of unnecessary variants where possible. The fact that many manufacturers believe that they could remove thermoplastic varieties they barely use, that many companies make basically the same plastic but under different names, and that they mention more standardization as a solution to a higher recycling rate means that a standardization of thermoplastics for different products and thus a reduction in the number is possible at either product or industry level.

5

Results from interviews with buyers

5.1 MOST USED THERMOPLASTICS

The most common thermoplastics in healthcare are, according to respondent P5, PE, PP, PVC and ABS. The products in question are tubes and catheters, blood bags, gloves, jars, bottles, test tubes, aprons and bags. Respondents P6 and P1, who also work in healthcare, agree. In the construction industry, packaging, rather than products used in the construction itself, make up a large part of the plastic products, say P3 and P4, who are both from large companies. According to P3 and P8, which both come from large companies, plastic products that are used can, for example, be pipes or PVC floors. In the traffic industry, plastics such as SIS and EVA are mentioned for road markings, but also that it is rather contractors who purchase the materials than, for example, the Swedish Transport Administration. The municipality P2 mentions that no mapping has been done with them regarding which types of plastic are used and where they are used, but that it is rather the suppliers who possibly have such information.

5.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF A SMALLER NUMBER OF THERMOPLASTICS

5.2.1 Within the construction industry

P3 describes that the challenge in the construction sector is that they receive kitchens, bathrooms and more in different deliveries, and it, therefore, becomes more difficult to sort. It is easy to separate the packaging plastic, but the plumber works in one place and the electrician in another. There is no physical space to be able to sort into many fractions at the workplace. Most often, it is the surface or the competence of the individual craftsman that limits it. If they sent a mixed fraction to the recyclers, they wouldn't sort it, P3 claims. There will also not be large enough volumes for it to be financially justifiable to send them back to the supplier, and it will also have to be stored somewhere in the meantime. P4, from a large company, believes that some form of law change is required. The new waste directive means that the sorting rate has increased. But the easier it is to sort, the better, so a smaller variance would only be good, they believe. P8, who comes from a large company, also tells us that there are rather demands on the end product and its function and that it should be possible to fulfil it in different ways with different plastics.

5.2.2 Within healthcare

P5 believes that from the perspective of healthcare, there are great advantages to the idea of reducing the number of types of plastic. It would simplify procurement, making it easier for them to make demands. One challenge, however, is that recycled plastic cannot be used in all healthcare products due to traceability requirements for medical devices. However, there are high volumes of high-quality plastic in healthcare, also often transparent or white. P1, from a large hospital, believes that a reduction would simplify all steps. According to the respondent, there is greater value in high-quality fossil plastics that can be recycled than in bioplastics that are simply burned up.

However, since the market is global, it can be difficult to agree on standardized plastics because the quality varies. Challenges also lie in getting everyone to follow the rules that are set. The advantages are that it would simplify flows if everyone did the same, and it would be easier to buy recycled plastic because it would be easier to trace what it contains.

5.2.3 Within municipalities

P2 believes that a reduction could eventually be feasible but that the big challenge is that there is an extremely large number of suppliers that need to be convinced first. According to P2, just changing from one product to another requires a lot of work.

It is not enough for the purchasing department to bring in reusable products instead of disposable products; it also needs to be explained why it is necessary or why they have purchased a product that may be more expensive than the one used before and to change habits.

5.2.4 Challenges with the transition

Respondent P7 from the large company believes that all industries are extremely niche and that it is, therefore, difficult to get everyone to cooperate. Companies also like to keep their own thermoplastic mixtures secret, and for the average customer, the content doesn't matter that much, and they don't really know either, he says. P9 believes that it might work for packaging but that it is then important that producer responsibility is maintained so that the packaging is also returned.

5.3 POSSIBILITIES TO REPLACE TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

5.3.1 Practical possibilities

Respondent P1 from a large hospital says that they had a project with Trioworld where they color-coded plastic aprons in healthcare to make that flow more circular and believes that there is interest in such ideas. P6 believes that it should be possible to reduce the number of plastic variants as long as the products still meet the functional requirements. However, they add that it is certainly different for plastics that are supposed to work inside the body. P5 agrees that function is the most important thing but that the focus should rather be on manufacturing products from one and the same plastic.

P4, from a large company, believes that it might have been possible to reduce the number of variants if they had only had a single supplier. Currently, however, they have a thousand suppliers who, in turn, buy from at least as many. Therefore, P4 believes that they themselves do not have the muscles to say that they only accept, for example, a certain type of thermoplastic. P3, from a large company, believes they should be able to reduce the number they use and another large company, P8, only uses PVC.

In the transport sector, P9 believes it depends entirely on what the alternative is. If a material has good durability and price, it can work. P7 from a large company believes that the two plastics they use for road markings could be replaced by one.

5.3.2 Legal amendments that may be necessary

Respondent P1, who comes from a large hospital, believes that colour coding products would make it easier for them to sort what can be sorted in healthcare, especially since many products in healthcare cannot be reused or sorted due to the hygiene aspect.

P4, from a large company, believes that with a reduction obligation, the plastics that are not recyclable would become less interesting to continue using, so the market might adjust itself over time. P8, also from a large company, believes that improved waste management would lead to a shift to more recycled material in products.

5.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THESE THERMOPLASTICS SHOULD HAVE

All three respondents who are purchasers in healthcare agree that it is important that the plastic withstands handling in hospitals. P1, from a large hospital, also mentions the tightness of the plastic, and P5 states that the plastic may preferably

be white or transparent. Among buyers in the construction industry, P3, who comes from a large company, believes that technical requirements and longevity are important. P4, also from a large company, believes that the cleaner the plastic, the better, and that it should preferably not be so coloured. P8, from a large company, also mentions the requirement for long durability and that the plastic meets environmental and chemical requirements.

Even the buyers in the transport sector believe that functional requirements such as longevity are important. P9 always chooses products with CE marking if that option is available. P7, from a large company, believes that properties such as flexibility and strength are important but also that the material is compatible with the other materials they already use. P2 points out that it is rather their suppliers who have information about which plastics are used and which requirements are appropriate.

5.5 DISCUSSION

Since only nine buyers were interviewed from a few different industries, the plastics mentioned as commonly used are not necessarily representative of reality. Exactly which plastics are used is not always mentioned, and the same applies to the requirements for properties and the performance of the plastics. Rather, it is specific product types or functional requirements that have been stated. This indicates that from the buyers' perspective, a reduction should be possible because it is rather the function of the products that is more important than the thermoplastic the product is made of.

In the construction industry, there are challenges, such as there being no surface at the constructions and renovations to sort the plastic on or that the knowledge of the individual craftsman is limited, and in healthcare, there is the challenge that recycled plastic cannot be used in their products due to the requirements for traceability. These challenges will most likely remain even if the number of plastic types decreases and will need to be addressed in order for the benefits but the reduction in the number of plastic types to be achieved.

As P2 mentions, an additional challenge is that there are many actors who would be affected by the reduction and who, therefore, probably need to be persuaded to agree to it. However, it would only be a problem if the reduction is based on voluntariness, but if demands are placed on the reduction, actors would not need to be persuaded. However, the introduction of such a requirement could meet resistance.

One possibility, therefore, is to deal with such challenges, including legislative changes. Additionally, several buyers believe a smaller number of thermoplastics could work for packaging. The advantages mentioned are also that more standards for what products may be made of would make the plastic waste flows more homogeneous, and then it would be easier to buy recycled plastic because it would be easier to understand what it contains.

6

Results from interviews with sellers

6.1 MOST USED THERMOPLASTICS

Among the sellers is white goods supplier S1, a large company that mostly uses variants of PP and ABS. S2 is a large seller in the food industry, whose largest plastic flows consist of packaging where the most common plastics are PET, PE, PP, PA and PS. In the automotive industry, it is mostly PP, PA, PET, and to some extent, ABS and PC that are used, says respondent S4 from the large company. S3, which also comes from a large company that manufactures vehicles for industries, mainly uses plastics such as ABS, PP, PC and PA.

6.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF A SMALLER NUMBER OF THERMOPLASTICS

S1 describes that they want to get plastic types that can work together. The idea that the Unity project is based on could be implemented, but not all applications will be optimal, so it will take a little more material and be a little more expensive.

In the first place, sorting should be improved. If the total number of thermoplastic varieties were to decrease by a quarter, there should still be plastics that work, believes S1. The large company in the food industry, S2, believes that the challenge is to find which properties are needed to get the right barrier properties in the plastic packaging in the food industry. A socioeconomic challenge is that consumers must learn about the importance of recycling, concludes S2. S4 describes that a challenge in the automotive industry is that a reduction can be difficult because it is not desirable to replace one component with another that increases the car's weight. S3 points out that a reduction would probably have been possible if there had been a better specification of the requirements. Products are often overspecified if there are uncertainties about the load case because this is generally cheaper than manufacturing the product and testing to see which type of plastic is sufficient. Furthermore, S3 believes that the tools for basic plastics are mass-produced, but for a particular technical plastic, there may only be one unique tool in the entire world. S3, therefore, believes that one possibility could be some form of modelling software to ensure that the item can handle the load case, as otherwise, too much resources, testing and hands-on work would be required to avoid over specifying.

6.3 POSSIBILITIES TO REPLACE TODAY'S LARGE VARIETY OF THERMOPLASTICS WITH A SMALLER NUMBER

6.3.1 Practical possibilities

S1 believes it is possible to reduce the number of mixtures they use. They currently have around a thousand different plastic specifications, but the reason for this is that they have a global supply chain and buy plastic from many different companies and regions. Furthermore, S1 describes that they have certain customers who do not allow certain types of plastic to be used in their products. S2 claims they are trying to reduce the number of grades used for PET, PP and PE. However, the PE that is used has a low melting point, and now there are variants that have a higher melting point and can be used to a greater extent.

S4 believes that there can be around 30 different plastics in a car, but around 10 would have been enough. PA can perhaps be replaced by PP, but then perhaps more filler is needed to compensate for the strength and temperature resistance. In addition, they do not want to change anything so that the car becomes heavier. S3, who works for a company that is a supplier of plastic products to the automotive industry, believes that better knowledge of the requirements of the products' needed properties for optimal performance could reduce the number of variants they use.

6.3.2 Legislative changes that may be needed

S2 thinks that plastic taxes might work. S4 believes that the requirement that 85% of a car's material can be recycled will contribute to a more circular use of plastic, but what is needed beyond that are things like standardization, a definition of what is recycled plastic and something that ensures that everyone measures in the same way and are transparent. S3 describes that something needed is an incentive for product owners not to use as many different thermoplastics in one and the same product because it is not penalized at the moment. As the demands on the industry increase, so will the recycling rate, concludes S3.

6.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THESE THERMOPLASTICS SHOULD HAVE

The respondent from the large appliance company, S1, believes that malleability in the processes is important. Among foods, according to S2, it is always about ensuring sustainability, which is why, for example, different barrier properties are important. S2 adds that it is necessary for the plastic to be durable in order to cope with the transports.

In the automotive industry, according to S4, there are sometimes requirements for a specific plastic, and sometimes there are requirements for final production functionality. Such requirements can, for example, be that a component must burn slowly, odour and emission requirements, not scratch, can be washed, or withstand UV radiation and high temperatures, adds S4. Sometimes the requirements apply to the entire cabin space of the car rather than to a specific component. S3 believes that function is most important and that this could mean impact strength in freezing temperatures or flame-retardant properties.

6.5 DISKUSSION

The sellers are the smallest group interviewed. Only four interviews were held, and two of the people who were interviewed were handpicked because they were considered suitable to interview, while the other two were considered suitable by the contact person at the respective company. The information from the interviews with the buyers is thus not necessarily representative of reality; however, individual perspectives can be highlighted and be useful.

Just like the buyers, the sellers also mainly mention functional requirements rather than material-specific properties and requirements, which indicates that it should be possible to implement a reduction in the number of plastics as long as the functionality of the product remains the same. At the same time, the difficulties in finding the right plastics that work for many applications, even within the same industry, are emphasized.

Regarding possibilities, all sellers claim that it should theoretically be possible to reduce the number of varieties of thermoplastics. One argument is that S1 has a global supply chain of many, many suppliers whose products should be able to be standardized so that fewer types of plastic are available. S2 explains that they are actively trying to reduce the types they use to just PET, PP and PE, which indicates a demand for fewer types of plastic. S4 describes that there can be around 30 plastics in a car, but that perhaps around 10 would have been enough. S3 further believes that it would be possible to reduce the number of thermoplastic variants if they had better requirements. This, as well as the fact that the buyers mainly mention functional requirements rather than material-specific requirements, indicates that it should be possible to also reduce the number of plastic types from the sellers' perspective.

7

Results from interviews with recycling companies

7.1 MOST USED THERMOPLASTICS

Both respondent R1 and respondent R2, from a large recycling company, believe that the most common types are PE, PP, PET and PS, followed by plastics such as PVC, ABS and PLA. R3 believes that they handle the same plastics as R2. R4 has five main groups that they handle, PP, PE, ABS, PC and PVC, as well as approximately 25 subgroups. R1 mentions that the recycling companies mainly handle thermoplastics from packaging, while R5 believes that the largest plastic flows come from the construction industry and electronics rather than packaging.

7.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF A SMALLER NUMBER OF THERMOPLASTICS

7.2.1 Simplified and more high-quality recycling

Both R1 and R5 believe that a smaller variation would simplify recycling because larger flows are obtained from the same plastic, which results in easier sorting. This, in turn, would cause recycling to increase, which should also lead to higher cost efficiency. R5 states that it is a fact that more standardized plastics would improve recycling. Furthermore, they believe that 70% of their collected plastic consists of the four major types of plastic. R3 also states that such a reduction would make recycling much more efficient because it would be easier to sort out, recycle and put it back on the market.

7.2.2 Mixtures would still be available

R2 believes that within each plastic family, there is a multitude of variants, and therefore there is always a mix when thermoplastics are recycled, and at the same time, believes that they never sort at the base plastic level. If only two grades of PP were used, it would certainly have been possible to sort more carefully, but this is not currently done.

7.2.3 A reduction is not requested by the industry

R2 believes that a limitation is that the recycled material does not always fulfil the function or have the right barrier properties that the industry demands. In addition, challenges can also be that a reduction could entail large investments in production equipment or that there are market reasons for having different looks on the packaging, believes R2. R5 also believes it is in the manufacturer's interest to have certain special plastics.

7.3 POSSIBILITIES TO REPLACE TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

7.3.1 Practical possibilities

R3 believes that it should absolutely be possible to reduce the number of variants in some cases. The complexity should be reduced, for example, by making cleaner laminates or using fewer colours. The end consumer is happy to take the cheap solution over the durable one, and therefore the end consumer must learn to live with, for example, transparent plastic instead of coloured, because a large part of the problem lies in the fact that brands want to stand out on the shelf. R3 adds that we are very far from having a closed recycling system for products for food approval, even if that would be beneficial.

R4 says that they process around 200,000 tons of material a year and that the majority of the products they recycle consist of unnecessarily complicated materials. Furthermore, they believe that their recycled plastic is often used in, for example, dashboards in cars, and therefore they believe that the requirements for certain products should often be able to be lowered.

7.3.2 Legislative changes that may be needed

R2 believes that differentiated fees do not help much because companies would rather take the hit and pay more. They propose requirements that manufacturers should not be allowed to put packaging on the market that cannot be recycled, which would force manufacturers to make recyclable packaging.

R5 suggests that the proposal should be taken via the EU so that they can discuss which plastics should be used and how the number of plastics can be reduced. However, they point out that from a climate point of view, it can sometimes be better to use a more complicated plastic than any other material, and therefore believe that there must be exceptions.

R4 believes that product manufacturers and brand owners should be able to start setting requirements so that the product's material also becomes attractive on the recycled market. Control instruments and quota obligations could also help, but for it to work, recyclable material is needed, which today, according to R4, is not available to a large enough extent, at least not for high-quality recycling. Furthermore, the respondent believes that it is not possible to have a deposit on everything, but in order to get a more high-quality recycling, the collection needs to be increased, for example, through an incineration tax or a legal requirement to collect more products than packaging.

7.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THESE THERMOPLASTICS SHOULD HAVE

The requirement that R2 has for them to recycle a certain type of plastic is that they need to be able to sort out so that approximately 95% of the collected products consist of the polymer they want to recycle. However, labels, corks and more are not taken into account in that requirement. There must also be a demand. According to R4, the requirement for them to recycle a plastic is that it is precisely one of those they are targeting, that is, PP, PE, ABS, PC or PVC. Other varieties may be classified as waste for them because it is not necessarily a variety they can recycle.

7.5 DISCUSSION

The recycling companies seem to agree that a reduction in the number of thermoplastic types would simplify recycling and thus lead to higher-quality recycling. Also, since recyclers lump together their incoming thermoplastics and categorize them by plastic families, it should also indicate that it is possible to reduce the number of plastics and still work in terms of recycling. Even the recyclers note that there is an overspecification in many products, which, according to them, is not necessary.

However, even if it is practically possible to make the reduction from a recycling perspective, there still remains the challenge that there needs to be a demand for recycled plastic, as mentioned by several recyclers. However, several recyclers believe that a higher quality recycled plastic would be obtained, which in turn has the potential to increase the demand for the recycled plastic.

8

Results from interviews with trade organisations

8.1 MOST USED THERMOPLASTICS

Regarding common types of plastic in the construction industry, T1 and T2 agree that it is PE, PP and PVC that occur most. They both mention pipes, soft carpets and wall coverings as common plastic products. In the chemical industry, T4 believes that PE, PET and PVC are the most common. Within the agricultural industry, it is mainly packaging made of either PE or PP that makes up the plastic products. T3 describes that PP and PA are often used in the automotive industry for everything from interiors to wheel arches and bumpers.

8.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF A SMALLER NUMBER OF THERMOPLASTICS

8.2.1 Products risk being overspecified without many variants

T2 means that they want as little material as possible and optimize the use in a certain function. A lower number of plastics means that they will no longer be able to optimize the function, which would lead to products being oversized. T2, therefore, believes that it should be better to focus on improved recycling. T4 also describes that thanks to all the variants, just as much plastic as is needed with just the right properties can be used. A smaller number of plastic types may mean that more material must be used to compensate, which in turn results in an increased environmental impact.

Furthermore, according to T4, not all thermoplastics can be used in all tools. Therefore, the respondent believes that special plastics are needed to optimize the machines in order to be able to use as little material as possible. Also, many products are overspecified because they probably just have a specification they have had for ten years because they know it works, while recycled material would probably have worked just as well. T4 also explains that if the product type is known, it should be possible to determine what it contains, and believes, for example, that packaging should be able to be used for new packaging.

8.2.2 Prevents no more recycled plastic from being used

T4 describes that a general reason why more recycled plastic is not used is that the technical competence needed to take care of the more difficult flows is not available, but that industrial waste works well because its content is known. The same, according to T3, applies in the automotive industry, who also points out that it is more difficult to guarantee that the right material properties are obtained in the recycled plastic and that one reason why no change takes place is that it is a matter of habit that virgin plastic is usually preferred, even though recycled plastic often had fulfilled the same function. T5 explains that in the agricultural sector, companies often want a specific colour, especially when it comes to packaging, but really there is no reason to have a specific colour.

8.2.3 Factors other than a large number of variants hinder recycling more

It will also be problematic in the next stage, says T4. Say there are 10 types of PE; those types will never be distinguishable from each other in a recycling process. Maybe there will be 90 different recycled qualities just after one loop. It is not a problem that there are many variants; the problem, according to T4, is that a product can consist of several different plastics in layers. A focus on design for recycling is needed rather than reducing the number of plastic types, T4 believes.

According to T5, the degree of purity of the incoming material from the agricultural sector is decisive for how much material is recycled. If it is too dirty, the cost of cleaning it becomes prohibitively high. T3 believes that an investigation should be conducted regarding how recycled plastic requirements should be specified. T3 claims that the automotive industry is quite traditional and old-fashioned, so there is probably a lot to grasp there. Furthermore, the respondent believes that now that they are moving from manufacturing combustion engines to electric vehicles, there will be completely different characteristics and functions in the vehicles that will become either more or less important. If something becomes less important, it could be specified down. For example, all components in the engine compartment previously had high requirements, but in electric cars, there is no such space. Under the "bonnet", there is basically only empty space that can be used as storage space because the battery is located further back on electric cars. T3 also believes that the vehicles will probably last longer because electric vehicles will be able to go further. They should rather be able to last 60-70,000 miles instead of the previous 30,000 miles, and then other demands are placed on the plastic components, which will probably be higher.

8.3 POSSIBILITIES TO REPLACE TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

8.3.1 Legal amendments that may be necessary

T1 believes that legal requirements are probably needed and that a good example is the EU's Substances of Concern, which are, for example, substances that make recycling difficult and are difficult to dispose of. The candidate list of REACH, which consists of listing potentially hazardous substances, could also be used to a greater extent. There would also be a need for legal requirements to sort out plastic and source sorting concludes T1. T2 explains that the regulations are not really adapted to the flows of the construction sector and therefore need to be remedied. Above all, this applies to the waste legislation, but also to some extent to the Environmental Code. T2 points out that function is the important thing, so if there are quality-assured products on the market, it is not a problem to use recycled plastic.

T4 also claims that the waste legislation is a bit cumbersome. For example, there will be different rules regarding how something should be handled when it is classified as waste, and then it will be difficult to know when waste stops being waste and can instead be used as a resource. Furthermore, T4 believes that quota obligations are discussed but points out that quota obligations are not applicable to all products. In addition, it is emphasized that quota obligations must be set at an appropriate level; if they are set too low, everyone may already be able to meet them, while if they are set too high, no one may be able to reach them. T5 also believes that quota obligations on recycled materials would help. T3 believes that SIS could set standards on

which plastics are permitted to be used in, for example, the car industry. The respondent also concludes that a definition of recycling is required to reduce the amount of plastic that goes to incineration and is called “energy recycling” and that deposit systems could work well for society in general.

8.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THESE THERMOPLASTICS SHOULD HAVE

Regarding which requirements for plastic the industry organizations consider important, only T5 answered concretely and considered that recycled plastic did not meet the requirements for cleanliness, mechanical properties and odours. It was also asked what the most important requirements for performance and properties of the plastics used are, but even there, only one industry organization could give a concrete answer, and the rest answered that it differs greatly between different products. T3 mentions that Germany is good at establishing standards such that only a certain number of plastics are allowed to be used within a certain industry.

8.5 DISCUSSION

The hope with interviewing industry organizations is that they would be able to speak generally for the entire industry in question. It is worth noting, however, that the interviewees emphasize that they cannot necessarily give a detailed and representative picture of the entire industry, and therefore many of the answers are general and sometimes more speculative.

Challenges mentioned are, among other things, that it is sometimes necessary to optimize the products or that different variants are needed to be able to optimize the machines’ runs. However, it is also mentioned that one reason for the overspecification that exists today may be that it is what works, and although recycled material would certainly have worked just as well, it may be easier to continue with what the company already knows works well. Thus, there are about as many challenges as benefits mentioned regarding products being or becoming overspecified.

It also addresses other factors that prevent a more high-quality recycling that would remain even if the number of plastic variants is reduced, for example, that the technical competence to take care of more difficult flows is lacking or that silage plastic that is too dirty may not even be worth recycling because it requires too much cleaning. Even if they are relevant for improved recycling, as said, they are obstacles that would remain even if the number of plastic variants is reduced, and therefore they are not as relevant to the project.

Regarding which performance requirements and specific properties the thermoplastics must have if the number is reduced, it is primarily functional requirements for the end products that are mentioned. It is an example of how the trade organizations, in particular, may rather have a more comprehensive overview of what requirements are placed on the plastic products within the industry and that their suppliers or manufacturers probably have detailed requirements for the thermoplastics to get an end product that meets the customer’s wishes and requirements.

9

Results from interviews with researchers and experts

9.1 MOST USED THERMOPLASTICS

E4 believes that the most common types of plastic are PE and PP, which are widely used in packaging but also in construction, household items, automotive items and healthcare items. LDPE is commonly used for films, and PS is often found in clothes hangers. Regarding technical plastics, PET and ABS are widely used. Among technical plastics, PC is common, and regarding high-performance plastics, PEEK, PPS, PPSU and PSU are common, according to E4. E5 believes that PE is by far the most important type of plastic, followed by PP, PVC, PC, PET, PS and ABS, which are all among the most important types. E8 describes that they expect that approximately half of Axfood's own brand products are recyclable, and what they count as recyclable are large types of plastic such as PE, PP and PET. E9 explains that there will be a new plastic flow survey in 2022 from the Environmental Protection Agency, but that they are using existing sources and not doing any new, own surveys. Existing sources can be, for example, from European Plastic Converters or sample analyses. Regarding the volumes involved, E4 also believes that European Plastic Converters has good statistics but also points out that it is difficult to know the exact volumes in Sweden because we both import and export.

9.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF A SMALLER NUMBER OF THERMOPLASTICS

9.2.1 A more high-quality recycling would be obtained

Regarding the recycling perspective, E7 believes that the fewer plastics, the more positive it is. In this way, a higher value can be obtained in the recycled plastic, and that plastic will thus come to the next customer with a higher value than before, and then, in turn, that plastic will also come back to recycling again with a higher value. If it was possible to set the demands on their purchasing department that they only want, for example, eleven specific varieties, then they would get a more high-quality recycling, he concludes. E3 believes that the big win would be if the idea possibly leads to more recycling and, in the best case, a more high-value recycling. At the same time, it can also have negative consequences, so it needs to be weighed up as to whether it is reasonable, he adds. E5 also believes that the smaller fractions there are to work with, the easier it will be to recycle. At present, the large recycling company R2 only handles 4-5 types of plastic. The fewer variants there are, the fewer variants slip through the NIR equipment that sorts the plastic and contaminates the mixture, he reasons. E9 and E4 also agree that the idea would probably lead to easier sorting and would be very beneficial for recycling.

9.2.2 Manufacturers would generate less waste

E4 believes that if the producers get a smaller number of variants to use, then special machines for special plastics will not be needed as much either. The producers of plastic granules may get larger batch sizes, but it is probably rather those who, in turn, produce products in plastic who will be most affected. When starting up a machine that makes plastic parts, it can generate close to 500 kg of waste to shape a plastic product correctly before all thicknesses and other parameters are correct. For injection moulding, it may be 10 kg of waste when a new type of plastic is to be used. Thus, such waste would be reduced with a smaller number of variants because the same machine might then only need to run one type of plastic instead of switching between different types of plastic. From the perspective of the manufacturing companies, it would also be positive because they would have fewer qualities to handle, as it would also affect capital formation.

9.2.3 Obstacles to the introduction of fewer types of plastic

E1 believes that a challenge with the idea is that it implies something of a precautionary principle that speaks against the encouragement of innovation that exists in today's society and which therefore risks receiving backlash from the industry. E5 points out that there are business reasons for having their own variants from the companies' perspective, that companies like to keep their secrets, and that convincing them to use fewer plastics can be challenging.

E6 believes that the idea goes against the entire EU's idea that there should be free competition and free movement. To then suddenly say that there is free competition, but only if the companies do what the EU says, would be contradictory. E5 believes that if products that are cheap and dangerous because they contain additives that are permitted abroad but not in Sweden are used, it is likely that it will be difficult for Sweden to succeed in coming up with a harmless, more expensive product. E4 also points out that Sweden alone probably cannot implement the reduction proposed by the Unity project. He believes some reductions can be introduced, but some coordination is probably needed within the EU.

E7 addresses the challenge of who should pay for the added handling. He believes that as soon as material is to be collected, national supervision is needed, and then it can be difficult to ensure that all municipalities carry out their supervision in the same way. The problem, according to the respondent, is that the politicians often think that it is good if the municipalities manage such things themselves, and then the politicians renounce that problem and hand it over to the municipalities, who do not necessarily have either the knowledge or the finances to manage the new systems that are required.

E11 believes that the discussions about regulations around recycling are more about the quantity of the plastic than the quality. The respondent believes that the majority of the material in the packaging sector is usually not recycled in a good way and that there is, therefore, still more discussion about increasing the amounts of what can be recycled rather than getting a more high-quality recycling. From a policy perspective, the plastic issue discussions are also hindered because no one wants to make costly investments that also have to compete against fossil plastics.

Furthermore, E11 believes that the discussions about new public procurement are about bioplastics or phasing out chemicals rather than being directly linked to recycling. E10 adds that there were discussions about introducing quota obligations on the proportion of recycled material in electronics, such as computers and mobiles. However, it was discontinued as it was deemed impossible to measure the amount recovered.

9.2.4 Challenges surrounding the choice of which varieties would be used

E9 points out that if the variety of thermoplastics is limited, it could end up in a sub-optimization so that it rather becomes "one size fits no one". A further challenge, according to E6, is that it could happen that it is decided that five varieties should be used, but then someone invents a sixth. The problem then becomes how to decide which of the first five should be removed if the sixth one turns out to be better than two of them. A solution could be to define what recycling means and set requirements for a certain percentage of recycling rather than setting requirements for a maximum of a certain number of materials. Then perhaps the same thing would be achieved without restricting the market as much.

9.2.5 General challenges with recycling and use of recycled plastics

E4 believes that it would probably have been easier to recycle packaging if it had only been clean laminates that were not so dirty. He describes that the NIR equipment used when sorting plastic is set to identify a certain type of plastic so that the rest is sorted out, which is an obstacle to larger quantities not being sorted out from the start. According to E4, as long as the customer does not say no or if the colour is wrong, recycled plastic should be able to be used. The respondent also points out that many Swedish converters are family businesses, not plastics experts. According to the respondent, the additive that hinders recycling the most is antioxidants.

E5 tells us that it is difficult to achieve clear, transparent products if the material used is already coloured, and black plastic cannot be identified by the NIR equipment either. Furthermore, he believes that products that are supposed to last a long time generally contain more additives than short-lived products, and therefore packaging is usually easier to recycle. It is much more likely that a plastic that has only been on sale for a few months could be reused than a product that has lived for 50 years. E9 believes that there are many reasons why more recycled plastics are not used. The respondent believes that the uncertainty surrounding the availability and quality of raw materials, as well as the price sensitivity as a consequence of these, is the biggest obstacle. The lack of traceability is also an additional reason. E1 responds similarly that the lack of transparency around the content is an obstacle to why more recycled plastic is not used. The respondent also adds that because there are so many different fractions, it will be difficult to achieve large-scale and, thus, high-quality recycling. In addition, different types of plastic retain their quality differently, which can also be a contributing factor, he concludes.

E10 describes that plastics in both the food and healthcare sectors often become exceptions because there are high demands on the exact content of the plastics so that they do not contain anything dangerous for humans in those sectors. However, the respondent believes that at the same time, attempts are being made to extend the use phase of plastic products, for example, by replacing single-use products with products that can be used several times.

9.3 POSSIBILITIES TO REPLACE TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

9.3.1 Opportunities for manufacturers

E6 describes a company that decided to use more recycled than new raw material, and then they needed to be a little more lenient with the variety. Then, the melt index could be allowed to vary between 1 and 1.5 instead of having to be exactly 1. The challenge is that those who are used to it are very spoiled by the polymer industry and can demand a melt index of exactly 1.1 if they claim that 1.0 is not working, says E6. That will never happen with recycled materials, no matter how good the companies are, he claims. The expectations of the industry for what they get when they buy materials are very high, and those expectations would not be fulfilled by recycled plastics. On top of that, there is the economic factor because if the high expectations for quality are to be met, it is more expensive to do it with recycled feedstock than from crude oil, so it will be disappointing because they will be buying something that is a little bit worse for a higher price.

9.3.2 Possibilities with packaging

E4 claims that all laminates are not needed and that, instead, they have come about due to either the cost issue or the barrier properties. Therefore, the respondent believes that one possibility is that companies can use transparent plastic in combination with labels with the company's colours and logos instead of colouring the entire package in the company's colour because there is no demand for coloured, recycled thermoplastic. Another example in the food industry is that the chain Marks & Spencer already has a sustainability goal that only one polymer should be used in the grocery trade, and they believe that it should be some form of PE, and therefore E8 believes that it should be possible to reduce the number of plastics within the food sector. E10 points out that consumers do not have a good picture of the total cost of ownership; they have it for their car or house but not for plastic. Therefore, he believes that one possibility is that if the price of plastic products increased, consumers would be more prepared to pay more and thus also be more willing to recycle it because they realize that the plastic has a higher value.

9.3.3 Possibilities with extended deposit systems

E2 and E3 believe that one possibility is to expand the deposit system on packaging to get cleaner flows. E4 also believes that more deposit systems would be needed to know the exact content of the recycled plastic. If it is ensured that collection takes place smoothly and that a deposit is introduced on more packaging, the reuse of plastic will increase, he claims. If there are no functioning collection systems, the recycling will not work either, and therefore the recycling industry needs to refine the collection systems, says E4. The respondent also says that the raw material producers may become the major users of recycled plastics that have been used by consumers, so one possibility is that they could control those flows and the quality better. Then there are companies that collect waste materials, and they would only have more to do. In the end, it is the customers who have to get used to recycled materials.

E5 believes that the common people must partly get better at recycling and partly must get better tools to be able to do so. He also suggests that the tools could be an extended deposit system for more products, such as ketchup bottles, shampoo bottles and washing-up liquid since there are approximately the same types of plastic in such bottles. The same is the opinion of E1, who believes that extended deposit schemes have great potential to increase the recycling and reuse of plastics, and he also mentions packaging for cleaning products and soap but also Tetra Pak for dairy products as suitable products to start with.

E3 believes that higher requirements for deposit and separate recycling could increase the reuse of plastic. However, the fact that more things are recycled is not the same as better recycling, he points out, but an investment in better sorting could increase the reuse of plastic.

9.3.4 Possibilities with more standardization

E1 believes that the ideal would be a high degree of transparency and standardization in various industries and that PP, PET and PE are the largest plastics used whenever possible, but that it is also possible to apply for a dispensation to use something else where it is legitimized. Examples of areas where it may be legitimate to use something else, he believes, could be, for example, among infrastructure, while products such as packaging are more standardized. Furthermore, E1 believes that some such policy probably needs to take place at the EU level due to the import aspect, alternatively to regulate which types of plastics that are allowed to be imported. E7 believes that the more standardization, the easier it will be and that it is rather the solution than a product passport.

9.3.5 Opportunities with quota obligations

E2 believes that legislation that specific products may only contain a certain amount of plastic could work. For example, require that where it is technically possible, at least 10% recycled plastic must be used, and the industry will adjust accordingly.

E7 believes that an increase in the demand for recycled plastic is needed, and for that, both procurement and an increased quota obligation are needed, for example, by setting requirements for sorting into more factions within the construction sector in combination with supervision, which E7 believes should be carried out by the County Administrative Board. This is because it is difficult to get a municipality to manage the sorting themselves, as tasks are delegated down to different levels, and thus the conditions are different. Furthermore, the Environmental Protection Agency should be the one that sets the regulations rather than trade associations. The procurements could take place at the EU level to send a signal to buyers and designers that there is a demand, while the supervision is national.

E9 claims that quota obligations should work but also believes it is a bit hasty to say there should be quota obligations on everything. The respondent believes that quota obligations become attractive because it is not possible to set any requirements on where raw materials are to be sent, but regarding design requirements, it is possible to be as tough as possible. Social economists believe it is better to put taxes on fossil raw materials, but the road to get there is longer, she adds. In addition, E9 points out that sometimes it is perhaps better that there are two materials that can be easily taken apart in one product than a light product in a single material but which is attached together.

9.3.6 Possibilities with better labelling systems

E4 believes there should be a requirement that there should be information on every new product on the market about how the product should be collected and recycled. On the packaging, the options could be a green arrow triangle if at least 50% of the product can be recycled into new raw material, or otherwise, a flame because then the product will probably go to incineration, he suggests. E3 agrees and believes that it can be difficult to specify quota obligations for particular product types and rather believes that labelling of products and stricter control is needed.

E1 believes that better labelling could perhaps create a debate or more awareness among consumers. He points out, however, that relatively large fractions of certain types of plastic are classified as “other” types in the current labelling system, but also that a future labelling system should not be made too complicated for the common person.

9.3.7 Opportunities with increased transparency around the content of plastic products

In the food industry, E8 claims that a major problem is that they do not receive sufficiently detailed information about the contents of the packages from the suppliers. The respondent would like to see legislation stating that whoever transfers a packaging or a plastic product to someone else must be obliged to declare added chemicals and detailed information about it. E1 also believes that there is a lot of potential in increasing transparency around the content of the plastic.

9.3.8 Other legislation that would be needed

E9 believes there would be a need for producer responsibility for packaging but also for cars and electronics because there is no incentive to recycle the plastic. Furthermore, the respondent believes it can be difficult for legislators or authorities to set restrictions because even if it is possible to set very strict design requirements, it is difficult to set them at the plastic-type level. It would entail long discussions, and exceptions would be needed for both, so such a task should rather be left to the industry in some way. On the other hand, it is always possible to try to control with, for example, differentiated fees or with guidelines that show when, for example, bio-based or recycled is the best fit. E9 also points out that manufacturers can independently reduce the number of plastics they use, and there is also nothing in the legislation that says they cannot introduce a deposit system themselves.

E4 suggests that if there are no absolute requirements for colours, transparent plastic should be used to increase the value of the recycled plastic. Also, there is built-in resistance to the system due to lazy buyers who say they cannot switch from one shade to another for their customers to approve first. E4 also points out that a 10% mixing of recycled material has, in principle, no effect on the properties of the new material, more than possibly affecting the colour somewhat. It is not until the relationship approaches half recycled, half new that the characteristics should perhaps be reviewed, he points out. What is proposed is that suppliers be required to use 100% recycled plastic where it is technically possible to do so. Then the industries will adapt, he believes. Furthermore, according to E4, producer responsibility should be extended.

E3 adds that it should be possible to continue working with the positive lists that arose when, for example, Japan and China reacted to the number of additives in plastic products, and instead of listing all prohibited additives, those that are approved were listed. At the same time, it can be more difficult when it comes to recycled materials. E2 believes that a lot probably lies in the design and that there will be an unnecessarily high use for products to be able to stand up by themselves and be shown on display in shops, especially regarding meat packaging. E3 adds that it is important not only to get stuck on the packaging but that there is just as much to do between companies or with, for example, stretch film and packaging.

E11 adds that it should first be ensured that recycling and the use of recycled material increases. After that, care should also be taken to reduce plastic use in general, for example, through taxes for new, fossil plastic raw materials or through more standardized packaging.

E10 believes that there should be requirements stating that the companies must achieve a certain goal within a certain period; otherwise, the business may not continue. In this way, it becomes the industry's problem to solve how the types of plastic can be standardized, to introduce deposit systems or to ensure that all material is recyclable.

9.3.9 Suitable products to start with

E3 believes that packaging, electronics, vehicles, textiles and construction products are examples of product categories that may be suitable to begin with measures, for example, by tightening producer responsibility or continuing with positive lists. E2 also believes that cars could be suitable because that industry is dominated by a few large manufacturers and all cars basically have the same functional requirements. At the same time, E5 said that it can probably be difficult in the automotive industry and that it is rather in packaging that the most can be done. E4 suggests tablet packaging as a concrete example that does not need to consist of two different materials.

E9 also believes that packaging is most appropriate to start with and that there have already been studies that have shown that it should be possible to do well with fewer plastics in packaging. Another suggestion often stated is composite products. Cars were also brought up as an example because there it is clear that different parts are put together that should have different functions and, therefore, it is likely to easily happen that there will be different types of plastic, although the parts could have the same properties with the same types of plastic in some cases. E9 clarifies that such applications could be chosen for the purpose of facilitating sorting by removing small flows. Even if the same thing is believed to be possible within, for example, healthcare equipment, E9 believes that it may be too niche a category because there are many other aspects added there.

9.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THESE THERMOPLASTICS SHOULD HAVE

E4 believes that in packaging, it is often an oxygen barrier that is needed. There PA, PET, EVOH or PE with an EVOH barrier could be used. For production, the viscosity and colour are most important; otherwise, for example, impact strength, modulus of elasticity, temperature stability or price are important, but at the same time, it differs enormously from product to product, he concludes. E5 lists stress cracking, impact toughness, flexibility and compressive strength as important properties. E8 tells us that there is an ongoing project in the grocery trade regarding printing ink on deep freeze, where it has been discovered that problems such as unwanted crystal formation can appear if the product is not coloured and exposed to light. The colour and appearance of the plastic are also important as some products don't look so good in transparent plastic, she adds. In addition to that, there is clear pressure from customers that they do not like plastic in general. As customers became more aware of plastic in the ocean, more packaging has appeared that mixes paper and plastic, just so that companies can tell customers that the company has reduced plastic, she concludes.

9.5 DISCUSSION

In general, the researchers and experts agree with the previously interviewed respondents about which types of plastic are most common. Several experts mention completed studies for which types of plastic are most common and in which sectors, including the Swedish Environmental Protection Agency's survey from 2019 (Ljungkvist Nordin et al., 2019) or European Plastic Converters from 2019 (PlasticsEurope, 2019). In order to answer the question about which are the largest thermoplastic volumes in products, it is perhaps rather more appropriate to look at the mappings already made than to base it on the interviews carried out in the project.

Regarding the benefits of the proposal to reduce the number of types of plastic, several researchers and experts are convinced that it should lead to higher quality recycling by both larger volumes being recycled and that it leads to a general increase in the quality of the plastic throughout the value chain.

Challenges, however, are that there may be some resistance in society to using a smaller number of varieties. The arguments that are raised include that the idea speaks against the encouragement of innovation that exists, that there are business reasons to have more varieties from the perspective of some manufacturers, that the idea goes against the EU's idea of free competition and movement, who should bear the costs and the handling involved or that Sweden would still not be able to implement a reduction in the number of types of plastic themselves. Just selling the proposal brings many challenges, which is reasonable as many companies and manufacturers in all industries would be affected by the reduction in some way.

Regarding the possibilities of replacing the large variance of thermoplastics with a smaller number, the answers of the researchers and the experts are relatively similar. Several suggest that packaging may be appropriate to start with. This is further strengthened by E8 pointing out that the Marks & Spencer chain already has a sustainability target for some form of PE to be the only plastic used in the grocery trade, as it indicates that they believe it should be possible to reduce the number of plastics. Other possibilities often mentioned by the researchers and experts are extended deposit systems, more standardization, quota obligations, better labelling systems or more transparency about the content of the plastic. It is worth mentioning, however, that sometimes it is claimed that the reduction could enable, for example, extended deposit systems or more transparency about the content of the plastic, while sometimes the possibilities are mentioned rather as general opportunities to increase recycling possibilities.

In addition to plastic packaging, product categories such as electronics, vehicles, textiles, construction products or composite products were also considered suitable to start with. However, according to the researchers and experts, it is precisely plastic packaging that is mentioned the most times as suitable products to start focusing on.

Regarding the performance requirements and specific properties that these thermoplastics should have, properties that are important from the production side and functional properties for the product itself are mentioned. However, it was also pointed out here that the specific properties required depend entirely on the product.

10 Results from the Workshop

During the workshop, two discussions were held, which are summarized in this chapter. The red text is the moderator's questions to move the discussion forward.

10.1 CONCLUSIONS AND ACTION PROPOSALS FROM THE INTERVIEW STUDY

Are the conclusions from the interview study correct, what are the challenges and what needs to be done? Is it possible to reduce the number of variants on plastic to a smaller number, and what would that require?

Challenges with the proposal to reduce the number of plastic types are that the Unity project's idea only works the first time the plastic is recycled because new varieties will emerge as they are mixed. The quality of the recycled plastic also depends on what the product has been exposed to during its life. In addition, even more variants arise if, for example, 30% recycled and the rest new raw materials are mixed. An additional challenge mentioned is that today it can be a competitive advantage to offer our own types of plastic. Another challenge highlighted is that overspecification could still occur because producers often do not know the exact material requirements, but they know what worked last and continue with it.

Possibilities with the proposal mentioned are that the only way to clean up among today's large number of plastics is for authorities to step in and regulate with the help of guidelines and laws. The same conditions are needed for the entire industry; otherwise, individual companies will optimize for themselves, and a multitude of variants will arise. A further possibility is that within the food industry, the issue of food waste is often prioritized rather than how the packaging can be designed as sustainably as possible. This means that food packaging can be a suitable first type of product to test the idea on. Other possibilities mentioned are that other requirements may apply to the quality of recycled plastic in order not to inhibit the use of recycled plastic. Therefore, it is considered important to specify that it is currently new plastics where the number of variants needs to be reduced. The proposal is believed to be able to be introduced, for example, with the help of product design requirements, financial incentives or joint legislation in the EU. In addition, it is mentioned that if consumers are allowed into the matter, there is a chance that the market will adjust itself.

More thoughts that were added after the workshop are, among others, included e.g. who should decide whether a plastic is needed or not. It is also claimed that the fewer plastics we have, the more variants will be needed of a specific plastic, making it more difficult to make a good recycled product. If all the PP in society were to be collected, it would be collected from packaging film, bumpers, shampoo bottles, garden furniture and fibre cloth for agriculture. If all of these products were melted down, one would probably not be able to use that material in any of those products again.

What the Japanese[2] had figured out was that it could be cost-effective to overspecify a bit to get the volumes up and thus ensure they got back volumes of the recycled materials that could compete with virgin plastic. What are the views on that?

It is emphasized that it would be possible to replace the more expensive materials with simpler variants where possible, for example, switch to more PP, HD or LD-based ones.

2 In the introduction to the Unity project during the workshop, a Japanese company that had done extensive research was mentioned, and how it concluded that it should be possible to use only about 10 types of plastic in total.

Which product categories could it be reasonable to start implementing the reduction in?
Batteries may be a suitable product to start with as it is considered a relatively new field. The vehicle industry also plans to introduce requirements for recycled content, so that could also be a suitable area to test within.

In the interviews, it emerged that many thought that food packaging should be an area that is reasonable to start with; what are the views on that?
It is emphasized that there is an increasing shift away from multi-layer laminates and multi-coloured packaging and that more transparent food packaging is beginning to appear. It is also pointed out that as long as there is freedom for the companies to decide for themselves, they will also do so. Therefore, very little progress has been made so far and thus is a need for stricter requirements for producers in general.

One participant is convinced that the materials that are not needed should be removed and that PE, PP, PET and EVOH would cover 99% of all plastic packaging in the food sector. There are also already existing systems for collection. This is supported by other participants, and proposals also come up to introduce additional requirements not to mix different types of materials such as plastic and paper and that it should be ensured that the whole of Europe works in parallel with this. There is also a need for a definition of "recyclable".

How much harmonization is taking place within the manufacturing industry at the European level? For example, to reduce the number of variants?
The participants are relatively unanimous that there is very little change that is actually taking place but that, at the same time, there is a lot going on. The problem that is mentioned is that as long as there are no demands from outside, the producers choose what customers want. Another problem is that the existing standardization work is not sufficient as it is neither considered sufficient nor applied enough. It is problematic because the EU believes less and less that the market should be able to self-regulate. Another problem that is raised is that there is a lot of greenwashing going on, that the pursuit of CO_2 has produced products that combine plastic and paper. Standardization is not considered a simple solution to the problem. Rather, the solution is considered to be clearer regulations and rewarding those who follow the rules. At the same time, also mentioned is that since the industry is increasingly interested in CO_2 footprints, it shows a desire to harmonize. It is also mentioned that design guides are becoming more common and that customer dialogues are increasingly advocated, which is considered a step in the right direction.

Products made of recycled plastic usually become low-value products that are then incinerated. From designing for better recycling to actually recycling and reusing at a higher level, what needs to happen?
The proposal is to set the requirement that if a packaging for food is produced, it must be able to be recycled using existing technology and that nothing should be called recyclable if it cannot be done with existing technology. Honesty throughout the value chain is needed, and different actors within the chain need to communicate with each other. It is not possible to just put pressure on the producers; more materials also need to be able to be recycled. It is also pointed out that someone has to use all the plastic collected, but it also seems that interest is increasing, and sorting and filtering techniques are getting better and better. A fundamental problem is considered to be that food packaging is hardly collected without being thrown in the garbage. The proposed solution is to expand the deposit systems for more plastic products to create incentives for recycling. However, it is pointed out that deposit systems

place high demands on logistics and are expensive, and are therefore not the solution to everything. At the same time, it is emphasized that there are functioning collection systems for products without a deposit, for example, some glass bottles.

Would it be possible to build systems so that products are used longer than they are today?
The problems mentioned are that some products are designed for recycling or reuse but still end up in the garbage. Another problem is that it is currently almost impossible to use recycled plastic in food packaging. In addition, an additional challenge is that recycling companies see that few companies actually design for recycling today. Challenges are also mentioned, such as determining how many cycles are required or what is classified as recyclable.

Possibilities mentioned are that where it is technically feasible, 10% recycled plastic should be used. It is also mentioned that the plastic does not always have to be of the absolute highest quality. Regarding food packaging, it is raised that EU legislation is far too harsh and needs to be addressed. However, it is mentioned that it might be easier to start with things other than food packaging, for example, products that can be made from a more standardized material or that can just as well be in recycled plastic. A participant in the workshop states, in conclusion, that traceability must also be improved. It was the engineers who wanted to increase the performance, but the willingness to pay for it was not there, nor was it needed to have as long a life as it would provide. So, in Japan, a cost was built in that no one really wanted. The question with food is, do people store it as long as the packaging is adapted to?

It is pointed out that many packages are designed so that the product can stay in the store for a long time, but once opened by the consumer, it really doesn't matter that much. It is also considered controversial to reduce the lifespan of products.

10.2 WHAT IS NEEDED TO MOVE FORWARD?

What is already going on? What kind of needs do you see?
The need that is raised is that there is a delegation for a circular economy with the government, but as long as they, or, for example, the Swedish Environmental Protection Agency, does not produce a set of regulations, nothing will change. Another suggestion is that in products where it is technically feasible, require it to be made of recycled plastic or start by requiring 10% recycled. It is considered that Sweden needs to push more at the EU level and that there is a lack of recycled plastic that can be used today. There is, therefore, a need to place higher demands on the collection, either through demands on consumers or producer responsibility. Furthermore, it is suggested that soft plastic film can be focused on nationally. However, at the same time, national quota obligations are considered to cause problems for the open market in Europe. Regarding what is already being done, it is mentioned that it has started to be investigated whether it is possible to distinguish types of plastic based on density. In retrospect, it is also proposed to categorize plastics according to their processing possibilities, for example, PE for extrusion, PE for film, PE for injection moulding and so on.

Could there be something in the fact that people think there is no point in sorting because it will still be incinerated?
One believes that the media must take it upon themselves, but also that the media, in particular, can spread more about the fact that it is certainly possible to sort and recycle. In addition, there are studies conducted that indicate that consumers seem to want to know more. Therefore, clearer information should be introduced on the packaging about how the product will be recycled and what it can be used for in a second loop.

What are some good examples of when recycled plastic is good to use?
One suggestion that is mentioned is that the regular garbage bag is made entirely of recycled plastic. Other examples are that Styrofoam boxes have very high recycling rates and become either new boxes or building insulation. Design guides for recycling are also mentioned as a good example.

Products with a lifespan of over a year also constitute a large volume, and printing and such feel more relevant on, for example, food products, is that interpreted correctly?
A participant's company tests its products to see if they can handle being made from recycled plastic. In an ideal world, it would be possible to characterize the recycled raw material more before they start processing it, but they think that is a long way off.

It is also discussed that many plastic recyclers can upgrade the plastic to almost any quality, but the willingness to pay is not there because it is more expensive than new plastic. Therefore, it is believed that the use of recycled plastic must be rewarded to reach larger volumes. A quota obligation is also a solution there because recycled plastic must be chosen, so maybe the one with a slightly higher quality is chosen even though it is a little more expensive, it is added.

It is claimed that there is a shortage of recycled plastic, is that true?
It is agreed, but the participants are quick to point out that the deficit is in recycled plastic of the right quality. At the same time, it is emphasized that today a lot of recycled materials are used where possible, and the industry is quite good at also recycling internally. There are also industries that are good at taking back their customers' waste, which is not always visible in the statistics. So, industries do a lot; it is the consumer products that need to be recycled to an even greater extent.

It is pointed out that the importance of reusing industrial waste internally should not be classified as recycling because, otherwise, productions that have a lot of waste will increase.

10.3 DISCUSSION

The purpose of the workshop is to get feedback on the action proposals in order to examine their reasonableness. Advantages, disadvantages, challenges and opportunities with these were discussed, and the proposals were approved and in principle, no direct criticism or strong objections were raised. This indicates that the proposed measures are reasonable. At the same time, the percentage of participant attendance was relatively low; only 10 out of 63 respondents participated during the workshop, which corresponds to about 16%. In addition, there was not a single representative from the seller category. Thus, the result from the workshop may not be fully representative of the whole. At the same time, the low attendance may be a sign that the respondents did not feel that they were sufficiently familiar with the research or the plastics industry as a whole to be able to assess the relevance of the Unity project's conclusions. After all, it is more difficult for an arbitrary manufacturer of a plastic product to have an opinion if they have no insight into what policies and instruments look like in the plastics industry or what the specific challenges are around recycling, and thus perhaps it is rather the opinions of the experts that should weigh heaviest. However, the workshop provided multiple perspectives, and those who wanted to express their opinions were given that opportunity, and therefore the outcome of the workshop is considered useful as it showed that the Unity project's conclusions and action proposals seem to be reasonable.

11 Discussion

11.1 MOST USED THERMOPLASTICS

Each interview group basically mentions the same types of plastic as usual, and overall, according to the respondents, PP, PE, PA, PET, ABS and PS seem to belong to the absolute most common types. This agrees with what the Environmental Protection Agency's survey of plastic flows in Sweden states (Ljungkvist Nordin et al., 2019). According to their compilation, PP, PE, PVC, PUR, PET and PS, respectively, are the most common plastics in Europe, and other plastics, including ABS and PA, make up only about a fifth of the total number of plastics in Europe. Since no relatively uncommon type of plastic was among the most common in this study's results, it indicates that a sufficiently large sample was made for the results to be useful.

For more data on plastic volumes and flows in Sweden, we recommend, for example, the Environmental Protection Agency's mapping of plastic flows in Sweden (Ljungkvist Nordin et al., 2019) and Material Economics (2017), A sustainable Swedish material system.

Summary:

- Polypropylene (PP), Polyethylene (PE), Polyamide (PA), Polyethylene Terephthalate (PET), Acrylonitrile-Butadiene-Styrene (ABS) and Polystyrene (PS) are among the most common types of plastic according to the results of the interview study. More studies in this area have also been carried out by the Swedish Environmental Protection Agency (Ljungkvist Nordin et al., 2019) and Material Economics (Material Economics, 2017).

11.2 ADVANTAGES, CHALLENGES AND CONSEQUENCES OF FEWER PLASTICS

Only a few previous studies advocate that a smaller number of types of plastic should be used, and that reason for the pros and cons of it; see, for example, Nielsen et al. (2018) and Material Economics (2017). The difference to this study is that within the Unity project, it is also proposed how the reduction could be achieved. In the Unity project's second literature study, which examined the focus and approach of new projects and studies, it is seen that the focus is often on waste management solutions, such as improved recycling opportunities through changes in the design of products, rather than a complete redesign of the plastic system as the Unity project proposes.

Something that often determines which benefits, challenges and consequences a respondent considers to exist is whether the interviewee assumed that simpler or more advanced plastics would be used. Several critical respondents reason that the extreme case is that only one plastic is used everywhere, which is considered completely impossible to implement because that plastic would have to be extremely versatile and work in all applications, and it would be extremely difficult to succeed in producing such a plastic. However, it is unlikely that such a reduction would occur, nor is it what the Unity project is proposing. The reduction proposed by this project means that today's simple plastics would be replaced by fewer simple plastics, and advanced plastics would be replaced by fewer advanced plastics (see also the illustration of the reduction in Figure 1). Thus, it should not even be a problem that either simpler or more advanced plastics will be used, but both simple and advanced plastics will still exist, just in a smaller number but with clear characteristics for functionality

and recycling. Therefore, negative consequences of someone having to use either a simpler or more advanced plastic than before should not be obtained. The criticism of the proposal to reduce the number of types of plastic in the study by Nielsen et al. (2018) is similar to the criticisms that this study has faced. Common examples of criticism are that the plastic could no longer be used as beneficially or that resource use would increase, but this should not occur either, thanks to the reduction proposed in this project by merging and replacing the plastics with higher-performance plastics. Thus, the same performance and function could be achieved as before, albeit with a smaller number of plastics. The challenges mentioned in the study by Nielsen et al. (2018) that remain, however, is that it can potentially inhibit future development in the area, as well as the problem of who should decide which types of plastic should remain.

Several manufacturers reason that they could remove the advanced plastics they rarely use, especially since many products they make themselves feel are overspecified, and therefore simpler plastics should be able to be used to a greater extent. Such a natural reduction could also serve as a first step to then be able to carry out a further reduction as this project proposes, in that the least useful plastics have already been phased out.

A benefit often raised by the respondents is that a higher quality recycling and reuse of plastics should be obtained as they assume that the reduction would mean that the volumes of base plastics should increase. If the volumes of basic plastics increase, many respondents also believe that the amount of recycled plastic used should increase because it would be easier to ensure the content of the plastic. However, this will only happen provided that the sorting works and that the products actually go to recycling, and therefore perhaps measures to increase the amount of plastic that is collected and recycled will be required in combination with the reduction in the number of types of plastic. Respondents' perceived benefits are consistent with the benefits of reducing the number of plastics that Nielsen et al. (2018) state in their study. Commonly assumed benefits are that there would be cleaner plastic flows, improved recycling and reuse and that a plastic system consisting of fewer types of plastic should also be able to increase the recycling rate because the risk would be reduced that plastics with low recyclability are mixed in flows with plastics with high recyclability. Material Economics (2017) also believes that a smaller number of plastics would lead to higher volumes and, thus, an increased recycling value.

Of the challenges raised by respondents, many are also linked to resistance that may arise from proposing a reduction in the number of plastics, as well as the actual implementation of the reduction. At the same time, Holmberg et al. (2021) note that there is great support among Swedes for taking measures linked to plastic use, and therefore the possible resistance that arose in connection with the interviews is not as great as was first feared. In addition, often, when new products are put on the market, the latest technology should be used; in this case, older types of plastic would automatically be phased out. However, Material Economics (2017) points out that manufacturers of secondary plastics claim that there is neither demand for recycled plastic nor willingness to pay for the upgrade that can raise quality. In addition, there are also challenges regarding which types of plastic would be selected or what would happen if a new type of plastic is found that is better than the ones selected. Even if the reduction were to happen, there are still challenges, such as a lot of work and resources may be needed to make it work.

There are also challenges regarding how it would be regulated in the best way so that it does not fall back to the development of new variants again. In addition, several of the interviewees pointed out that society needs to understand the importance of recycling in order to have a good effect on the reduction in the number of thermoplastics being carried out. Several of those interviewed point out that there are other factors that hinder recycling more than a large number of varieties of plastic, for example, collection and sorting. At the same time, there may be obstacles that would be overcome precisely by a smaller number of variants. Furthermore, PACE (2021) claims that it is quality and price that drive customers the most, and since this study proposes to use high-performance plastics, it becomes an additional challenge to produce such at a low selling price in cases where new types of plastics need to be produced.

Production-related challenges that are often mentioned are that a reduction in the number of variants could mean that production processes may need to be redone because they are often adapted to a specific plastic. Another challenge is that if a piece of plastic does not look right when it has solidified, manufacturers often test it with another similar plastic to get the piece of plastic just right. The idea of the Unity project is that a group of similar types of plastic can be replaced with a smaller number, but this also means that the supply of similar plastics will decrease because there will then be a greater difference between the future types of plastic. If, for example, the geometry is wrong on a plastic product, there is a risk that the only alternative is to redo the mould or tool, which several manufacturers point out is significantly more expensive and resource-intensive than testing with a slightly different plastic. However, one solution is for manufacturers to adjust a plastic with additives to give it the desired properties.

One thing that can be stated is that few studies have been conducted on the effects of reducing the number of plastics, but since the pros and cons that have been mentioned in this study are very similar to those mentioned by both Nielsen et al. (2018) and Material Economics (2017) regarding the proposal to reduce the number of types of plastic, it indicates that the effects may be true. More similarities among the potential effects are that even Material Economics (2017) believes that such a reduction could halve carbon dioxide emissions, and respondents in this study also believe that a reduction could bring about positive environmental effects. Furthermore, members of Circular Sweden write that there are also financial gains for both companies and society at large from circular products and services (Ahlvar et al., 2021), which also agrees with the results of this study.

Summary:

- An advantage from a recycling perspective of reducing the number of thermoplastics is that it would lead to higher volumes of base plastics for those who recycle plastics, whereupon they can sell larger volumes of recycled plastics with more consistent quality at a lower price. This would, in turn, lead to higher-quality recycling, provided that collection and sorting work well.
- The respondents assume that a negative consequence of the proposal to reduce the number of thermoplastics is that you no longer have the large selection of thermoplastics that exists today.
- There are challenges associated with the very proposal to reduce the number of plastics, to implement and maintain it. In order for any effect to be achieved, sorting and recycling also need to be improved first; however, this may also be a consequence of just a smaller number of plastic types.

- Challenges are that production processes may need to be redone. The reduction that the project proposes means that the supply of similar plastics will decrease because the reduction will mean that there will be a greater difference between the new plastics. As a result, the production process, tool or mould may need to be redone. Several manufacturers point out that it is significantly more expensive and resource-intensive to change the tool than to test with a slightly different plastic when the geometry of a plastic product is not quite right.
- Several manufacturers reason that they could remove the advanced plastics they barely use, especially since many products were considered overspecified. It could be another natural reduction method, which could also be easier to implement in practical terms. Alternatively, it could be a a first step for manufacturers to phase out the plastics they rarely use, and the remaining plastics are then combined according to their material properties and reduced in the way the Unity project suggests.

11.3 OPPORTUNITIES TO REPLACE TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

Many of the interviewees talk about an opportunity to reduce the number of plastics because many products are overspecified and therefore consist of more advanced plastics than is necessary. However, manufacturers, sellers and experts mention that the reason products are overspecified is that it is easier and requires both less time and money to do so than to find out which plastic is good enough by building prototypes and testing their way. Thus, it is a problem that may remain even after reducing the number of thermoplastics.

The majority of manufacturers also talk about the fact that a reduction should be possible because they could reduce the number of plastic types they use, as many of them have types in stock that they rarely use. Manufacturers, sellers, researchers and experts also mention that one reason why there is so much variance is that many companies have their own type of plastic, but that many are basically identical, and therefore more standardization in either industries or specific products could be possible. Especially since many of the interviewees who are not manufacturers believe that function is the important thing rather than specific material properties.

Challenges that were often raised are that both producers and consumers have unsustainably high expectations for the quality of the recycled plastic. Therefore, an additional opportunity to replace today's large number of thermoplastics with fewer, more high-performance plastics is if producers and consumers could accept the quality obtained from recycled plastics. Since a preliminary conclusion is that a more high-quality recycling should be obtained, it should also mean that it may not be as difficult to get manufacturers and consumers to accept precisely the quality that would be obtained from the fewer, higher-performing types of plastic.

To achieve a more high-quality recycling and circular use of plastic, many of the respondents believe that more measures are required in addition to the reduction. Measures for this that are mentioned by both the industry and the experts are deposit systems, quota obligations, higher requirements for traceability and extended producer responsibility. More measures suggested by those interviewed are stricter standards, reporting requirements on the amount that companies send to incineration and taxes on fossil plastics. According to Holmberg et al. (2021), there is generally great support among Swedes for taking such measures for improved plastic handling. This applies to, for example, general regulations around

plastics, an extended deposit system or a tariff on imported fossil-based plastics. Furthermore, for example, Katrin Molina-Besch, former assistant university lecturer at the department of packaging logistics at Lund University of Technology, said that in order for the food industry to be able to use more recycled plastic, closed recycling systems are needed (Orkla, 2021). Therefore, the measures that came up in this study could be feasible given the support that is available.

Other concrete suggestions from experts are to demand that where it is technically possible, 100% recycled plastic should be used, and if there are no absolute requirements for colour, then transparent plastic should be used to increase the value of the recycled plastic. Packaging can be marked with a green arrow triangle if at least 50% of the product can be recycled into new raw material; otherwise, it is marked with a flame because the packaging is then likely to be incinerated. It is also proposed to set the requirement that every time a new product is put on the market, there must be information on it about the exact content, as well as how it should be collected and recycled. Similar proposals exist; for example, the Nature Conservation Society proposes that plastic products should be labelled with a QR code that should provide information about the product's contents so that it remains with them until it is time for the product to be recycled (Naturskyddsföreningen (2021). A concrete measure mentioned to reduce the risk of products being overspecified is some form of strength modelling program to ensure that a prototype can handle the load case, thus avoiding prototypes having to be redone and tested repeatedly before a good enough material can be selected. It is thus a combination of the reduction, legal requirements and similar measures needed to achieve a more circular handling of plastics and a more high-quality recycling.

It is worth noting that many of the action proposals that arose in this study are within the framework of Sweden's current action plan for plastics. To name a few, the government must propose global standards for plastic products at the international level and work towards an ambitious product policy framework (Regeringkansliet, 2022). The variant of standardization that this project proposes is to reduce the number of plastic types, potentially by standardizing more at the product or industry level. The government's action plan also includes that certain plastic products must have information requirements about how the product should be handled when it has become waste, which is also a recurring proposal for action in this study. Another focus area in the action plan is the "driving force for business and other actors who promote innovation and circular business models for plastics and plastic products". Although the purpose of the Unity project is to promote circularity, some respondents believe that the proposal may inhibit innovation because the project technically limits which types of plastic may remain for use. Therefore, there is a risk that the proposal is not completely in line with Sweden's action plan for plastics because that action plan includes promoting innovation. The reduction that the Unity project proposes and its proposed measures could also function as an application within the EU's current action plan for plastics. This is because it includes measures such as increasing the proportion of recycled material, measures for better separate collection of plastic waste, directing investments and innovations in the direction of circular solutions and supporting multilateral plastic initiatives (European Commission, 2018). The justification is that the majority of those interviewed assumed that the reduction would lead to an increase in the amount of recycled material and that the collection would be facilitated. If standardization across industries takes place, it can also become a multilateral initiative because many companies are also active abroad.

Summary:

- One possibility to reduce the number of thermoplastics can be through more standardization within industries, which in turn can mean that the number of plastic types can be reduced separately within specific industries or product categories. This is partly because many manufacturers believe that the products are often overspecified, partly because many companies manufacture basically the same type of plastic but under different brands.
- One possibility to implement the reduction in the number of thermoplastics is if manufacturers and consumers accept the quality obtained from recycled plastic or the quality of plastic products that do not have unnecessary additives but still meet the demands placed on the plastic. Since the reduction is believed to lead to higher quality recycling, it should not be as big a change in quality to accept as using today's recycled plastic.
- A potential, short-term solution to enable a reduction in the number of thermoplastics could be to advocate that companies themselves can set requirements to only use selected plastics, but then there is probably a need to spread knowledge about the challenges that exist in today's plastic use as well as the advantages of having a smaller number of plastics. Alternatively, clear recommendations can be made for which types of plastic should be used in particular products or industries precisely because it should be extremely difficult to find a few types of plastic that work for all types of plastic products.
- A combination of measures to reduce the number of types of plastic used can create a more circular system of plastic use.

11.4 PERFORMANCE REQUIREMENTS AND SPECIFIC PROPERTIES THAT THE PLASTICS THAT REMAIN SHOULD HAVE

During the interview study, it emerged that it is mainly manufacturers and some buyers who can answer which concrete material properties are important and that the rest rather address functional requirements for the plastic part. This is probably because the manufacturers are the ones who work most with the materials and material-specific properties than, for example, buyers and sellers do, who may therefore have a better overview of what is required for the products in their industry. However, it is worth noting that manufacturers mainly list material-specific properties as important, for example, viscosity or impact strength, while buyers, sellers and industry organizations rather mention functional requirements such as wear resistance. The manufacturers seem to have more detailed knowledge of what is physically possible than the remaining groups, who rather answered on a more general level. In connection with a discussion with one of the experts interviewed, it appears that the fewer thermoplastics should have the following material properties:

- Good impact strength for certain types of thermoplastics in, for example, the automotive industry and for certain household items,
- Good wear and tear resistance in, for example, conveyor belts and shoe soles,
- Good chemical resistance for example, for protecting household items against oils and acidic products, as well as protection of industrial plastics against oils, coolants and other automotive chemicals,
- Good color fastness which, for example, applies to protection against UV radiation for plastic products used outdoors,

- Good moisture and oxygen barrier, which apply to food packaging, and
- Good recyclability, which applies to all types of plastic products and a functioning system for recycling.

At the same time, it is important to note that many of the manufacturers are family companies with extensive experience but are not necessarily plastics experts. The fact that the functionality of the final product is considered more important than the specific material properties of the plastic for buyers, sellers and industry organizations indicates that it is possible to reduce the variety of thermoplastics. What the interviewees seem to agree on is that which performance requirements and specific characteristics are important is entirely product dependent. In order to find out more detailed requirements for material properties, more studies must be carried out at the industry or product level.

Summary:

- The most important material properties to be considered the fewer thermoplastics are: good impact strength, good wear resistance, good chemical resistance, good colour resistance, good moisture and oxygen barriers and good recyclability. These requirements are determined by the application for which the plastic products are to be used

11.5 CLOSING DISCUSSION

The Unity project's approach to reducing the number of plastics seems to be unique, and no similar idea has been identified among the ongoing projects and studies reported in Tables 4 and 5. However, in some cases, they seem to have roughly the same objective, that is, to get a more sustainable use of plastic, especially by achieving a better circularity. Rather, the focus seems to be on solutions such as compostable plastic or bio-based plastic, how to make it easier to recycle multi-layer packaging, packaging in general, better sorting systems or how to achieve more recycled plastic in specific sectors. Thus, the identified ongoing studies and projects seem to have more of a waste management approach, while the Unity project rather attacks the root of the problem and proposes a completely new plastic system.

Regarding the results of this study, the response is generally positive from the respondents. Many manufacturers believe that the products they make for their customers are overspecified, and a majority of manufacturers believed they could reduce the number of thermoplastics they use. Several interviewees point out the difficulties in getting the cooperation, supervision or standards that would be needed to work for everyone, and several have also pointed out that many types of plastic with different company names are basically the same. Those who are most questioning often interpret the idea as meaning that there would only be a few "superplastics" left in total and that the rest would be completely removed, which is considered completely impossible by them. However, there are already such proposals. For example, the World Economic Forum et al. (2016) suggest that it may be relevant to try to find a "super polymer" that is cheap, has high performance, has many functions and should work optimally for reuse, or Marks & Spencer's plan, to use only one type of plastic in its food range (Packaging News, 2018). To implement a general reduction, Nielsen et al. (2018) state that special additives that are difficult to recycle should be phased out, that creating products from only one type of material should be marketed, that the number of plastics allowed should be limited and that innovations that add complexity to the plastics system should be discouraged, which is also similar proposals developed by the Unity project.

This study within the Unity project points out that if a reduction in the number of varieties of thermoplastics were to take place, it might be most reasonable that it be done at either the product or industry level. This means that, for example, all Swedish manufacturers of vacuum cleaners review which types of plastic they use that are not really necessary for the function of the vacuum cleaner and phase them out, or that the necessary types of plastic are identified and that standards are introduced that state that Swedish vacuum cleaners may only consist of these. On the one hand, it may mean that competing companies use more similar plastics so that their products are generally easier to recycle; on the other hand, it may mean that it becomes more difficult for the manufacturing companies to compete so that the free market is threatened. Thus, it may be important to find a reasonable level for such potential industry standards.

Another possibility for reducing the number of thermoplastics is if manufacturers and consumers lower their expectations of the quality of plastics and get used to the quality obtained from recycled plastics. Furthermore, since the reduction proposed by this project is believed to result in higher-quality recycling, it should not involve as great a lowering of standards as the use of today's recycled plastics would possibly entail.

The hypothesis that was set at the beginning of the Unity project is that a smaller number of plastic variants with higher performance and clear properties is expected to provide several direct benefits, such as simpler logistics and separation, higher volumes and an increased recycling value. Together, the direct benefits are expected to provide additional environmental benefits and financial gains for the actors involved in plastic recycling. According to the interviewees, the environmental benefits are, among other things, reduced use of virgin plastic raw material, which leads to a reduced amount of plastic waste that cannot be recycled and thus reduces CO_2 emissions from the production of virgin plastic raw material and waste incineration. An economic advantage of recycled plastic with high performance and specific properties in combination with large volumes is that it then becomes more interesting for companies to reuse the plastic in new products.

From a socioeconomic perspective, there are also several advantages with reduced costs due to the CO_2 problem. Easier logistics and separation, as well as higher volumes and an increased recycling value, are mentioned as a potential consequence by several respondents within different groups. The same applies to the fact that those consequences could, in turn, lead to environmental benefits and financial gains for not only the actors involved in plastic recycling but also those who manufacture products from plastic. The more specific hypotheses, such as a reduced use of virgin plastic raw material as a result of the recycled plastic becoming more in demand, also appear frequently as answers among different respondents. That the idea would reduce CO_2 emissions is also taken up by the respondents as an indirect consequence of the number of thermoplastics decreasing. Thus, the idea of using a smaller number of plastic variants with higher performance and clear characteristics should generate the expected effects.

There are similarities between the challenges identified in this study and challenges in previous studies. Concrete examples are that the use of fewer types of plastic can mean that the plastic cannot be used as advantageously as it is today and that this, in turn, can hinder future developments in the area, which Nielsen et al. (2018) mention. They also mention challenges such that such a reduction could lead to an increased use of resources, especially when the advantages of plastic outweigh the disadvantages. In addition, they also address the issue of who should decide which plastics are

permitted. All the challenges that Nielsen et al. (2018) address were also identified in this study. The big difference, however, is that Nielsen et al. (2018) talk about a reduction in general, and not that all today's plastic types would be merged and partially replaced with other types, which the Unity project is doing.

Opportunities to replace the current large number of thermoplastics with a smaller number have been suggested by both Material Economics (2017) and Nielsen et al. (2018), which was also investigated in the Unity project. Furthermore, the Unity project also proposes proposals such as an extended producer responsibility, an improved labelling system, extended deposit systems, quota obligations or improved sorting, which are common proposals to improve circularity in general, and are therefore not necessarily unique to this study.

Besides the fact that this study is relatively alone in suggesting that all of today's thermoplastics can be grouped together based on similar properties and partially replaced by a smaller number, this study has also identified a number of action proposals that have not been identified in other studies. These are:

- Make requirement specifications for plastics less harsh where possible
- Standardize more industry-wise and product-wise and only allow a special selection of plastics with clear recycling properties
- Manufacturers can actively try to cut down on the number of plastics they use
- Use transparent plastic where possible
- Use recycled plastic where possible
- Introduce tariffs on imported plastic

11.6 TWELVE PROPOSALS FOR ACTION FROM THE UNITY PROJECT

Based on the interview study of the players in the plastics industry, the following 12 action proposals have been identified with an associated description and justification of how they can work together in practice.

1. **Make requirement specifications less harsh where possible** – lowering requirement specifications where possible could enable a natural reduction in the number of plastics, as products would then not be as overspecified.
2. **Standardize more by industry and product and only allow a specific selection of plastics** – more standardization over which plastics should be used or allowed within a certain industry or for a product type would result in larger volumes of the same types of plastics being used, which is also an enabler to reduce the number of further types of plastic. In addition, manufacturers with few suppliers have a greater opportunity to agree to use a limited number of plastics. Manufacturers with many suppliers will probably find it more difficult to control which types of plastic are used themselves, but if there are few suppliers or customers, these may be easier to integrate into such decisions.
3. **Manufacturers of plastic products can actively try to cut down on the number of plastics they use** – this can lead to fewer plastics in circulation for specific product types or industries, which in turn can help determine which plastics can be phased out for those specific product types or industries. For example, lists such as the EU's Substances of Concern or the Candidate List of REACH can be used to a greater extent as a basis for which plastic variants may be reasonable to phase out. It could facilitate the work to limit which types of plastic are suitable for use and where.

4. **Introduce labeling systems that facilitate sorting for individuals** – For example, on the packaging, the options could be either a green arrow triangle if the product can be more than 50% recycled into new raw material or a flame if it is less than 50% because then the product will probably go to combustion. Such a system could make it easier for consumers to make active choices that contribute to improved recycling and circularity and for consumers to learn the difference in the quality of packaging made from, for example, virgin plastic or recycled plastic. That, in turn, could potentially lead consumers to get used to and accept that quality of recycled plastic, which in turn could enable more plastics to be phased out in the long run.
5. **Use transparent plastic where possible** – then a coloured plastic does not need to be used, and then the recycled transparent plastic would have a higher recycling value compared to the coloured plastic.
6. **Use recycled plastic where possible –** then interest in working for a more circular system and recycling would increase, resource efficiency would increase and environmental gains would be made.
7. **Use transparent plastic in combination with labels rather than colouring entire packages –** this would mean that more quality is retained in the recycled plastic, which in turn could facilitate and enable a reduction in the number of thermoplastics.
8. **Design products that enable recycling** – this, too, could mean that more quality is retained in the recycled plastic, which in turn could facilitate and enable a reduction in the number of thermoplastics.
9. **Expand producer responsibility for plastic products** – to increase the number of products collected for recycling so that higher flows are obtained, whereupon higher quality recycling can be obtained.
10. **Expand deposit schemes for plastic products** – to increase the number of products collected for recycling so that higher flows are obtained, whereupon higher quality recycling can be obtained.
11. **Introduce tariffs on imported plastics** – to avoid unnecessary plastic imports and to prevent CO_2 leakage, namely, that the CO_2 emissions disappear in Sweden but are transferred to another country without the same regulations.
12. **Introduce quota obligations for recycled plastic** – it would stimulate the use of recycled plastic, but it needs to be set at an appropriate level for different industries.

On the one hand, however, it can be argued that without a functioning collection and recycling and that the recycled plastic is actually used, the effects of reducing the number of types of plastic would not be achieved, and that this needs to be addressed before a reduction can be introduced. On the other hand, the reduction itself would also increase both the recycling rate and the amount of recycled plastic actually used. Most likely, however, they go hand in hand with each other and probably need to be done in combination.

11.7 LOOKING AHEAD BASED ON THE TWELVE ACTION PROPOSALS

A potential solution that could be introduced now to enable a reduction in the number of plastics (especially among those used in large volumes) could be for the manufacturers themselves to require only a certain number of selected thermoplastics to be used. In the case of advanced plastics used in smaller quantities, a deposit system may be introduced. In that case, however, there is probably a need to spread knowledge about the challenges that exist in today's plastic use, as well as the advantages of having a smaller number of plastic types. Alternatively, clear recommendations could be drawn up for which types of plastic may be used in specific products or industries precisely because it will be extremely difficult to find a few types of plastic that work for all applications. To produce such recommendations, it may be relevant to further interview constructors, designers and product developers to get the perspective of those who actually set the requirements. Interviewing more manufacturers and requirement setters for plastic products would also be interesting. Something that may also be relevant to investigate is the environmental benefit of using as little material as possible, and thus perhaps needing more advanced plastic variants, compared to the environmental benefit of using one and the same plastic in a product, and thus possibly over-dimensioning the product but at the same time improving the possibility of recycling. It may also be of interest to investigate the possibility that manufacturers review and lower the requirements for their products rather than focusing on ensuring the content of the recycled plastic. Investigating such things could be helpful in developing standards within the various industries in order to find out which types of plastic should be used for what and why. Perhaps it is the case that a reduction in the number of plastics is not beneficial in all industries or product groups but only in particular ones. Different industries may also require different types of reductions so that one industry may tend to use more advanced plastics in general while another uses simpler basic plastics.

In conclusion, it seems that the Unity project's proposal is in line with both the Environmental Protection Agency's roadmap and the Swedish government's action plan. For example, this study has shown that the reduction in the number of types of plastic contributes to several of the points that the Swedish Environmental Protection Agency deems necessary to change; for instance, the reduction can lead to increased multiple-use, resource-smart business models and design principles, increased lifespan for products, good knowledge of which plastics that fit were viewed as opportunities to minimize environmental impact from a life cycle perspective, as well as more closed loops. In addition, the Unity project is in line with all points of the Environmental Protection Agency's thoughts on general needs for change, that is, an increased collaboration for the development of system solutions, that the design phase is completely rethought to change existing business models as well as a smarter use of resources and an increased collection for material recycling.

12 Conclusions

Here follows the Unity project's most important conclusions linked to its purpose and questions.

12.1 THE LARGEST VOLUMES OF THERMOPLASTICS IN PRODUCTS

The interview study shows that the most common thermoplastics are Polypropylene (PP), Polyethylene (PE), Polyamide (PA), Polyethylene Terephthalate (PET), Acrylonitrile-Butadiene-Styrene (ABS) and Polystyrene (PS).

12.2 ADVANTAGES AND CHALLENGES OF A HIGH-QUALITY REUSE OF THERMOPLASTICS IN PRODUCTS

Reducing the number of variants of thermoplastics is an advantage from a recycling perspective because actors believe that it can lead to larger volumes of base plastics arriving at the recycling facilities. The larger volumes of base plastics mean that the plastic recyclers can produce larger volumes of recycled thermoplastics at a more consistent quality and lower price. A challenge in obtaining a high-quality reuse of thermoplastics is to achieve a better collection and sorting of the most used thermoplastics. If the collection and sorting become better, it also contributes to the plastic recyclers getting larger volumes and cleaner fractions of basic plastics.

12.3 OPPORTUNITIES AND CHALLENGES IN REPLACING TODAY'S LARGE NUMBER OF THERMOPLASTICS WITH A SMALLER NUMBER

According to several of the manufacturers that were included in the interview study, it appears that they manufacture some advanced plastics that are not really needed. By stopping the production of these plastics, a natural reduction in the number of thermoplastics would be achieved.

Another possibility to reduce the number of thermoplastics is to start collaborating more within each product category. The various manufacturers then need to agree on which thermoplastics to use within a specific product category. In this way, the number of thermoplastics for each product category is reduced. However, it will be a challenge to agree on which plastics to use and stick to these for future products instead of developing new thermoplastics.

A challenge mentioned during the interview study is also getting manufacturers and consumers to accept the quality of the future recycled thermoplastics. If you can get a better acceptance of recycled plastic, the possibilities of being able to use recycled plastic in more products also increase. Another challenge mentioned is that some production processes need to be changed in order to be adapted to the fact that fewer varieties of thermoplastics are used. It may be that geometry and tools need to be adjusted in order to be able to use a smaller number of thermoplastics but still achieve the desired material properties. These adjustments require time and resources from the manufacturers.

12.4 REQUIREMENTS FOR PERFORMANCE AND SPECIFIC CHARACTERISTICS

Within the Unity project, it has emerged that the material properties that the fewer thermoplastics should have are good impact strength, good wear resistance, good chemical resistance, good colour resistance, good moisture and oxygen barriers and good recyclability. The requirements for the material properties of the thermoplastics are linked to which plastic product is manufactured, and more studies should be carried out for which thermoplastics and material properties are desirable at the industry and product level.

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A Appendix

APPENDIX 1 – INTERVIEW QUESTIONS

Manufacturer

1. How many different types of thermoplastics, including variants with additives, do you use, and for what?
2. Please state the weight and total percentage of production volume.
3. Who are your main customers (private/public sector)?
4. What properties are important for these plastics?
5. What are the most important requirements for performance and properties that you place on the plastic you buy in?
6. What are the most important plastic-related requirements for performance and properties that your customers place on the products you manufacture?
7. Do you think your products are overspecified?
8. Toy with the idea of replacing today's large number of variants with thermoplastics with a smaller number of thermoplastics. How many variants could you narrow down to?
9. Have you perhaps already reduced the number of plastics you use? What replaced what and why?
10. What would be the challenges and opportunities with the above idea?
11. How would the idea affect the price and demand for the plastics?
12. How would you as a manufacturer be affected if you succeeded in reducing the number of types of plastic, e.g., how would your processes be affected?
13. How are you affected by new Swedish/EU regulations?
14. Is there anything you want to add that we haven't asked about?
15. Are there other actors you think we should interview?

Seller

1. What are the most common types of thermoplastics among the products you buy in?
2. What are the most important requirements for performance and properties that you place on the thermoplastic used in the products that you purchase?
3. What are the most important plastic-related requirements for performance and properties that your customers place on the thermoplastics in the products you sell?
4. Play with the idea of replacing today's large number of varieties of thermoplastics with a smaller number of thermoplastics; what would be the challenges? How many varieties could you reduce yourself to?
5. Have you perhaps already reduced the number of plastics you use? What replaced what and why?
6. What would be the challenges and opportunities with the above idea?
7. What requirements would you place on the plastic?
8. How would this be affected by EU and Swedish regulations?
9. Is there anything you want to add that we haven't asked about?
10. Are there other actors you think we should interview?

Purchaser

1. What are the most common plastic products you buy? What types of plastic are they?
2. What are the most important requirements for performance and properties that you place on the thermoplastic used in the products that you purchase?
3. Play with the idea of replacing today's large number of varieties of thermoplastics with a smaller number of thermoplastics; how many could you reduce to?
4. Have you perhaps already reduced the use of plastic?
5. What would be the challenges and opportunities with the above idea? Do you think it is doable, to begin with?
6. What requirements would you place on the plastic?
7. What regulations would be needed to enable the idea?
8. Is there anything you want to add that we haven't asked about?
9. Are there other actors you think we should interview?

Trade organizations

1. What types of thermoplastics are used, and in which products?
2. What volumes are there in Sweden?
3. How much is recycled plastic?
4. Why not use more recycled plastic?
5. What requirements do you consider important that recycled plastic does not meet? Please be specific.
6. If it could be guaranteed that the properties of the recycled plastic were exactly the same as the newly produced plastic and that the plastic was not mixed with other plastics, do you think the use would increase? If so, how much?
7. What do you consider to be the most important requirements for the performance and properties of the plastics used?
8. What would it take to increase the reuse of plastics?
9. Which products and actors would be most suitable to start with?
10. What legislation and other barriers would need to be changed?
11. Technically, how would this affect production, use and recycling?
12. How would the industry be affected if one succeeded in reducing the number of types of plastic?
13. How are other players in the industry affected?
14. How would this be affected by, e.g., EU and Swedish regulations?
15. If the number of plastics is reduced, how would you be affected?
16. Is there anything you want to add that we haven't asked about?
17. Are there other actors you think we should interview?

Recycling company

1. How many different types of thermoplastics, including variants with additives, do you handle?
2. What are the most common types of plastic, in terms of volume, that you collect and recycle? What kind of products are they?
3. What requirements do you place on the plastic so that you can recycle it?
4. Play with the idea of replacing today's large number of variants of thermoplastics with a smaller number. Do you think it is feasible?
5. Speculate yourself; what would the challenges and opportunities be?
6. Which regulations would need to be introduced/changed to increase recycling?
7. Is there anything you want to add that we haven't asked about?
8. Are there other actors you think we should interview?

Researchers and experts

1. What types of thermoplastics are used, and in which products?
2. What volumes are there in Sweden?
3. How much is recycled plastic?
4. Why not use more recycled plastic?
5. If it could be guaranteed that the properties of the recycled plastic were exactly the same as the newly produced plastic and that the plastic was not mixed with other plastics, do you think the use would increase? If, how much?
6. What do you consider to be the most important requirements for the performance and properties of the plastics used?
7. What would it take to increase the reuse of plastics?
8. Which products and actors would be most appropriate to start with?
9. What legislation and other barriers would need to be changed?
10. Play with the idea of reducing the large variety of thermoplastics that exist. Do you think it would be feasible?
11. Many manufacturers believe that much is overspecified. Do you agree?
12. Technically, how would this affect production, use and recycling?
13. How would the industry be affected if one were to succeed in reducing the number of types of plastic?
14. How are different players in the industry affected?
15. How would this be affected by, e.g., EU and Swedish regulations?
16. If the number of plastics is reduced, how would you be affected?
17. If you can speculate for yourself, what are the opportunities and challenges of the idea?
18. Is there anything you want to add that we haven't asked about?
19. Are there other actors you think we should interview?

APPENDIX 2 – DETAILED RESPONSES FROM MANUFACTURERS

In this appendix, the more detailed answers provided by manufacturers to questions are presented where possible. Thus, the concise answers are not presented, but only the more developed ones to highlight more perspectives. It is the manufacturers' responses that are presented because they formed the largest sample group, and thus the responses were summarized in the results section of the report.

Do you find that the products you manufacture tend to be overspecified?

Statement	Respondent
Most often	
Packaging should certainly work just as well with recycled plastic, but customers often require it to be transparent.	M3
Within the medical industry, there is a great reluctance to change or replace materials. There, the products are often incredibly overspecified.	M13
Most of the time, it is engineers who make the decisions. For example, plastic shrinks, and certain dimensions are critical for quality, but certainly not all. To avoid overspecified products, we work with tolerance standards instead of redesigning the product.	M27
The customers know incredibly little about plastics. You notice that someone in purchasing does not understand. There is a great deal of ignorance about plastics from the perspective of consumers.	M29
Two phone manufacturers had different specs: one expected it to give x number of defect complaints but thought it was worth it to get a cheaper product; the other wanted rather to have zero defects throughout the chain resulting in expensive material-wise instead.	M23
The customer's customer has a lot to say about the material, but the bar is often set very high. We, therefore, want to have more contact with the customer's customer to remedy this.	M25
Probably due to the fact that the customers have different levels of knowledge about the materials.	M28
Usually not	
Of course, things must not break. I don't know if the bar is set high for what the customer wants the product to handle.	M2
Customers are terrified of things breaking.	M16
We own our products ourselves and follow our standards, so we are exactly on top of what is required.	M4
New customers can have it, but the problem is probably that it is a challenge to find the optimal plastic, so you take steps to avoid finding what is just right.	M8
In some cases, however, instead of doing those tests to find a material that just meets their requirements, we go with a really good plastic that is guaranteed to meet their requirements. However, it comes with a price tag that not many people are keen on; then the designers have to justify why if they still want the more advanced plastic.	M10
A customer who has been with us for a long time has a fairly narrow portfolio of materials that they know work.	M30

Play with the idea of replacing today's large number of thermoplastics with a smaller number; how many variants could you reduce yourself to?

Statement	Respondent
Should go but don't know how much	
Packaging should absolutely work just as well with recycled plastic.	M3
Then we would switch to the worst material we have, maybe replace everything with PEEK, but will anyone estimate that the price goes from SEK 20/kg to SEK 1000/kg?	M10
It could possibly spare some quality of PP. Changing the variety, however, would partly be more expensive, partly not accepted by the customers or work in the manufacturing processes.	M12
If you don't have to worry about cost, you could reduce the number of plastics. A simpler plastic is often chosen because it costs less to manufacture.	M21
Maybe you should overspec and run 20% fiberglass to get rid of a variant?	M23
You should be able to check how materials overlap using the Ashby method and reduce based on that!	M27
Regarding packaging, it should be easier to opt out of plastic.	M29
Should not go	
The whole industry is looking for new materials, so the demand for many materials is there.	M8
The problem is that if you want to reduce, you have to remove the simplest variants. PE can be replaced with a POM, no weirdness for us, but it might be more expensive and unnecessarily over spec'd in the end, which might not be in demand by the customers. Then customers might switch to aluminium.	M9
Products that have to enter the body can be difficult to change.	M13
Then we get to use the same plastic but with different additives for each variant that is needed.	M15
Removing certain materials means that those that remain have poorer properties.	M18
We only use one plastic.	M19
We are very much driven by the customers.	M30
A particular variety should be phased out	
ABS should be able to be phased out. Theoretically, PETG should be interchangeable with PC. PS should be phased out completely.	E4
PA is used very little.	M5
Could make almost any pipe out of just PVC or PE.	M14
PE or PP could probably be phased out.	M20
Should be able to reduce by 20-50%.	
If the customers weren't so rigid, almost half could probably be removed.	M16
If the customers are flexible, it could certainly be halved.	M28

Have you already reduced the number of plastics you use? What replaced what and why?

Statement	Respondent
Yes	
The reason may be that we want to avoid having so many different suppliers.	M2
We had 20 different variations on the top sheet; today, we have two.	M3
We have deliberately worked to have a few varieties from the beginning.	M13
Sometimes if we find a more cost-effective material.	M15
A lot in recent years; at the same time, we are increasing now due to an increased use of recycled material.	M21
Yes! We would rather have large volumes of fewer numbers, but it is not always easy.	M22
We are trying! Recently, it has become easier to specify for customers and influence them. In the past, it has been too difficult and expensive.	M23
Continuously! Using more and more recycled material.	M27
We have phased out a lot of additives. In some cases, we have been able to take something we use a lot already; there is usually something equivalent already because the specs do not differ much.	M28
No	
One is rather reluctant to make those investments.	M1
We need four large varieties, the rest we haven't had time to remove. PP is among the most environmentally friendly materials in terms of density, reusability, etc.; therefore, we try to use it the most.	M4
It is rather a growth; new customers often mean new materials.	M6
No, demand is rather increasing.	M9
We have always only used one plastic.	M19
No, but if a customer questions something, we make sure to use some material we already have.	M30

What would be the challenges and opportunities with the idea?

Statement	Respondent
Opportunities/advantages	
Make everything transparent! Take the example that Heinz makes red ketchup and shows it, while Felix also makes red ketchup but does not show it. Both use PET as material in the bottle, but one is red, although it doesn't really need to be.	E4
Could trace elements be used to simplify sorting? In terms of colour, it is more of a design issue in which colours can be removed.	M6
There would be a clear flow for recycling.	M14
Borealis has no vested interest in having something they don't sell; the suppliers make what the customers want. The problem rather lies with the manufacturers, and then it self-adjusts there. It would be better for us to buy in large batches.	M18
Those of us who work with extrusion want viscous materials, but others with mould casting want easy-flowing materials! Film blowing wants something else, etc., so maybe you need to add something instead so that you get plastic with a certain fluidity and add additives?	M22
With fewer plastics, there would be fewer suicides because the volumes are too small to manufacture. Many plastics are basically identical but with different company names, so it would definitely be doable! It would result in shorter set-up times, and companies should become more efficient, but competition might increase because there are fewer varieties. If the flora is reduced, market advantages can be gained because more people can fight for it. The one who does it the fastest is the one who survives. Then the level of service determines the availability, and Europe can supply Europe, which brings environmental benefits!	M23

The challenges can be getting the right wording so that it works for many. Some industries may have no alternative.	M25
One could check how materials overlap using the Ashby method.	M27
Then you wouldn't have as many suppliers anymore, and larger volumes and less handling would make it more efficient in terms of costs.	M28
In packaging, it is probably easier to opt out of plastics.	M29
In the last 20 years, a lot of plastics have come out that have very similar properties; it should be possible to reduce them.	M30
Challenges/disadvantages	
Our products last so long that there is really no incentive to switch from plastic. In addition, it is difficult to make such a change in just Sweden because we are a multinational company.	M1
It can be difficult to get an acceptance for lower requirements. Customers would like to control and set things themselves, but the cost issue is often too great.	M2
The extreme case is that only one type of plastic is used everywhere, which would lead to no competitive advantage. The only one who survives is the one who can manufacture it the fastest.	M3
The challenge is the cost! We have looked at alternatives to PP that could cover 3 of the 4 plastics we use, but the price is too high. It might be contradictory if the reduction would mean that thicker products of more material are required, especially when it might not even be better properties because you might need to use a worse plastic for the purpose? It becomes a challenge when the industry is looking for new materials; there is a demand for many materials.	M8
The problem is that if you want to reduce, you have to remove the simplest variants. PE can be exchanged for a POM, which can be exchanged for a more expensive one. It's not strange for us; it might be more expensive and unnecessarily overspect'd in the end, which might not be in demand by the customers. Then customers might switch to aluminium.	M9
It may be possible to replace everything with PEEK, but will anyone appreciate that we go from SEK 20/kg to SEK 1000/kg?	M10
It is impossible to get a single plastic that works everywhere; it is better to invest in a refined recycling!	M12
We are located far up north, so there will probably be no major environmental impact; the trucks still have to be driven.	M15
There are many manufacturers; if you were to reduce the number of plastics, some manufacturers would disappear from the market because they are not needed and that only increases the existing production of the most common plastics.	M16
If you remove material, it gives poorer properties in the selection that remains.	M18
It should be possible to reduce, but we must be prepared for increased costs because it entails more exclusive plastic in simpler articles. We can't have things that break from an environmental perspective, so you always have to choose the one that's best. A simpler plastic is chosen because it costs less to manufacture. Nylon is a good plastic but is more expensive than PP, so the customer doesn't want to pay for it. Cost is the biggest reason for having different variants.	M21
There are many different brands, and everyone protects their own, even if there are small differences.	M22
If you were to reduce, you would get a strong overspecification of the products, which definitely affects the climate footprint! If you overspecify, you get a climate burden that is unreasonably large. Rather, one should question which materials one uses and use the right plastic in the right place.	M26
The customers are the problem! They are conservative, and buyers and technicians don't want to make any changes if it already works. People are very careful about taking risks, and companies want their own secrets to survive.	M27

How would you as a manufacturer be affected if the number of plastic types was to be reduced? For example, how would your manufacturing processes be affected?

Statement	Respondent
The processes should still work	
We are quite flexible for different materials; all that is needed is a trial run process.	M2
Most ABS customers could use polycarbonate without too much change.	E4
Injection moulding is fairly standard, so it is possible to run quite a lot of other things.	M4
All our manufacturing is tool-based in casting moulds; if a material shrinks differently, adjustments may be needed in the tool. We are a hundred-percent contract supplier, so the customers own the tools; therefore, it is up to them to decide.	M10
Many manufacturers can produce from several plastics with the same machine.	M14
If you want the optimum for each material, you need a tool for each material, but you probably don't always need the optimum.	M18
The equipment should probably still work, but the runs may need to be re-optimized. The same material group should still work.	M28
In Germany, you only run one plastic per machine, but we can't afford that here. Therefore, we configure our machines so that they can handle several different plastics.	M29
As long as the materials are equivalent, it should work!	M30
The process consists of the same steps; what differs between different types of plastic are only different settings regarding things such as temperature and time.	M23
The processes should be redone	
If we are to use plastics with poorer properties, the products need to be redesigned, and new processes are required.	M1
We use rotational moulding, and it won't work with just any plastics.	M5
More expensive plastics usually withstand higher heat; then, other machines may be required.	M9
We are very sensitive to material changes, very many of the tools would probably need to be redone.	M22
Depends on the circumstances	
Depends on whether it results in more advanced or simpler plastics staying put.	M8
If the shrinkage changes, adjustments are needed in the moulds.	M10
Would work on some lines but not all.	M11
Fluidity and heat resistance are the most decisive factors for whether a plastic works or not.	M12
The machines are relatively general, but the moulds are made for a certain plastic, and there you may have to compensate for a different shrinkage in a different plastic.	M13
The machines are probably not affected; rather, the moulds, which become problematic as they are based on the shrinkage level of the plastic to be used.	M17
The process must be adapted to the material, but if the new material is similar to the previous one (applicable temperature, pressure, speed required) then it does not matter much.	M27
A completely different type of plastic probably wouldn't work, but a similar one.	M30
Positive influence	
A reduction to 10 recipes would result in much lower costs, lower set-up times, higher capacity in the factory and less waste.	M3
Will be cheaper as we get less stock; we can buy in larger volumes at a lower price.	M4
It would be much easier for us to choose which one is the best among a smaller number than among 5000 variants.	M6
Then we wouldn't have to have so many article numbers in stock, so everyday life would probably be easier that way.	M16

If one were to see the optimum for each product, we would have 250 materials and 250 tools, but we would rather have 10. We would have lower purchase costs and, in the long run, become more interesting for more suppliers. Therefore, there should be a vested interest in not having too many variants.	M18
Fewer variants would be good in terms of stock.	M30
It is possible to make the machines more efficient if you only use one plastic because you can optimize the process according to that particular material.	M29
Fewer plastics would mean that we don't have to learn a lot of specific runs, and all our employees can learn it instead of there being some employees who are particularly good at the laying on of hands which then becomes less complicated.	M23
Logistics will be easier.	M24
Should the standard qualities increase and better designs for recycling be obtained, the volumes that are recycled will increase, and we, as sellers of recycled material, can then sell even more recycled.	M25
Negative impact	
It can take several years to develop the products again if a different material than the one used now is to be used instead.	M1
If the cycle time increases, more new machines are needed to manufacture more products at a time.	M8
Either they have to re-direct or close down due to the competition.	M15
The reason why we have different qualities is that sometimes when manufacturing in plastic, the geometry is not completely correct when it solidifies. Then you may have to compensate by switching to another quality and see if it gets better. If we do not have the replacement qualities available, we may have to make new tools, which takes time and is costly. Then both our costs and the customers' costs would increase in total.	M21

How are you affected by new Swedish/EU regulations?

Statement	Respondent
Industry standards.	M1
Those recently banned masterbatches in Sweden can still be bought in from China.	M2
Rather than the customers who are affected, we just do as they say and deliver.	M6
At the moment, it mostly happens around single-use products or, for example, a tax on virgin plastic.	M8
REACH and environmental requirements.	M10
The materials available are already approved for use.	M11
Medical Technology Certifications. They are very regulated and have little freedom of movement, so we have to ensure everything.	M13
REACH and standards on hazardous chemicals.	M15
An upcoming directive is that cars manufactured after 2025 must contain at least 25% recycled plastic.	M21
REACH, but the material manufacturers adapt very well.	M22
Municipal control, but it is an interpretation of EU legislation.	M23
There are a lot of new standards. Sweden is good at new recycling standards with data sheets or being able to better compare qualities with each other.	M25
New standards around plastics mainly concern single-use plastics, so it doesn't affect us that much. Otherwise, REACH and what things may contain, but it is basically fulfilled automatically.	M28

APPENDIX 3 – DETAILED RESPONSES FROM RESEARCHERS AND EXPERTS

In this appendix, the more detailed answers that researchers and experts gave to questions are presented where possible. Thus, the concise answers are not presented, but only the more developed ones to highlight more perspectives. The researchers' answers are presented because they have a lot of knowledge about the subject, and therefore, their answers are relevant to emphasize.

Why not use more recycled plastic?

Statement	Respondent
There are so many different factions! It will be difficult to get it on a large scale and therefore more high quality. For example, PET maintains its quality better than other plastics, so the properties decide with. Lack of transparency about the content is also a factor.	E1
If it had only been clean laminates that are not dirty, it would probably have been easier to recycle packaging. NIR works as if you set it on a plastic and sort out everything else so that everything that disturbs remains in the residual fraction. Many Swedish converters are also family businesses, not plastics experts!	E4
It is difficult to achieve transparent, transparent products if the material used has been coloured before, and black plastic cannot be identified by the NIR equipment. In general, products that are supposed to last a long time contain more additives than short-lived products. Therefore, the packaging is usually simpler.	E5
A lot of things! But uncertainty about the availability and quality of raw materials, and thus becoming price sensitive, I think, is the biggest obstacle. Lack of traceability too.	E9

What would it take to increase the reuse of plastics?

Statement	Respondent
Reuse of plastic requires better loops and a change in norms around used. For increased recycling, a simplification of the plastic system is required! The problem with recycling is that there are so many additives, and it is unclear what the plastic contains; therefore, more standardization and more transparency around the content are needed. Expanded deposit schemes can also help.	E1
Higher requirements for deposits and separate recycling. More standardization. However, the fact that more things are recycled is not the same as better recycling. Some believe that we are creating functional landfills. We use a lot of recycled plastic as filling, which only ends up in planks and floors, e.g., which is not a better recycling. We could invest in better sorting!	E3
There is a built-in resistance in the system, and a lot depends on lazy buyers who say, "No, we can't change from one shade to another, then we have to go back to our customer and ask...". It works so well between industries because if a customer sends it back to the industry that produced it, they can use it again because they know exactly what the plastic contains. Make demands on the suppliers that where it is technically possible to use 100% recycled, this should also be done, then the industries will adapt. Also, make sure that everything is collected smoothly. Deposits on even more packaging would also be good.	E4
The man in the street needs to get better at recycling, and the man in the street needs to get better tools to be able to do it. For example, an extended deposit system for more products such as ketchup bottles, shampoo bottles and washing-up liquid. It's actually pretty much the same types of plastic in the mustard bottle and the ketchup bottle, etc. It is the colours and the designs that differ.	E5
It needs to be sorted when it gets to us. The less mixed it is, the higher value it gets and the more we can pay the customer in the end as well. If we could set the requirements for purchases that we only want these "11 varieties", then we could get a more high-quality recycling.	E7
For example, that quota obligations will come on PET bottles, it is a bit hasty to say that you should have quota obligations on everything, but it is moving in that direction. Social economists believe that it is better to put taxes on fossil raw materials, but there is a longer way to get there. We also struggle with the quality of recycling because it is cheaper to recycle to poorer quality. You can't set any requirements that you have to send your raw material here or there, but with design requirements, you can be as tough as you like. So, quota obligations become attractive. Sometimes it might be better that you have two materials that can be easily taken apart than a single material that is super light that sticks together, so we try to incorporate that in the EU context that you have to keep in mind.	E9

Which products and actors would be most appropriate to start with?

Statement	Respondent
Right now, there is only a deposit system for PET. It should be possible to do something similar with packaging for cleaning products, soap packs etc., or tetra paks like for dairy and juices. In the long run, the deposit system is probably a good first step!	E1
Packaging, food packaging and consumer products, e.g., like the positive lists. Producer responsibility could be tightened! For example, different for electronics or vehicles! You mustn't forget textiles either! Standardization of building products that are built in, e.g., drums, floors, etc., can also be made.	E3
Blister packs, perhaps? M26, Trioplast and Stena Handling are good examples of players.	E4
It seems to be difficult in the car industry; it is probably in packaging that the most can be done. New rules and regulations from the EU mean that companies themselves are starting to think along these lines, so much can probably sort itself out as segment after segment improves.	E5
Packaging every time! It is there that you know that a more standardized solution is just as good an alternative. There are already studies that show that you should do well on only a certain number of plastics. Then maybe compound products. Cars, I don't know if it's a realistic example, but it's clear that you put together a few different details that should have different properties, but that it might be easy today to have different types of plastic, even though you could get the same properties with the same types of plastic in some cases. So, such applications could be chosen with the aim of facilitating sorting and thus getting rid of small flows. I had definitely ignored niche products, e.g., complicated healthcare equipment, because there will be so many other aspects there, so it will probably be difficult to penetrate, even if the same thing could certainly be done there.	E9

What legislation and other barriers would need to be changed?

Statement	Respondent
Perhaps legislation that specific products may only use so much plastic or additives. For example, shampoo bottles?	E2
The question is, to what extent can legislation be done? Labelling of products would possibly work, but mainly stricter control. However, it is probably important not to get stuck in just packaging! Business-to-business, stretch film and packaging are also current areas.	E3
Require whoever uses plastic to use at least 10% recycled plastic where it is technically possible. Then the industry will change. Also require that every time you put a new product on the market, there must be information on it about how it should be collected and recycled. Packaging could have two figures: a green arrow triangle if more than 50% of the product can be recycled into new raw material. Otherwise, a flame, because then it is less than 50%, and then the product will probably go to combustion.	E4
Demand needs to increase. The cost, in the end, to handle the plastic, manufacture it and make it usable is higher than if you take it via oil. Procurement is easier because you can change it now. If you set requirements in the construction sector for sorting into more fractions, it would improve in combination with supervision. So, 1. obtain procurement, 2. increased quota obligation. The County Administrative Board should be the ones responsible for supervision. It is difficult to get a municipality to manage it itself, and if you delegate, the municipalities will interpret regulations a little differently. The Environmental Protection Agency should step forward and be the ones to set the regulations. In my opinion, it is not the responsibility of trade associations to create the change. The organization Wrap can be of help regarding legislation at the EU level. The Swedish Environmental Protection Agency has signed that they support that work. In tenders, a signal is sent to buyers and designers that creates a demand. Then the market will follow, but at the same time, supervision must exist and be national. We do not believe in product passes as a solution, but rather standardization! The greater the standardization, the easier it will be.	E7
The fact that we do not receive sufficiently detailed information about the contents of the packaging means that we pay the high packaging fee for many products because we do not have sufficiently detailed information about the product. We see this as a big problem. We would actually like to have legislation that when you hand over packaging or other products, then you must be obliged to state added chemicals and detailed information about the plastic product.	E8

A producer has responsibility for packaging but also for cars and electronics because there is no incentive to recycle the plastic. An old habit is our greatest enemy, and it also applies here. It is probably difficult for legislators or authorities to step in and actually say that it should be exactly these requirements. Even if you can set very strict design requirements, it is difficult to set them at the plastic-type level. Because you will end up in very long discussions in different ways, and exceptions are needed for the first and the fifth, and so on. So, you will probably always want to leave that to the industry in some way. On the other hand, you can then try to control with, for example, differentiated fees or something like that on properties that nudge in the right direction. In our new government mission, the right plastic in the right place, there is a component of suggesting what fits where, e.g., when can bio-based be good, when is recycled best, etc., but it can be as big as you like.	E9
You have to say either you reach this goal within five years or you are out, so that becomes the problem of the industries. Then they have to solve the problem by, for example, standardizing the plastics, introducing a deposit system or making sure that everything is recyclable.	E10
Perhaps one could focus on two things at the same time: partly increasing recycling, especially the use of recycled material, and partly how to reduce the use of plastic in new products in general. Perhaps through taxes for fossil materials or perhaps more standardized packaging solutions. Especially those that can be reused rather than disposable packaging. But the main obstacle is that this may not be in demand by manufacturers.	E11

What are the opportunities and challenges of the idea?

Statement	Respondent
It is a political challenge! Speaks against the way policy looks today. Innovation is advocated today, and this idea becomes like a precautionary principle on plastics and would therefore get a lot of backlash from the industry, who would see it as their downfall because you "prevent innovation". There is probably a potential for increasing transparency! Swedish manufacturers probably have more exchanges with each other, but developing new plastics is an innovation process, and company secrets bring potential business, which can be difficult to tackle on a global level. The ideal would be a high degree of transparency and that it is standardized in different industries! There are plastics with different properties that are good in different cases. Perhaps one should stick to PP and PE whenever possible. Consumers probably have a tendency to choose things that look fresh, and manufacturers notice that. Pant fulfils a function in the behavioural aspect, but it is probably not a majority that takes the sorting seriously. In my utopia, it is much more standardized! We roll around on PP, PET and PE as the big plastics. Then you might be able to apply for a dispensation where it is possible to authenticate, for example, in durable plastics such as in infrastructure. But that more standardization is found among the short-lived products. The user path might be inhibited? We can't do all these things anymore, so maybe the quality drops? Some such policy probably needs to take place at the EU level; it is not possible within Sweden alone. There is an import aspect to it. Maybe you can regulate which plastics can be imported? Or introduce better labelling? You probably have to work with both post-consumer and pre-consumer. The more the industries have control over their own plastic and its content, the more money there is, but consumers also need to get a better role.	E1
It will be very difficult to control it because the system is so complex. There are different degrees and applications. If you want to keep the flows clean, perhaps you should work on expanding the deposit system for packaging. Maybe cars are a possibility? The industry is dominated by a few large manufacturers, and all cars basically have the same functional requirements.	E2
PET now allows juice packaging, so it would certainly be possible to expand more! We have already seen the first step, the emergence of the positive lists. It is Japan, China and others that have reacted to the amount of additives and introduced positive lists of plastic products to be approved for food contact. Instead of listing all additives that are prohibited, all that are approved are listed.	E3
Honestly, you don't need all laminates. They have come forward either because of the cost issue or for the barrier properties. Companies can use labels with their colour instead of colouring the entire package.	E4

One challenge is that there are business reasons for having your own variant, and you want to keep your secrets.	E5
A company had decided that they would use more recycled than new raw material, and then they needed to be a little more lenient with the variety. Then the melt index could vary between 1 and 1.5 instead of being exactly 1. The challenge there is that those who are used to it are so spoiled by the polymer industry that they can say, for example, that No 1 doesn't work for us; we can get 1.1 instead. So, it will never be recycled, no matter how good we become! So, the expectations from the industry about what you get when you buy something are set very high, and it doesn't rhyme with recycled. The next thing is the money, because if you want as good as they want, it's actually more expensive to do it with collected goods than from crude oil, so people will be disappointed because they will buy something that is a little worse, but they will pay a little more.	E6
Marks & Spencer has such a sustainability goal that only one polymer should be used in the grocery trade, and they believe that it must be PE then.	E8
That would lead to supposedly easier sorting. There are different additives within PP and PE, and if you were to limit it, you could end up sub-optimizing so that it becomes "one size fits no one".	E9

APPENDIX 4 – IDENTIFIED ACTION PROPOSALS BASED ON THE INTERVIEW STUDY

Through the interview study and the subsequent workshop with players in the plastics industry, the following action proposals were developed to enable a reduction in the number of variants of thermoplastics:

- Make requirement specifications for plastics less harsh where possible.
- Standardize more industry-wise and product-wise and only allow a certain selection of plastics, especially manufacturers with few suppliers are more likely to agree to use a limited number of plastics than manufacturers with many suppliers.
- Manufacturers of plastic products can actively try to cut down on the number of plastics they use; for example, lists such as the EU's Substances of Concern or the Candidate List of REACH can be used as a basis for which plastic variants may be reasonable to phase out.
- Introduce labelling systems that facilitate sorting for individuals.
- Use transparent and recycled plastic where possible.
- Use transparent plastic in combination with labels rather than colouring entire packages.
- Design products that enable recycling.
- Expand producer responsibility for plastic products.
- Expand the deposit systems for plastic products.
- Introduce tariffs on imported plastic.
- Introduce quota obligations on recycled plastic.

The proposed measures can be implemented separately or in combination with each other. A more detailed description of these action proposals can be found in Chapter 11.6.

Avfall Sverige, Swedish waste management, is the municipalities' trade association in the field of waste management and recycling. Avfall Sverige's members ensure that waste is collected and recycled in all Swedish municipalities. We perform our work on behalf of society: in an environmentally sound, sustainable and long-term manner. Our vision is "Zero Waste". We are taking action to minimise waste, promote reuse and ensure that the waste produced is recycled, recovered and managed in the optimal manner. Municipalities and their enterprises are the ambassadors, catalysts and guarantors of this change.

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