

Collection & recycling of plastic waste

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*Anna Fråne, Åsa Stenmarck, Stefán Gíslason, Kari-Anne Lyng,
Søren Løkke, Malin zu Castell-Rüdenhausen and Margareta Wahlström*



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Introduction and background

This report is the first deliverable within the project *Improvements in existing collection and recycling systems of plastic waste from households and other MSW sources*. The report has been prepared by IVL Swedish Environmental Institute, Ostfold Research, VTT Technical Research Centre of Finland, Aalborg University and Environice in Iceland. The project is initiated by the Nordic Waste Group (NAG).

Background to the project

The background to this project begins in 2011 when the working group formed in 2010 by the Nordic Prime Ministers presented its report on favorable areas for Nordic cooperation and future priorities within the area of green economic growth.

The Nordic Prime Ministers' green growth initiative, The Nordic Region – leading in green growth, identified eight specific target areas where a joint Nordic cooperation was considered beneficial for the Nordic countries. All of the target areas were accepted by the Nordic Prime Ministers and it was decided that the work should be carried out by the Nordic Councils of Ministers.

One of the eight priority areas was to develop innovative technologies and methods for waste treatment, aiming at resource efficiency and life cycle thinking in the waste management sector. To carry out the work under the target area, NAG was asked to develop a Nordic project activity. As a response to this, NAG initiated the overall project *Resource efficient recycling of plastic and textile waste*. In 2012 a pre-study was performed in order to explore the potential for increased recycling of plastic and textile waste in the Nordic region.

NAG developed six associated recycling projects based on the pre-study, three concerning plastic waste and three concerning textile waste. *Improvements in existing collection and recycling systems for plastic waste from households and other municipal waste sources* is one of the three plastic projects.

Goal and Scope of the project

The overall aim of the project *Improvements in existing collection and recycling systems for plastic waste from households and other MSW sources* (part 1 and part 2) is to pave the way and provide conditions for more efficient collection and recycling of plastic waste from households and other municipal sources in the Nordic countries, striving towards higher recycling rates. The existing collection and recycling systems in the Nordic countries will be challenged by creating a Nordic knowledge base on collection and recycling of plastic waste from households and from other MSW sources. The Nordic knowledge base will be compiled into guidelines for plastic packaging waste collection.

The guidelines will contain information about relevant aspects to consider in order to improve and expand the existing collection and recycling systems, best practice in the Nordic countries and identified drivers and encouragement for stakeholders. The project will also suggest future solutions to increase the recycling rate of plastic waste from households and other municipal sources, including possibilities for Nordic cooperation within the area.

The project considers:

- Plastic packaging waste from households and other MSW sources.
- Plastic bulky waste from households and other MSW sources.
- Small plastic waste other than packaging from households and other MSW sources.

Other municipal waste sources commonly refer to waste generated by other sources than households, but with the same composition as household waste. In some Nordic countries the term household waste includes “similar waste” from businesses. Examples of similar waste are waste generated in canteens, or in toilets and bathrooms etc.

The meaning of plastic bulky waste is large items of plastic waste that do not fit into bins and bags and therefore need different handling. Examples of plastic bulky waste are plastic garden furniture and buckets.

Small plastic waste other than packaging is plastic items that fit into the same collection system as plastic packaging waste.

Plastic waste excluded in the project is plastic waste classified as hazardous waste, WEEE (Waste Electrical and Electronic Equipment) waste from end-of-life vehicles, leisure boats and plastic waste from the agricultural sector.

Timeline and structure of the report

The project started in June 2013. The final results of the project will be presented in a second report in December 2014.

The project group covers five of the Nordic countries: Sweden (IVL Swedish Environmental Research Institute), Norway (Ostfold Research), Finland (VTT Technical Research Centre of Finland), Denmark (Aalborg University) and Iceland (Environice). Partners from Greenland, Åland and the Faroe Islands are represented in the project group, but key actors of these regions are involved to make sure that the Nordics is entirely covered. Greenland, Åland and the Faroe Islands are referred to as independent Nordic countries in the project.

The project work is divided into two parts:

- Part 1: Fact finding and benchmarking as basis for guidelines and Analysis and assessment of alternative future solutions.
- Part 2: Development of guidelines for collection of plastic packaging waste and Development of a proposal for future solutions and instruments.

This report is created based upon Part 1. The main focus of Part 1 has been data collection, mapping and description of the collection and recycling systems in place for plastic waste from households and other MSW sources in the different Nordic countries. The information sources have primarily been:

- Existing literature sources.
- Interviews with key actors and stakeholders in each Nordic country.
- The project partners' experience from other projects in the area of plastic collection and recycling.

The gathered information has functioned as a basis for comparison of the collection and recycling systems of plastic waste and other MSW sources in the Nordic countries. Input to the project was also provided during a joint workshop for the three plastic projects under the *Resource efficient recycling of plastic and textile waste* initiative. Stakeholders within the field of collection and recycling of plastics participated.

The analysis will be deepened in part 2 of the project.

Overview of the report

As previously mentioned this report presents results and findings from the first part in the project: *Fact finding and benchmarking as basis for guidelines* and *Analysis and assessment of alternative future solutions*. The report contains detailed information about how plastic waste fractions under the scope of the project are currently being collected and recycled in the Nordics. In chapter 1–8 the systems regarding key actors, existing collection systems and financing measures are presented for each of the Nordic countries. Both collection and recycling systems designated to plastic packaging waste are described for each of the Nordic countries as well as how other plastic waste fractions under the scope of the project are taken care of. In chapter 9 the known plastic waste flows in the Nordics are quantified. Chapter 10 contains a compilation of the gained knowledge reported in the previous chapters as well as other interesting information found in the project so far such as identified potentials for increased recycling and differences between the collection and recycling systems in the Nordics. Success criteria and alternatives for possible solutions are described in Chapter 11 and 12.

Setting the scene

The conditions for collection and recycling of plastic waste from households and other MSW sources differ within the Nordic region. Population, way of living, population density and the number of municipalities and households in the Nordic countries are listed in Table 1. The Nordic population is characterized as scattered with a low population density. According to EU, a region with a population density lower than 12.5 inhabitants per square kilometer is a region with a low population density. If the same measure is applied on a municipal level nearly half of the Nordic municipalities are classified as sparsely populated. 80 percent of the ice-free land areas in the Nordic countries are covered by these municipalities, but only 10 percent of the population lives there (Hansen *et al.* 2011).

Relatively high population density areas are mainly found in Denmark and in the southern coastal parts of Sweden, Finland and Norway. These regions are Oslo, Stavanger, the Stockholm-Västmanland axis, the Øresund region (Skåne and Zealand), Aarhus, the Helsinki-Tampere axis and Vaasa (Hansen *et al.* 2011).

On a national level the population density varies between 0.14 (Greenland) and 130 (Denmark) inhabitants per square kilometer land area (Table 1). The population density in the Nordics is 17 inhabitants per square kilometer land area compared to 117 in the EU27 (Nordic Statistical Yearbook, 2013).

The number of municipalities compared to population is rather varying as well. The Faroe Islands and Åland have the lowest number of citizens per municipality, in average 1,600 and 1,800 people per municipality respectively, in comparison to Denmark with around 57,000 people per municipality.

Table 1. Demography in the Nordic region

Country	Population	Number of households	Number of municipalities	Number of households in different types of dwellings	Population density (nr per km ²)
Denmark ¹	5,602,628*	2,597,968	98	Total: 2,597,968 Single-family houses: 1,552,969 Multi-dwellings: 1,024,998 Others: 20,001	130.6*
The Faroe Islands ²	48,197*	-	30	-	34.7*
Finland ³	5,426,674*	2,571,000	320**	Single family houses: 1,041,782 Multi-dwellings: 1,490,457 Others: 47,542*	17.9*
Greenland ⁴	56,370*	8,618	4		0.14*

¹ Statistics Denmark (2013). <http://www.dst.dk/en>

² ÅSUB (2013). www.asub.ax

³ Statistics Finland (2013). http://www.stat.fi/index_en.html

⁴ Statistics Greenland (2013). <http://www.stat.gl/?lang=>

Country	Population	Number of households	Number of municipalities	Number of households in different types of dwellings	Population density (nr per km ²)
Iceland ⁵	321,857*	123,900	74	One or –two family houses: 65,000 Multi-dwellings: 59,000	3.6*
Norway ⁶	5,051,275*	2,258,794	428	Singe family houses: 1.2 million (53%) Two-dwelling buildings: 200,000 (9%) Multi-dwellings: 300,000 (townhouses – 11%) + 500,000 (blocks 23%) Other: 75,000 (3%)	16.5*
Sweden ⁷	9,555,893*	4,660,356	290	One-or two family houses: 2 million Multi-dwellings: 2.5 million	23.5*
Åland	28,502*	13,100 ⁸	16	-	18.4*

* Source: Nordic Statistical Yearbook, 2013.

⁵ Statistics Iceland (2013). www.statice.is

⁶ Statistics Norway (2013). www.ssb.no

⁷ Statistics Sweden (2013). www.scb.se

⁸ ÅSUB, 2013b.

Summary

This report is the outcome of part one in the project *Improvements in existing collection and recycling systems for plastic waste from households and other MSW sources* initiated by the Nordic Waste Group (NAG). The project is carried out by five organisations covering different parts of the Nordic region: IVL Swedish Environmental Research Institute (project leader), Østfold Research, VTT Technical Research Centre of Finland, Aalborg University and Environice.

In the report the collection and recycling systems for plastic waste generated by households and other MSW waste sources are described for each of the Nordic countries, including The Faroe Islands, Åland and Greenland. The report entails detailed information about the collection and recycling of plastic packaging waste, plastic bulky waste and non-packaging small plastic waste generated by households and other MSW sources. By packaging means “all products to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer,” as stated in the Packaging directive.⁹ By plastic bulky waste means large items of plastic waste that do not fit into bins and bags and therefore needs different handling. Small plastic waste other than packaging is items that fit into the same collection system as plastic packaging waste.

The information presented in the report is based upon interviews with key actors in the respective Nordic countries, as well as information gathered from previous studies and projects. The main findings in part 1, providing important input for part 2 of the project, are summarised below.

The report is part of the Nordic Prime Ministers’ green growth initiative: The Nordic Region – leading in green growth. Read more in the web magazine Green Growth the Nordic Way at www.nordicway.org or at www.norden.org/greengrowth

⁹ The Packaging and Packaging Waste Directive (94/62/EC) (amendments by Directive 2004/12/EC and Directive 2005/20/EC).

Collection and recycling systems in place

Municipalities are responsible for collecting plastic packaging waste in the entire Nordic region (including regions where plastic packaging waste is not subject to separate collection), apart from Sweden. In Sweden the producers of plastic packaging are responsible for collection and recycling of plastic packaging waste discarded in the collection and recycling systems they provide. Five of the Nordic countries have implemented producer responsibility obligations on packaging and packaging waste, including plastic packaging. Sweden, Finland, Åland and Iceland have a legal form of producer responsibility, whilst Norway has chosen a different approach in the form of a voluntary producer responsibility. In Denmark the packaging directive has been implemented without use of a producer responsibility scheme. The responsibility for recycling of plastic packaging waste rests on the producers in the countries with producer responsibility (in Finland only from industries).

The Nordic municipalities are responsible for plastic bulky waste from MSW sources, as well as for non-packaging small plastic waste.

Two strategies of separate collection of plastic packaging waste can be distinguished in the Nordic region. One is to collect and recycle plastic packaging waste from MSW sources (Denmark, Norway, Sweden and Iceland), and the other is to separately collect the plastic packaging waste for energy recovery as a fuel of high calorific value (Finland and Åland). Bring systems are the most common way to separately collect plastic packaging waste from MSW sources in Denmark, Iceland, Sweden and Åland, as opposed to Norway where kerbside collection is dominating. Kerbside collection includes a broad range of practical solutions such as multi-compartment bins and source sorting in differently coloured bags prior to optical sorting.

Rigid and flexible plastic packaging is collected together throughout the Nordic region apart from Finland and Åland. In Finland packaging and non-packaging plastic waste is collected and treated together and in Åland only rigid plastic packaging waste from MSW sources is source-sorted and separately collected. PET bottles are collected and recycled through separate deposit return systems in the Nordic region apart from Greenland. Åland and Finland have a joint deposit return system whereas there is one deposit system for each region in the rest of the Nordics.

Plastic bulky waste and non-packaging small plastic waste items are not subject to any dedicated, nationwide collection and recycling systems in the Nordics. However, small-scale initiatives between municipalities and waste management companies exist and the trend is on the increase.

Non-packaging small plastic waste is taken care of in a similar manner in the Nordic region (collected together with other types of waste and sent to energy recovery or landfill). Some non-packaging small plastic items unintentionally follow the plastic packaging waste stream. The fraction is then subject to recycling if the polymer types correspond with the polymers sorted out in the plastic packaging sorting process.

The collected amounts of plastic packaging waste in Norway and Sweden follow the same sorting and recycling route. Förpacknings- och tidningsinsamlingen FTI and Grønt Punkt Norge have four contracted sorting facilities for their collected plastic packaging waste, one operator in Sweden and three in Germany. The polymer types currently sorted out from the Norwegian and Swedish plastic packaging waste flows, thus subject to recycling, are LDPE (low-density polyethylene), HDPE (high-density polyethylene), PP (polypropylene), and PET (polyethylene terephthalate). PS (polystyrene) is sorted out at the German facilities. Other possible polymer types present in the plastic packaging waste flow are not subject to recycling. The sorting into different polymers is roughly based on NIR (Near Infrared) technology. The secondary raw material from rigid plastic packaging waste is generally recycled into plastic products such as flower pots, pipes and benches, and not back into plastic packaging. Flexible plastic packaging waste is frequently recycled back into packaging in the form of plastic bags. PET bottles are commonly subject to bottle-to-bottle recycling.

Known plastic waste streams and recycling rates

Around 600,000 tonnes of plastic packaging and 56,000 tonnes of PET bottles are known to be put on the Nordic market annually.¹⁰ 284,000 tonnes of plastic packaging waste (excluding PET bottles) are separately collected, whereof 161,000 tonnes are subject to recycling.

Goals targeted on plastic packaging are of two origins, the minimum requirement stated in the Packaging directive and national recycling targets. The Faroe Islands and Greenland have no objectives specifically targeted on plastic packaging. Iceland, Finland and Åland have chosen not to go further than the minimum requirements in The Packaging and Packaging Waste Directive (22.5 percent). Sweden has a higher national

¹⁰ As a general rule agricultural film is not included in the figures. However, in the Danish and Finnish statistics it is not possible to separate plastic packaging from agricultural film.

objective than the requirements in the directive, and so is the target within the Norwegian EPR agreement. Denmark, on the other hand, has a target for all recyclables, including plastics.

The recycling objective for PET bottles varies between 80 percent (Finland and Åland) and 90 percent (Sweden). No Nordic country has specific targets for collection and recycling of plastics other than for plastic packaging.

Comparing recycling rates for different Nordic countries is challenging as the calculation methods vary substantially. According to Eurostat data (Packaging directive) Norway has the highest recycling rate for plastic packaging in the Nordics. Sweden and Finland meet the target. Denmark reported a slightly lower recycling rate in 2011 than required by the directive. The national targets for plastic packaging waste are met in Norway and Finland, but not in Sweden, Iceland and Åland. However, the recycling rates calculated to follow-up the national objectives for recycling of plastic packaging waste differ between the Nordic countries. In Finland, Denmark and Åland, PET bottles are included in the separately collected amounts whereas they are not in the Swedish and Norwegian figures. For Finland and Åland this makes an important difference as hardly any plastic packaging from households apart from PET bottles is subject to recycling. To consider or not consider moisture and contaminants in the plastic packaging waste flows also contributes to difficulties in comparing statistics.

Kerbside collection of plastic packaging waste seems to generate the highest collection rates compared to other collection systems. This conclusion will however be more profoundly analysed in part 2 of the project as comparisons are difficult to make. The link between collection rates and collection system are not easily analysed as the collection rate is influenced by many factors.

Potentials for increased recycling

The potential for increased recycling both deals with collection of plastic waste, i.e. to get hold of the material, and of possible technical improvements in the sorting and recycling processes. Identified potentials of a more general kind are related to the fact that plastic waste is still landfilled in the Nordics (e.g. in Iceland, Greenland and in Finland), source-sorted plastic packaging waste in Åland and Finland is not subject to recycling, but to energy recovery, and non-packaging small plastic items and plastic bulky waste are not collected for recycling through dedicated, nationwide collection and recycling systems in the

Nordics. Possible improvements related to the sorting of plastic packaging waste are e.g. to sort out a higher number of polymer types.

The theoretical potential in the form of plastic waste in mixed MSW fractions in bins and bags are estimated to around 690,000 tonnes, although the uncertainty should be noted. The realistic potential, i.e. the amount of generated plastic waste available for recycling is likely to be significantly lower. The presence of potential hazardous substances undesired in the recycling system is a factor decreasing the potential for recycling.

Identified challenges hampering the collection and recycling of plastic waste are lack of communication and trust for collection and recycling of plastic waste in general, lack of treating and sorting capacity in the Nordic region, costly treatment and logistics, difficulty with obtaining high-quality secondary raw material to enable competition with virgin material, lack of product design to facilitate recycling (e.g. black plastics are not sorted out with NIR technology), weak market demand for recycled plastics and absence of incentives and goals for boosting recycling of plastics.

Possible alternative solutions for increased recycling of plastics in the Nordic region could be collection of plastic packaging in mixed waste fractions or in mixed packaging waste fractions followed by central sorting, collection in material streams, the use of weight-based waste fees, and increased Nordic cooperation within collection and recycling of plastic waste.

The findings presented in the report are part of the Nordic Prime Ministers' green growth initiative, The Nordic Region – leading in green growth.

1. Denmark

1.1 Key actors

Danish Waste management regulation is characterized by a combination of traditional regulation through laws and executive orders, and a wide range of other instruments such as taxes, fees, subsidy schemes, and agreements.

Waste management is regulated in the environmental protection law (consolidation Act no 879, 26th June 2010) and the related executive orders (bekendtgørelser), and hereunder especially the executive order on waste (executive order no 1309, 20th December 2012). Since 1st January 1997, Denmark has banned the landfilling of waste suitable for incineration. As a consequence, flexible PVC is being landfilled as it is harmful in the incineration process and no current methods are available for recycling in Denmark.

As the only exception from the general rule in the EU, Denmark has no packaging producer responsibility scheme for plastic packaging (except the deposit system for beer and soft drink containers, which is detailed in the next subsection). According to the environmental protection law, the responsibility for collecting and assigning all waste is allocated to the municipalities. The legal requirement is that the municipality shall establish arrangements that secure an environmentally sound waste handling. This entail that the municipalities by default has the responsibility for waste management. However, the responsibility for source sorted waste from businesses, suitable for recycling or recovery rests with the businesses, but under the authority and supervision of the municipalities.

Table 2. Key roles in collection and recycling of plastic packaging waste in Denmark

Key actor	Role
Importers and producers of plastic packaging	Put plastic packaging on the Danish market.
Municipalities	Responsible for collection of household waste. Responsible for establishment and operation of recycling centres that must be able to receive sorted waste from businesses.
Consumers of plastic packaging	Buy plastic packaging on the Danish market.
Waste transporters (Affaldstransportører) & Collection companies for sorted recyclable waste (Indsamlingsvirksomheder for kildesorteret genanvendeligt erhvervsaffald)	Transport the plastic packaging waste from businesses to recyclers, register volumes and report to the EPA (waste-database).
Recyclers	Recycling of plastic packaging waste into new products.
The Danish EPA	Collects data on the recycling of plastics and reports data to Eurostat according to the Packaging directive.

Besides the executive order on waste, a number of executive orders regulate specific waste fractions for which municipalities do not have responsibility. This includes for plastics the executive order on deposit and collection of beverage containers for beer and certain soft drinks, where the collection is done by Dansk Retursystem A/S in a producer responsibility scheme paid by producers and importers (Dansk Retursystem, 2013). The system implies that these products only can be marketed in recyclable or refillable packaging, and importers and producers pay for the collection and recycling.

Beverage packaging is a special focus area in Denmark, as it represents a considerable volume. In 1978, a weight-based fee on new beverage packaging, creating a motivation increase of reuse and minimization of volume was introduced. In 1988 there was placed a levy on disposable tableware and in 1994 levies was placed on plastic shopping bags, both stimulating reuse. Weight-based fees were introduced on sales packaging and multipacks with volumes less than 20 litres, and in 2000 the fees were adjusted according to results from Life Cycle Assessment to reflect both weight and environmental impact.

In Denmark, plastic bulky waste is collected at recycling centres.

1.2 Collection and recycling of plastic waste

Around 70 percent of the plastic waste collected from households originates from packaging, and it is mainly constituted by LDPE (Low-Density Polyethylene), HDPE (High-Density Polyethylene), PP (Polypropylene), PET (Polyethylene terephthalate) and PS (Polystyrene) and EPS (Expanded Polystyrene) (DEPA, 2011).

Household waste is collected by the respective 98 Danish municipalities, and this takes place in accordance with specific waste regulations according to the single municipality, and accordingly the collection schemes differ from municipality to municipality.

Municipal collection schemes for plastic range from permanent individual and joint full service collection of waste at household and collection points, to the approximately 500 manned waste collection centres where citizens and smaller businesses bring relevant waste fractions, hereunder plastics, for recycling.

Collection frequency varies from weekly to bi-weekly. In approximately 25 percent of the municipalities household waste is only collected as residual waste, 40 percent sorts one fraction (mainly paper), and the remaining municipalities have collection of two to five fractions, and approximately 22 percent collects household plastic waste fractions separately. All municipalities have waste collection centres with collection of rigid plastic waste.

The waste collection centres collect all types of waste except residual waste and a typical layout is depicted in Figure 1. Currently, there is no comprehensive information on how collected plastics are being treated after collection, but the main route is to export the collected plastic waste to sorting facilities in Sweden, Germany and the Netherlands.

Figure 1. Typical layout of a waste collection center. In the plastic collection area, bottles, bulky plastic waste such as garden furniture, rigid and flexible PVC, and plastic foils are received

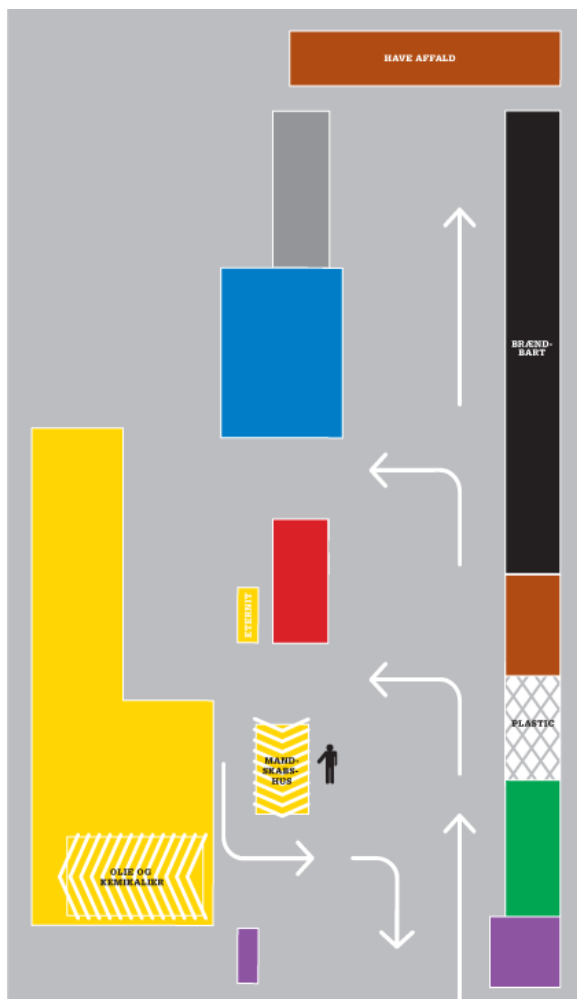


Illustration: Aalborg municipality.

Plastic waste is presently becoming a focus point nationally and in the municipal collection schemes, leading to a general trend of increased source sorting and collection of plastic waste.

Based on a review of the municipal waste directives it is assessed that in 2013, 22 out of the 98 municipalities have established kerbside collection of rigid plastic waste, and in the majority of these, the collection is limited to detached houses. The rigid plastic waste collection schemes in 2013 cover some variations including:

- Collection frequency varies between one and two weeks.
- In few municipalities plastic waste is also collected from apartment buildings (among these Copenhagen, Frederiksberg, and Gladsaxe).
- The plastic waste collected is mainly plastic packaging, but some municipalities collect also other types of rigid consumer plastic waste.
- Some municipalities have voluntary purchase of sorting bins (reducing the more expensive residual fraction).

Figure 2. Kerbside collection. Source-sorting system in Herlev municipality, Denmark



Photographer: Herlev municipality. Illustration: Herlev municipality.

Flexible plastic waste is collected with the residual waste, but can also be delivered at some municipal collection stations. Flexible PVC is, as the only plastic waste fraction, sent to landfill.

The frequency of municipalities with separate collection is likely to increase as several municipalities currently are running pilot tests with household source sorting and collection. One example of these developing arrangements can be found in Aalborg, where the fractions received are:

- Drinking bottles.
- Containers used for shampoo and conditioner.
- Containers used for washing and cleansing agents.
- Plastic bins, tubs, pots, jars, small buckets, and flowerpots.
- Plastic trays used for meat and vegetables.
- Various plastic foils and plastic bags, although not bread bags or plastic that has been in direct contact with food.
- Toys and other plastic articles from households.

The resource plan for waste management (2013–2018), sets up a framework for the municipalities within which the municipalities are in the process of developing appropriated source sorting of household waste, and the frequency of multi-compartment waste bins is increasing.

1.2.1 PET bottles

PET bottles, are being recycled in two ways in Denmark. The system for collection and recycling of PET bottles is regulated in executive order 1129, 27th September 2010. Here it is defined that the collection is performed by Dansk Retursystem A/S in a producer responsibility scheme paid by producers and importers placing filled bottles on the Danish Market. (Dansk Retursystem, 2013) The system encompasses all PET-bottle types sold with beer and carbonated- and non-carbonated soft drinks. Excepted are e.g. milk, juice and concentrated juice. At the collection sites also bottles without deposits are being collected, and these are transferred to incineration.

The second and “old” system for recycling of PET bottles is based on refillable plastic bottles and in 2009, approximately 20 percent of the units were covered by PET-bottles washed and reused by the breweries.

1.2.2 Plastic bulky waste

Plastic bulky waste is covered by the waste executive order, and is collected at the manned waste collection centres. Bulky waste originating from households is under the responsibility of the municipalities, i.e. all municipalities collect this fraction at the recycling sites. Bulky waste originating from businesses is the responsibility of the companies.

The sorted plastic bulky waste is collected and compressed into bales, and send to sorting facilities, mainly in northern Germany and Sweden, though a few facilities does exist in Denmark.

1.3 Financing measures

Waste incineration with energy recovery has dominated Danish waste management at least up until the new waste management strategy – or resource strategy as the new term is (DEPA, 2013a). Waste incineration with energy recovery is a well-organised business and a well-developed district heating system secures that about 20 percent of district heating and 5 percent of the electricity supply comes from these plants. The flip-side of this worldclass efficient energy recovery structure, is that the recycling of MSW is markedly lower compared to countries such as Sweden, Norway, Germany, and the Netherlands, and there are indications that the present arrangements creates incentives for incineration over recycling (DEPA, 2010). This is revealed when comparing recycling and incineration rates in municipalities having incineration plant ownership with municipalities not having ownership. To counterbalance this, a CO₂-tax on fossil content in the waste is being phased in from 2010 to 2015, creating an economic incentive for the owners of the waste incineration facilities, i.e. the municipalities, to avoid plastics in the waste being incinerated.

As a rule, collection and sorting of plastic packaging is a cost. In Denmark, the municipalities are responsible for collecting all MSW, and the cost is covered by a fee paid by the citizens to the municipalities. Typically, the citizens pay through the collection of the mixed waste, whereas the sorted fractions are collected under coverage of the general collection fee (or can be delivered without extra cost to a recycling station) which creates a citizen incentive for source sorting. Hence, the service is a part of the fee paid.

Examples of fee structures are depicted below. Some municipalities (e.g. Skive) do also place a smaller fee on bins for plastic sorting (smaller compared to the residual waste collection fee).

Table 3. Examples of waste fee structures

Municipality	Numer of fractions collected for recycling	Collection/basic cost	Fee (DKK) pr 100 liter residual waste/year
Viborg	0	100 liter weekly	1,105
Holstebro	3 (incl. plastic)	240 liter Biweekly	625
		Basic cost	970
Rødovre	6 (incl. plastic)	125 liter weekly	908
		Basic cost	2,359

The majority of beverages, e.g. mineral water, soft drinks and beer can only be put on the market in refillable take-back containers or one-way containers included in the deposit and return system managed by Dansk Retursystem A/S. When breweries or importers place a product on the market they therefore either pay a deposit depending on the number of units of one-way bottles placed on the market, or establish a take back arrangement where the refillable bottles are returned to the producer.

Figure 3. Bottle- and deposit-flow in the Danish one-way beverage container deposit system

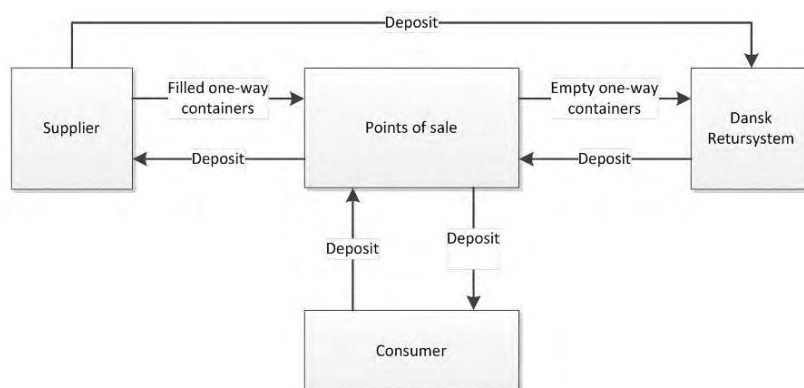


Illustration: Dansk Retursystem.

One way bottles must be labelled with one of the following Danish deposit labels:

- “Pant A” – DKK 1.00: All bottles and cans smaller than 1 liter (not PET bottles).
- “Pant B” – DKK 1.50: All PET bottles smaller than 1 liter.
- “Pant C” – DKK 3.00: All bottles and cans from 1 to 20 litres.

Refillable bottles have no label, but the following deposits:

- PET bottles smaller than 1 litre: DKK 1.50.
- PET bottles equal to or larger than 1 litre: DKK 3.00.

When breweries and importers sell beverages in PET bottles to grocery stores and shops they charge a deposit per bottle and an administrative fee to Dansk Retursystem, covering the costs of the system. The shop is compensated by Dansk Retursystem for the handling of the bottles. Furthermore the system has an income from selling PET from the one-way bottles. As a general principle, Dansk Retursystem only sells the recycled PET for reprocessing for similar purposes, i.e. bottle grade recycled PET.

The management of municipal recycling centers is financed through general waste management fee paid by citizens to the municipality. This fee may be included in the collection fee, or it may be a separate basic fee combined with a collection fee for residual waste. The recycling centers pay either for the bulky waste to be incinerated or for the plastic bulky waste fraction to be sent for sorting and recycling.

Collection and incineration of non-packaging small plastic items is financed by the municipalities through the waste management fee. The municipalities pay an incineration fee per tonne of fossil waste incinerated.

Table 4. Waste tax rates in Denmark DKK per ton 1987–2010

	1987	1993	1997	1998	2001	2009	2010
Incineration with electricity production	40	160	210	280	330	330	330
Other incineration			260	260	330	330	330
Landfill	40	335	335	375	375	475	475

(Warberg & Skovgaard, 2012)

The revenue from the tax enters the state budget, which corresponds to approximately DKK 1.2 billion per year.

2. The Faroe Islands

2.1 Key actors in the Faroe Islands

Producers and importers of plastic packaging take no formal responsibility for the collection and recycling of plastic packaging in the Faroe Islands. Municipalities are responsible for the waste management of household waste including plastic packaging. Plastic waste from municipal sources is not separately collected in the Faroe Islands and end up in mixed combustible waste fractions together with non-packaging waste items. A deposit return system for PET bottles is in place. Interkommunali Renovatiónsfelagsskapurin L/F (IRF) is a municipal cooperation organising waste management in the municipalities of the Faroe Islands, apart from Torshavn municipality, which has a separate organisation, Kommunala Orku- og Brennistøðin (KOB). Collection of plastic waste from businesses (as well as paper and cardboard) is handled by IRF, also for Tórshavn Municipality/KOB. There is presently no legislation in place requiring recycling (Interkommunali Renovatiónsfelagsskapurin, 2013).

2.2 Collection and recycling of plastic waste

Collection of household waste is carried out in single bins. The waste is incinerated in one of two incinerations plants in the Faroe Islands.

Flexible plastic waste generated by businesses can be sorted out in 240 litre bins in marked bags; one bag contains a certain plastic waste fraction. The fractions are transparent flexible plastic waste (LDPE), coloured flexible plastic waste, and other plastic waste. Both packaging and non-packaging is collected, but flexible plastics from packaging occurs the most (Interkommunali Renovatiónsfelagsskapurin, 2013).

The plastic bags are collected by the same collection vehicles as paper and cardboard, and are transported to a receiving point where the bags are separated from the cardboard and baled without further separation or handling. The plastic waste fractions are sold and transported for recycling by boat, mostly to Denmark or Holland (Interkommunali Renovatiónsfelagsskapurin, 2013)

There is at least one manned recycling central in each of the 28 member municipalities of IRF accepting bulky waste from households (around 40 recycling centrals in total). Businesses are charged for this service. There are currently no separate containers for plastic bulky waste, but it could be a future possibility (Interkommunali Renovatiónsfelagsskapurin, 2013).

There are two dominating importers of PET bottles in the Faroe Islands, Poul Hansen (Coca Cola etc.) and Poul Mikkelsen (Faxe etc.). Consumers can return their PET bottles to shops (importers), but also to breweries. One obstacle reducing the collected quantity is that various producers and importers of a given product only accept return bottles from their own production or import (Interkommunali Renovatiónsfelagsskapurin, 2013).

The shops and breweries deliver the PET bottles in 240 liter plastic bags to IRF (a few other smaller actors exist). Other businesses than shops and breweries can deliver PET-bottles to IRF in the same manner (Interkommunali Renovatiónsfelagsskapurin, 2013).

2.3 Financing measures

Collection and treatment of household waste is financed from tax revenue, which gives little incentive for source sorting as the households are charged regardless of the amount of discarded waste. It is however more economic for businesses to source sort plastic waste than choosing not to. The plastic waste fractions are either collected for free (transparent and coloured flexible plastic waste) or collected by IRF for a smaller sum, and then sold to Denmark or to the Netherlands as previously mentioned. The pricing depends on the pureness of the fractions. Prices vary according to international price fluctuations, but a relatively clean fraction with less than two percent contamination is generally worth over DKK 3,000 (Interkommunali Renovatiónsfelagsskapurin, 2013).

Households could deliver plastic waste fractions to IRF, on their own initiative. IRF's technical setup does not allow for sorting of mixed household waste. Furthermore, the space for recycling is presently much too limited to handle mixed waste or sorted waste with more than negligible impurities. (Interkommunali Renovatiónsfelagsskapurin, 2013).

The deposit for PET bottles is currently DKK 2 (Interkommunali Renovatiónsfelagsskapurin, 2013).

3. Finland

3.1 Key actors

The producer responsibility obliges producers and importers of packaging to collect and recycle packaging waste put on the Finnish market. Companies fulfill the obligation by joining the producer responsibility organisation or by taking care of the treatment themselves (reporting to the supervising authority, Pirkanmaa Centre for Economic Development, Transport and the Environment, ELY; Elinkeino, liikenne ja ympäristökeskus, is required) (Pirkanmaan ELY, 2013). The producer responsibility organisation Pakkausalan ympäristörekisteri, PYR Oy (The Environmental Register of Packaging), organises the collection and treatment of plastic packaging waste in Finland. The producer responsibility organisation only arranges for treatment of industrial plastic packaging waste; the waste generator (e.g. industry) is obliged to collect and transport the plastic packaging waste to a treatment facility (PYR, 2013b).

Municipalities are responsible for household waste in Finland. The responsibility for waste that is similar to MSW was in 2007 taken away from the municipalities with some exceptions. The municipalities are still responsible for the “similar waste” that is generated in the public sector and for “similar waste” that is generated from businesses in dwellings (Avfall Sverige, 2009).

The majority of plastic waste from households is collected within an energy waste fraction or in mixed household waste, of which part is recovered as energy. Some of the municipalities contracted waste management companies arrange for collection of plastic waste (packaging and non-packaging together) at recycling stations as a separate plastic waste fraction or as an energy waste fraction. The plastic waste is not subject to recycling in either of the two cases.

The new Waste Act [646/2011] was implemented 1st May 2012 and is a part of the reformation of the Finnish waste legislation. Plastic packaging is currently covered by a partial producer responsibility stipulating the producers to see to the recycling of 22.5 mass-% of the plastic packaging put on the market. In the new waste decree this responsibility is proposed to be 30 percent in 2016; for plastic packaging there should also be at least 500 public recycling stations collecting household plastic waste; in

every populations centre with at least 10,000 inhabitants, there should be a public plastic collection station. The producer responsibility for plastic packaging will be expanded to also cover household packaging (including collection, transport and treatment) together with a landfill ban on organic waste that will be implemented in 2016 (Blauberg, 2013).

A summary of the key actors and their role in the collection and recycling system for plastic packaging is presented in Table 5.

Table 5. Key actors in collection and recycling of plastic packaging waste in Finland

Key actor	Role
Importers and producers of plastic packaging	Put plastic packaging on the Finnish market.
Municipalities	Responsible for collection of household waste. Communication to households about management of household waste is also part of the municipal responsibility.
Consumers of plastic packaging	Buy plastic packaging on the Finnish market.
PYR	Responsible for treatment of plastic packaging waste from businesses. Reports to Pirkanmaan ELY.
Pirkanmaa ELY centre	Supervising authority, gathers statistics and reports to Eurostat.
The municipalities contracted waste management companies	Collect plastic waste (excl. PVC) at public collection points, either in a separate plastic fraction or as a mixed energy fraction.

Recycling of plastic waste from households is mainly represented by PET bottles collected within a deposit return system for PET bottles. Suomen Palautuspakkaus Oy (PALPA) promotes and administrates the recycling of beverage bottles (deposit return system).

There is no legislation specifically covering non-packaging plastic waste and plastic bulky waste. Both fractions are part of the municipal responsibility. Plastic bulky waste generated by households is commonly taken care of at manned recycling centrals, and subject to energy recovery.

To prepare for collection of plastic packaging waste from households the producer responsibility organisations, the Environmental Register of Packaging PYR Oy, The Finnish Grocery Trade Association PTY, the Finnish Commerce Federation, Finnish Food and Drink Industries' Federation ETL, and The Finnish Solid Waste Association JLY have conducted a pilot study on recycling stations, aiming to map the capacity need for the collection network of packaging waste. The study started in 2012 and was conducted in Tampere and Kuopio, mainly on existing recycling stations. In Tampere all household plastic packaging waste was accepted, whereas in Kuopio only hard plastic packaging was collected, i.e.

PET, HDPE, LDPE and PP. Similar plastic site sorting experiments have been conducted earlier, but none of them have proven to be successful.

The plastic packaging waste from the Kuopio collection points has proven recyclable after sorting. In the sorting process non-plastic materials (10 percent) and non-packaging plastics (10 percent) are removed. After sorting the fraction can be recycled to profiles used as sealant in concrete elements. The material collected in Kuopio is sufficient to cover the domestic market demand and, thus, this system cannot be expanded to cover the whole country.

The fraction collected in Tampere included plastic films, and yet no one has been found to recycle this fraction. Currently approximately 25 tonnes of separately collected household plastic packaging waste is stored in Tampere waiting for a suitable recipient.

The results from the study show that the Finns are well capable of site sorting when receiving good instructions. The cardboard, glass and metal fractions were very clean, but some impurities were found in the plastic fraction. This was mainly explained by the many different plastic types and lack of knowledge of the material (PYR, 2013c).

3.2 Collection and recycling

3.2.1 *Plastic packaging and non-packaging small plastic items*

Plastic bags (LDPE) are collected for recycling in Finland. Plastic bag collection is common in recycling stations, as well as in supermarkets close to the deposit bottle return machines. The plastic bag collection is commonly organised by the supermarkets and included in their own waste management programme. The bags are mixed with other flexible plastic packaging waste from the supermarkets, and transported for recycling. In the plastic recycling facility the material is crushed and pelleted/granulated before transported to product manufacturers. Recovered LDPE is suitable for production of new plastic bags; in Finland plastic bags are made with approximately 60 percent recycled LDPE. Recycled LDPE is also used for other plastic products, such as flower pots, rainwater chutes, coat hangers etc. (Muovikassikiertoon, 2013).

As previously mentioned, some waste management companies collect plastic waste in local recycling stations (non-packaging and packaging). Currently there are 302 reported public stations which collect household plastic waste. 197 of these are managed by one company, and

several of them are actually property specific waste collection points (kerbside collection). Some of the public stations do not collect plastic waste separately, but as mixed energy waste, although Jätelaitosyhdistys ry (JLY – Finnish Solid Waste Association) reports them to have separate plastic collection (Ekorosk, 2013; Millespakka Oy, 2013; JLY, 2013).

Figure 4. Collection of plastic bags at a recycling station in Espoo, Finland



Photographer: Margareta Wahlström, VTT Technical Research Centre of Finland.

3.2.2 PET bottles

PET bottles are collected through a PET bottle deposit scheme. The main part of the PET bottles (incl. caps) is collected by Suomen Palautuspakkaus Oy (PALPA). PALPA has approximately 4,700 deposit bottle return machines in Finland (TOMRA's Sure Return™ Technology), commonly connected to supermarkets (PALPA, 2013). The PET bottles collected through PALPA's deposit scheme are sorted and mainly transported to Pramia Plastic Oy for treatment, but also to treatment facilities in Sweden and Latvia where they are grinded, washed and pelleted/granulated. Pramia Plastic Oy sorts the PET bottles into three fractions; clear, coloured and caps. The fractions are then washed and crushed. The crushed

PET can be used in the textile industry, pelleted/granulated or used for preform production.¹¹ Pramia Plastic produces clear and coloured PET flakes, flakes from PET-bottle caps (50 percent HD-PE and 50 percent PP), finely crushed PET, PET lumps (by-product from the PET flake pelleting/granulation process), PET pellets and PET preforms (Pramia Plastic Oy, 2013). The clear pellets are recycled as raw materials for new

PET bottles, and the coloured pellets are recycled in e.g. the packaging and clothing industry (PALPA, 2013).

3.2.3 Plastic bulky waste

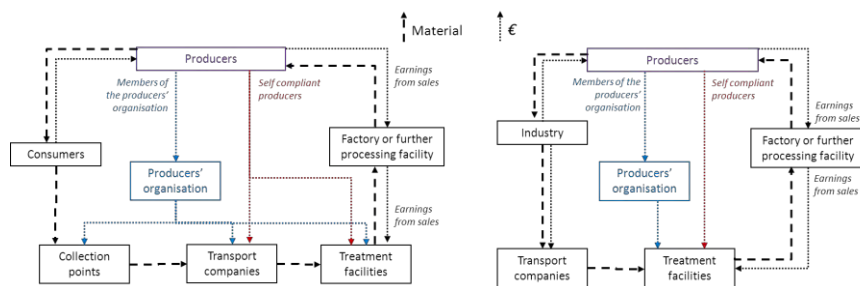
Plastic bulky waste from households is taken care of at manned recycling centrals. If the fraction is considered recyclable (decided by the personnel) the material is further sent to recycling, otherwise to energy recovery. This is case-specific and the stations are not obliged to accept consumer plastic waste for recycling (JLY, 2013).

3.3 Financing measures

The producer responsibility organisation PYR collects annual fees from producers and importers of plastic packaging based on the company's turnover, in addition to fees collected based on the packaging quantities. In 2012, the recovery fee for plastic packaging was EUR 0.021 per kg excluding VAT (Pirkanmaan ELY, 2013; PYR, 2013b). The plastic packaging fee is only covering the treatment of plastic packaging waste from businesses, but when the collection and treatment of plastic packaging from households will be included, the packaging fees might rise. The material streams and financing of plastic packaging under the producer responsibility are illustrated in Figure 5.

¹¹ Preforms, i.e. bottle blanks, are manufactured from PET pellets, resembling a test tube, with the bottle-cap threads already moulded into place. The preforms are then moulded into bottles by the beverage producer.

Figure 5. Material and money streams of plastic packaging waste in Finland



On the left is an assumption of the coming consumer packaging system and on the right the current system for industrial plastic packaging waste.

4. Greenland

4.1 Key actors

The local authorities (municipalities) of Greenland are responsible for the collection and treatment of municipal waste, including all types of plastic waste and plastic packaging waste. Kanukoka is the waste management company representing the Greenlandic municipalities and collects waste from households and other municipal waste sources.

4.2 Collection and recycling

There is no sorting or recycling of plastic waste in Greenland. Collection of household waste is carried out in single bins by private companies using compactor trucks or small trucks. As it is not as profitable for private companies to collect household waste in less densely populated areas, it is mostly municipalities who are in charge of the collection there. As opposed to the private companies, the municipalities use small tractors or terrain vehicles for the waste collection. Houses in small villages are often linked together by gravel paths, making it difficult for larger vehicles to get access.

In towns with incinerators the mixed waste is landfilled and the combustible waste incinerated. In smaller villages and settlements there is only one mixed waste fraction containing both combustible and non-combustible waste. The six bigger incinerators are producing heat, but as heat from fossil fuels and electricity from hydro-power is very price-worthy, an average of 70 percent of the heat produced is cooled off. The smaller modified straw incinerators are used for hygienic reasons and are not recovering any energy from the waste (Eisted and Christensen, 2011a).

Bulky waste from households is often collected by the municipalities, independently of the actor in charge of the collection of the household waste. Every town has containers for bulky waste. In the towns with access to waste incineration the bulky waste is source separated into a combustible fraction and a non-combustible waste fraction. According to Eisted and Christensen (2011a) this source-separation is not well-functioning as the different waste fractions often end up in the wrong container. Bulky waste

is shredded prior to incineration. A waste pick-up for the collection of bulky waste from businesses can be ordered from the municipality.

4.3 Financing measures

Collection and treatment of household waste is partly financed from tax revenue and partly from waste fees. The waste fees paid by the households are mostly covering the collection costs, whereas the treatment costs are covered by municipal taxes. The citizens can often choose between one to three collections per week, and pay EUR 10–18 per month as an average (Eisted and Christensen, 2011b).

5. Iceland

5.1 Key actors

The Icelandic Recycling Fund (IRF) plays a central and exclusive role in the management of plastic and other packaging waste in Iceland according to the *Processing Charge Act* No. 162/2002. The fund charges producers and importers of packaging material with a fee (IRF-fee) that is used to secure a proper management of the waste categories in question through contracts with private so-called service providers on the collection, transportation and recycling of this waste.

Local authorities (municipalities) are responsible for setting up a system for collection of household waste according to the Waste Management Act no. 55/2003. The operation of the system is however often outsourced to private waste management companies, at least to some extent. The term “similar waste” exists, but the municipalities are not responsible for the collection of this waste fraction.

Table 6. Key actors in collection and recycling of plastic packaging waste in Iceland

Key actor	Role
Importers and producers of plastic packaging	Put plastic packaging on the market in Iceland.
Municipalities	Responsible for collection of household waste. Communication to households about management of household waste is also part of the municipal responsibility.
Consumers of plastic packaging	Buys plastic packaging on the market in Iceland.
The Icelandic Recycling Fund (IRF)	Charges producers and importers with IRF-fee.
IRF's contracted service providers	Carry out collection, transportation and recycling of plastic packaging waste.

Wasted PET bottles are covered by the “Law on Prevention of Environmental Pollution Caused by Disposable Packaging for Beverages” No. 52/1989. The not-for-profit company Endurvinnslan (Recycling Ltd) is operated according to this law and to Regulation No. 368/2000.

Small items of plastic waste other than packaging are not covered by any dedicated ordinance or law. These items are normally mixed with other household waste, where landfilling is the dominant disposal op-

tion. The same applies for plastic bulky waste, even though a small part of that may be taken care of at manned recycling centrals.

5.2 Collection and recycling

5.2.1 *Plastic packaging*

Local authorities are responsible for setting up a system for collection of household waste according to the Waste Management Act no. 55/2003. The operation of the system is however often outsourced to private actors, at least to some extent. Kerbside collection of unsorted waste is a dominating practice, except from the most rural areas.

There is no rule deciding how plastic packaging is collected from households. This may be decided by the local authorities in question or left open for actors submitting a tender for the collection and management of recyclable waste fractions. Three main options are by far the most common:

- The first option is kerbside collection. Every household is in that case equipped with a separate bin (most often referred to as the “green bin”) or a few bins or a small container in the case of multi-family dwellings.
- The second option are small unmanned recycling stations (“neighbourhood containers”), often located close to shops, petrol stations and in residential areas. At these points people can leave their plastic packaging waste and other accepted recyclable waste fractions.
- The third option is a central recycling station with regular opening hours where households can leave their sorted or unsorted waste for free up to a certain maximum, while companies are charged by volume or weight of the received waste.

Most municipalities seem to offer either option 1 or option 2.

In all cases both rigid and flexible plastic packaging waste is collected together in a mixed fraction.

Thirteen out of 74 municipalities in Iceland (18 percent) seem to offer kerbside collection of plastic packaging waste (Bændablaðið (Farmers Magazine), 2013). However, these municipalities host only 11 percent of the total population. Kerbside collection seems to be growing, but the “neighborhood containers” (small recycling stations) are still more common as municipalities in the capital area do not offer kerbside collection for the time being. These municipalities host almost 65 percent of

the entire population of Iceland. Central recycling stations are to be found in most municipalities except from the most rural ones, regardless of whether they offer kerbside collection or “neighborhood containers”.

It should be noted that the “green bin” system for kerbside collection of plastic packaging waste is not designed for plastic packaging waste only, as these bins are used for the collection of paper, cardboard, paper cartridges and metals as well. The plastic packaging waste is to be left in the bin in transparent plastic bags and the same applies to the metals. Paper, however, can be left in the bin without any wrapping-in. The green bins are emptied in a waste truck only used for this purpose and brought to a central facility where the material is roughly sorted into plastic, metals and one or more category of paper/cartridges.

Service providers accepted by The Icelandic Recycling Fund take care of the packaging waste on its way from the collection points to the final recipient. The role of the service provider includes transport and in some cases some sorting and treatment to maximize the value of the waste handed over to the recipient. The recipient is in most cases a recovery plant or a trader of recycling material. A vast majority of the plastic packaging waste for recycling is exported, mainly to The Netherlands and, to a less extent, to Sweden. The Netherlands has a competitive advantage in this respect, bearing in mind the smooth sea transport connection between Reykjavík and Rotterdam.

Some plastic recycling takes place in Iceland but the raw material for this is mainly fishing gear and agricultural film, not covered by this project. Less than 2 percent of the plastic packaging waste collected in 2012 was recycled domestically.

Almost no pre-processing takes place in Iceland prior to export, as the price difference for unsorted and pre-processed plastic waste does not allow for any investments due to the very limited amount generated. Some efforts are made, however, to sort out coloured plastic and other items that would obviously lower the export value.

5.2.2 PET bottles

PET bottles are included in deposit return scheme, and thus almost entirely absent from the main stream of plastic packaging waste. PET bottles are covered by the “Law on Prevention of Environmental Pollution Caused by Disposable Packaging for Beverages” No. 52/1989. The not-for-profit company Endurvinnslan (Recycling Ltd) is operated according to this law and to Regulation No. 368/2000. Producers and importers of PET bottles and other drink cartridges defined by the legislation are charged a fixed

amount per unit put on the market, making it possible for Endurvinnslan to pay ISK 14 (EUR 0.09) deposit for every bottle or can handed in.

Endurvinnslan is the only actor in Iceland that pays deposit for bottles and cans. From a consumer point of view, however, there are three different options available. Firstly, Endurvinnslan and its subcontractors operate 60 return facilities all over Iceland, where people can return their empty bottles and cans, sorted into certain categories, and get their deposit paid back (Endurvinnslan (Recycling Ltd), 2013). Secondly, numerous NGOs, such as sport clubs, scouts associations or voluntary rescue teams, have set up their own containers to collect refund bottles, often located close to petrol stations, tourist destinations or in front of their offices, where people can leave their bottles or cans without getting the deposit back, thus supporting the organization in question, which in turn gets the deposit from the nearest return facility when handing in the “catch”. Thirdly, young people from sport clubs and other organizations often go house-to-house to collect bottles to raise money for specific projects, traveling costs to sporting events, etc. There are, on the other hand, no automatic reverse vending machines for bottles or cans operated in Iceland.

As far as known, the Icelandic deposit system is the only existing system of this kind that accepts crashed bottles and cans. This can be expected to contribute to a somewhat higher recycling rate, as some part of this type of packaging will always get damaged during and after use (Endurvinnslan (Recycling Ltd), 2013).

The PET bottles returned to Endurvinnslan are exported to the Netherlands as a raw material for the production of PET flakes for various industrial purposes.

5.2.3 Plastic bulky waste

There are no collection systems in place for this waste category. Plastic bulky waste is not covered by the Processing Charge Act, or by any other EPR-related system. This waste category is normally mixed with unsorted household or business waste, where landfilling is the dominant disposal option. However, waste companies have in exceptional cases put up containers for the collection of plastic bulky waste on a seasonal basis, such as for plastic garden furniture and plastic waste from horticulture. Plastic bulky waste may also be included in some contracts between businesses and waste service providers in cases where feasible recycling options exist. This applies inter alia to car parts from garages, such as bumpers and fenders of plastic, as this material is often homogenous and well-fitted

for recycling. A vast majority can thus be expected to end up in landfills. A trivial amount is collected and exported to the Netherlands.

Non-packaging small plastic waste

Small items of plastic waste other than packaging, such as toys, light household equipment etc., are not covered by any dedicated ordinance or law. These items are normally mixed with other household waste, where landfilling is the dominant disposal option. However, a small amount may by mistake end up in the plastic packaging waste fractions and be exported for recycling. This is most likely a negligible amount.

5.3 Financing measures

The collection and treatment of plastic packaging from households is partly financed by the municipality through a share of the total waste fees from households, which should be adjusted to the actual total waste management costs, and partly by the plastic packaging fees to The Icelandic Recycling Fund. The waste fees from municipalities cover kerbside collection of plastic packaging waste, as well as collection at small unmanned recycling stations (“neighbourhood containers”) and at central recycling stations. The plastic packaging fees to The Icelandic Recycling Fund subsidise the transportation costs of plastic packaging from municipal collection points according to a specific list, varying in line with the distance between the origin of the waste and the nearest export harbour. The maximum subsidy is close to ISK 20/kg (EUR 0.12/kg) for plastic packaging waste from the most remote regions of Iceland (Icelandic Recycling Fund, 2006). In addition, The Icelandic Recycling Fund pay a fixed sum per kg treated plastic packaging waste, according to The Icelandic Recycling Fund’s list of tariffs, decided by The Icelandic Recycling Fund board. The current payment is ISK 20/kg (EUR 0.12/kg) for all types of plastic packaging waste except from styrofoam where the price is ISK 30/kg (EUR 0.18/kg) and for unsorted plastic packaging waste where the price is only ISK 1/kg (<EUR 0.01/kg). IRF is considering a revision of the list of tariffs to better reflect the different treatment costs for different categories of plastic waste (The Icelandic Recycling Fund, 2013a).

Producers and importers of plastic packaging pay fees to The Icelandic Recycling Fund as decided by the Processing Charge Act No. 162/2002. The current fee is ISK 12/kg (EUR 0.07/kg). In cases of goods imported in plastic packaging, the fee per unit of goods is calculated with the help of a product-specific computer model to give an estimated fee of ISK 12 per kg of the plastic packaging part. The amount of the fee is decided by the law,

based on an estimate of the total sum needed each year to create viable market conditions for the collection, sorting and recycling of plastic packaging waste. Apart from plastic packaging, The Icelandic Recycling Fund also manages several other product categories. Each category should be non-profit in the long run, i.e. the total annual payments from producers and importers to The Icelandic Recycling Fund should be equal to total annual payments from The Icelandic Recycling Fund to approved actors taking care of the collection, sorting and recycling.

Transactions may take place between municipalities or other operators of the collection system and service providers who are responsible for the next steps in the life cycle of the waste in question. The same applies to every other transfer of the waste from one actor to the next one until the waste has reached the final recipient, i.e. the final link in this particular supply chain, (in most cases a recovery plant or a trader of recycling material). The service provider is, however, the only actor in this chain that receives payments from The Icelandic Recycling Fund.

Figure 6. The Icelandic system for recovery of plastic packaging waste (including plastic packaging waste) with an indication of the flow of waste, information and IRF money

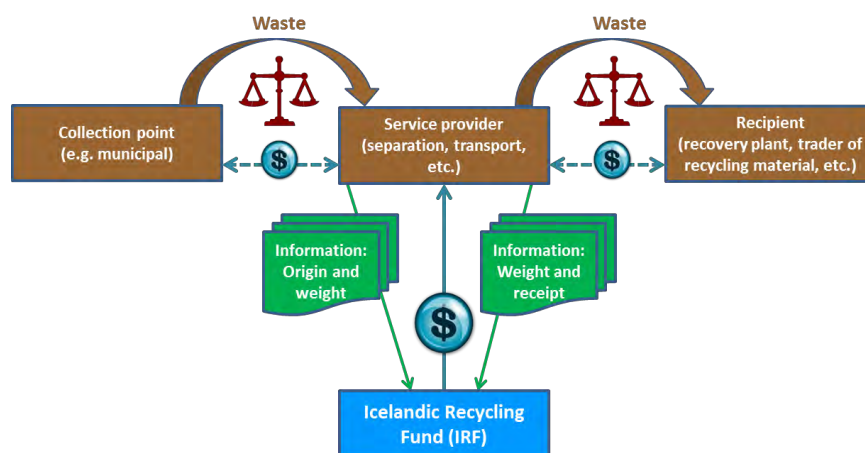


Illustration: Environice.

Producers and importers of PET bottles and other drink cartridges defined by the “Law on Prevention of Environmental Pollution Caused by Disposable Packaging for Beverages” No. 52/1989, pay a fixed amount to the not-for-profit company Endurvinnslan (Recycling Ltd) per unit put on the market. This fee makes it possible for Endurvinnslan to pay ISK 14 (EUR 0.09) deposit for every bottle or can handed in. The recovery rate of PET bottles (bottles handed in/bottles put on market) is ap-

proximately 87 percent, which in practical terms means that Endurvinnslan can use the remaining 13 percent, as well as the revenues from sales of exported waste, to cover all costs related to packing, transporting and recycling of the used bottles.

There is no specific financing system in place for plastic bulky waste. Costs related to bulky waste delivered to municipal recycling centres are covered by waste management fees in the case of households and by the owners through contracts with waste companies in the case of business waste.

There is no specific financing system in place for non-packaging small plastic items. This waste category ends normally up in bins or containers for unsorted waste and is sent to landfill. The costs for this are thus in one way or another included in municipal waste management fees or in contracts between businesses and waste companies.

6. Norway

6.1 Key actors

The voluntary extended producer responsibility (EPR) agreement was established in 1995 and renewed in 2003. The agreement includes all plastic packaging to all product types, excluding packaging that includes pollutants and packaging that has contained hazardous chemicals. The responsibility of ensuring funding from fees paid by producers and importers of packaging is handled by Grønt Punkt Norge on behalf of Plastretur. Plastretur is the only organisation handling the collection and recycling of plastic packaging.

Norwegian municipalities are responsible for collecting waste from Norwegian households, including source separated plastics packaging waste. It is, however, up to the municipality to decide what waste types of waste that are separately collected and what kind of waste management systems to choose. Municipalities that do not have their own waste treatment plant have to announce public tenders and have open competition about waste treatment services. Many of the Norwegian municipalities are very small and in order to fulfill their responsibility on plastic packaging many of them have formed intermunicipal collaborations.

The definition of household waste differs from the Swedish definition. There is no such term as “similar waste”, waste generated from businesses is commercial waste and is not included in the municipal responsibility (Avfall Sverige, 2009). In Norway, municipal waste sources refer therefore only to waste generated by households.

When the municipality or the municipality’s contracted waste management companies have collected at least 15 tonnes of plastic packaging waste from households, Grønt Punkt Norge collects the plastic packaging waste from the municipalities. Grønt Punkt Norge manages collection from municipalities and the transport and sorting of plastic packaging waste (Grønt Punkt Norge, 2013b).

The sorting of plastic packaging is carried out by sorting companies through tenders from Grønt Punkt Norge. The contracted sorting facilities are the same as for Förpacknings- och TidningsInsamlingen (FTI) in Sweden.

Table 7. Key roles in collection and recycling of plastic packaging waste in Norway

Key actor	Role
Producers and importers of plastic packaging	Put plastic packaging on the Norwegian market. Responsible for paying fees that finance the collection and sorting system, and packaging optimisation and declaration according to CEN-standards.
Municipalities	Responsible for collection of household waste. Communication to households about management of household waste is also part of the municipal responsibility.
Consumers of plastic packaging	Buys plastic packaging on the Norwegian market.
Grønt Punkt Norge (on behalf of Plastretur)	Responsible for collection of plastic packaging waste from municipalities (when at least 15 tonnes have been gathered by the municipality), transport and sorting of plastic packaging waste.
Grønt Punkt Norge's contracted sorting facilities	Clean and sort mixed rigid and flexible plastic packaging waste in order to separate polymers and obtain upgraded salable polymer fractions. Common tenders with the Swedish FTI.
Grønt Punkt Norge's contracted transporters	Transports the plastic packaging waste from Grønt Punkt Norge's receiving points to contracted sorting facilities.
The Norwegian EPA	Follow up the EPR agreement and reports data to Eurostat according to the Packaging directive.
Recyclers	Recycle plastic packaging waste into new products, by buying the clean and sorted plastic packaging waste from Grønt Punkt Norge's contracted sorting facilities.

PET bottles for beverages are not part of the EPR agreement. Responsible for the deposit based return system is Norsk Resirk A/S.

6.2 Collection and recycling

6.2.1 Plastic packaging

90 percent of the Norwegian population lives in a municipality that separately collects plastic packaging waste (Grønt Punkt Norge, 2013a). The way of collecting plastic packaging waste is up to each municipality and accordingly the collection systems vary. Around 70 percent of the population with access to source sorting of plastic packaging waste has kerbside collection in bags. 12 percent is using bring systems and 18 percent Optibag systems (Grønt Punkt Norge, 2013b). Rigid and flexible plastic packaging waste is sorted together at source.

The plastic packaging waste was for a period sent to Sweden and to two sorting facilities in Germany, and then further sent to recycling in Germany or China (Lyng and Modahl, 2011). In 2011 Grønt Punkt Norge launched collaboration with the similar Swedish organization (FTI) for a common tender for treatment of plastics from households. This resulted in a two year agreement with one sorting facility in Sweden and two in Germany (Grønt Punkt Norge, 2013a). According to new agreements from 2014 the plastic packaging waste from Grønt Punkt Norge and FTI will continue to be sorted at Swerec AB in Sweden and at DELA GmbH in Germany. Two additional actors have been contracted from 2014 and onwards; RELUX GmbH and EING Kunststoffverwertung GmbH, both operating in the north of Germany. The last mentioned sorting facilities do not only sort, but also produce secondary plastic raw material and recycle it into new plastic products. EING produces for example garden furniture. RELUX has mostly production of agglomerate used in the manufacturing of new plastic products (Grønt Punkt Norge, 2013e).

6.2.2 PET-bottles

All shops that sell beverages have no choice other than to accept a reasonable amount of bottles and refund the deposit. Norsk Resirk A/S is responsible for collecting and recycling the collected PET bottles. The collected PET bottles are sent to Sweden, Denmark and Germany for recycling into new bottles or into other products.

6.2.3 Plastic bulky waste and non-packaging small plastic waste

There is no designated system for plastic bulky waste in Norway. Plastic bulky waste is brought to recycling centrals by the consumer, where it most commonly is sent to energy recovery. As far as known some piloted tests where plastic bulky waste is sorted at recycling centrals are in place.

Plastic waste from other types of products from households ends up in the residual waste and is sent to energy recovery.

6.3 Financing measures

The collection of plastic packaging from households is carried out by the municipalities, and the costs are covered by the general waste fees (covering the collection of all households waste) paid by each household.

The transport from the municipalities is financed through a fee paid by the members of Plastretur. The considerations also covers information campaigns and reporting to authorities. Municipalities that choose to source separate plastic packaging will get financial support per ton of plastic being collected and delivered to Grønt Punkt Norge.

The current consideration fee to Grønt Punkt Norge for producers/importers of plastic packaging is NOK 1.15 per kg plastic packaging (NOK 2.20 for EPS) (Grønt Punkt Norge, 2013d). EPS may be collected from households at central collection stations. However, the significant amount of EPS is generated by businesses.

For PET bottles the Norwegian fee system for beverage packaging rewards systems with high collection rates. Cans and bottles have an environmental fee decided by the Norwegian pollution authorities. The fee is reduced according with higher collection rates. In 2012 the environmental fee was removed completely, as Resirk obtained 95 percent collection rate. In addition to the environmental fee, there is a base fee for all non-refillable cans and bottles (currently NOK 1.06) (Norsk Resirk, 2012).

The management of municipal recycling centers is financed through waste management fees. The recycling centers pay either for the bulky waste to be incinerated or for the plastic bulky waste fraction to be sent for sorting and recycling.

Collection and incineration of non-packaging plastic waste is financed by the municipalities through the waste management fee. The municipalities have to pay an incineration fee to the heat and power company per tonne of residual waste that is incinerated. Many waste-to-energy plants are municipally owned.

7. Sweden

7.1 Key actors

According to the environmental code (chapter 14), Swedish municipalities are responsible for the collection and treatment of household waste, and waste that is similar to household waste from businesses. However, producers and importers of plastic packaging are since 1994 legally responsible for organising a collection and recycling system for the plastic packaging waste entering the Swedish marketplace according to the producer responsibility on packaging (Ordinance 2006:1273 on packaging). The producer responsibility applies for all kinds of plastic packaging independently on end-consumer of the plastic packaging, i.e. if the plastic packaging is consumed by households or by businesses. The producers are responsible for the collection and treatment of the packaging waste discarded in their collection and recycling system. Collection and treatment of unsorted packaging waste in mixed MSW fractions are nevertheless covered by the municipal responsibility.

In order to facilitate for actors under producer responsibility obligations a service organisation called Förpacknings- och TidningsInsamlingen (FTI) has been established. Nearly 10,000 companies are affiliated with FTI, covering the absolute majority of the packaging material put on the Swedish market (excluding PET-bottles). FTI is owned by four “material companies” where Plastkretsen, representing producers of plastic packaging is one (FTI, 2013d).

Plastkretsen is a not-for-profit organisation with the aim of ensuring that the producer responsibility is met for plastic packaging put on the Swedish market. The operational work is carried out by FTI. Although, FTI is the major actor representing producers and importers of packaging on the Swedish market there are other actors fulfilling the producer responsibility for their customers. For plastic packaging waste, one example is TMR AB.

The ordinance on producer responsibility on packaging and packaging waste opens up for the possibility for municipalities to organise a collection system for packaging of their own. Several municipalities have chosen to do so, for example in the form of kerbside collection (Avfall Sverige, 2010).

Municipalities are according to the ordinance on producer responsibility on packaging responsible for the communication to households and other MSW sources about collection and sorting of plastic packaging. In the renewed version of the ordinance from 2006 this wording was removed due to uncertainties in the legal status. At the moment there is therefore no stated legal responsibility for the communication to households about collection and recycling of plastic packaging waste (FTI, 2013d).

FTI has a number of contracted waste collectors that collect the plastic packaging waste at the recycling stations managed by FTI. The source-sorted plastic packaging waste is transported to one of four contracted sorting facilities, the same as for Grønt Punkt Norge (FTI, 2013a).

The key actors and their respective role within collection and recycling of plastic packaging waste in Sweden are summarised in the following table, Table 8.

Table 8. Key actors and their role within collection and recycling of plastic packaging in Sweden

Key actor	Role
Importers and producers of plastic packaging	Put plastic packaging on the Swedish market. Responsible for paying fees that finance the collection and sorting system, and packaging optimisation and declaration according to CEN-standards.
Municipalities	Responsible for collection and treatment of household waste, excluding source-sorted plastic packaging waste discarded in the producers' system. Some municipalities have chosen to arrange for collection of plastic packaging waste themselves.
Consumers of plastic packaging	Buy plastic packaging on the Swedish market.
Förpacknings- och Tidningsinsamlingen (FTI) on behalf of Plastkretsen, TMR AB	Responsible for the collection and recycling of source sorted plastic packaging waste on behalf of their registered producers.
Contracted sorting facilities	Clean and sort mixed rigid and flexible plastic packaging waste in order to separate polymers and obtain upgraded marketable polymer fractions
FTI's contracted transporters	Transports the plastic packaging waste from recycling stations to FTI's contracted sorting facilities
Recyclers	Recycle the sorted and upgraded plastic packaging waste into new products by buying the clean and sorted plastic packaging waste from FTI's contracted sorting facilities.
The Swedish EPA	Supervising authority and responsible for reporting to Eurostat.

Special legislation applies to aluminum cans and PET bottles (Ordinance 2005:220 on deposit return systems for plastic bottles and metal cans). Returpack AB is in charge of a deposit return system for PET bottles in

Sweden. The PET bottles handled within the system of Returpack is processed and recycled by Cleanaway Svenska PET AB.

Plastic bulky waste is part of MSW and is therefore under the responsibility of the Swedish municipalities. There is no law or ordinance specifically targeted on plastic bulky waste, and there is not a nationwide collection and recycling system in place for this fraction. However, some municipalities collect plastic bulky waste on their own initiative based on agreements with waste management companies. The same applies for small items of plastic waste other than packaging. There is no designated collection and recycling system for this fraction, but some non-packaging small plastic waste is sorted out among the plastic packaging waste.

7.2 Collection and recycling

7.2.1 *Plastic packaging waste*

Generated plastic packaging waste is either collected through traditional bring systems or by different kinds of kerbside collection.

Bring system

The main part of the plastic packaging waste from households is collected through bring systems. FTI is in charge of approximately 6,000 unmanned recycling stations throughout Sweden where households can leave a mixed fraction of rigid and flexible plastic packaging waste. The recycling stations are placed at frequently visited areas such as close to shops, petrol stations and in residential areas. There is no rule deciding the number of recycling stations in each municipality, but FTI is obliged to consult with the municipalities about where recycling stations are best suited. The number is decided upon local conditions and the number of citizens. Establishing a new recycling station should also be “environmentally motivated” (FTI, 2013d). The recycling stations may have different design but usually includes separate containers for packaging waste of metal, plastic, paper, colored and transparent glass and newsprint. The containers are emptied by crane trucks or front-loaders on a regular basis dependent on the material type (Göteborgs Stad, 2012).

Figure 7. Recycling station in Gothenburg



Photographer: Kretslopp och vatten, Göteborgs Stad.

The unmanned recycling stations are only for households. A company generating plastic packaging waste can use so-called receiving points dedicated for companies. Actors with smaller volumes, up to one cubic meter and material type, may leave their plastic packaging waste free of charge to those manned receiving points. The receiving points counts to around 100 (FTI, 2013a). Another alternative is to enter into agreement with a private waste company. In the latter case, FTI is not part of the value chain.

Kerbside collection

Apart from the bring system provided by FTI there are different kinds of kerbside collection for plastic packaging waste in place throughout Sweden. The kerbside collection is either managed on behalf of the producers or under the management of the municipality. In the first case, the municipality has entered into agreement with an EPR organisation (FTI is dominating) and receives compensation for the collected material, as opposed to the second case where the municipality arrange for the collection without involvement of EPR organisations (Avfall Sverige, 2010). In either way, rigid and flexible plastic packaging waste is source sorted together in a mixed plastic packaging waste fraction.

The responsibility for collection of plastic packaging waste is currently under investigation. In SOU 2012:56 *Mot det hållbara samhället* –

resurseffektiv avfallshantering, on behalf of the Swedish government, the waste management in Sweden is scrutinized in order to make improvements in the Swedish waste management. One of the main proposals in the report is that the responsibility for collection of packaging waste should be taken from the producers and given to the municipalities.

Kerbside collection of plastic packaging waste is facing an increase in popularity, both for apartment buildings and for single-family homes. Of the total number of households in single houses, 5 percent of the total number of households in single-family homes has kerbside collection of packaging and newsprint. Roughly, 8–9 percent of the total single-family households have some kind of kerbside collection of packaging and newsprint (Avfall Sverige, 2013).

According to SOU 2012:56, 50 percent of all apartment blocks have kerbside collection of packaging and newsprint. Kerbside collection for apartment buildings mainly consists of separate containers for different kinds of packaging waste, there among plastic packaging waste. The containers are placed in the building or close to the building in a so-called “miljöhus”.

Kerbside collection from apartment buildings is either arranged by a contract between the property owner and FTI. The property owner can choose a contractor under the conditions that the contractor is registered as collection contractor of FTI, and has thereby obtained a general mandate of FTI on kerbside collection. The collected material is treated the same way as the material collected from recycling stations (FTI, 2013d).

The other alternative is that the municipality arrange for kerbside collection, as described above. The containers are primarily emptied by vehicles equipped with one or two compartments. (Göteborgs Stad, 2012).

Figure 8. Kerbside collection in Gothenburg



Photographer: Kretslopp och vatten, Göteborgs stad.

Available ways of kerbside collection from one or two family dwellings are by multi-compartment containers. 25 municipalities offer kerbside collection in the form of multi-compartment containers (four compartments), although some are at a test stage. The share of single-family households using multi-compartment containers in these municipalities vary from 4–5 percent to 96–100 percent. The average in these 25 municipalities is 50 percent (Avfall Sverige, 2013). Every household has two containers with eight compartments in total. Each container has compartments of two different sizes, two smaller and two larger. The collection frequency varies depending on which compartment is used for which fraction. The compartments are dedicated to six packaging fractions, one food waste fraction and one residual waste fraction. An example of the organisation of fractions is to have one container with residual waste, food waste, coloured glass and paper packaging waste. The food waste and the coloured glass are discarded in the two smaller compartments. The container may be emptied every second week. The second container contains metal packaging, transparent glass, plastic packaging and newsprint. Metal packaging and transparent glass are sorted out in the two smaller compartments. This container is commonly emptied every month (Göteborgs stad, 2012).

There are also other kinds of kerbside collection from single-family houses, such as sorting in differently coloured bags prior to optical sorting. The bags are then placed in the same container, which usually is

emptied every week by one-compartment vehicles. Transparent and coloured glass is discarded at recycling stations. Eskilstuna municipality was the first municipality to organise this kind of kerbside collection (in 2011) (Göteborgs stad, 2012).

Example of kerbside collection in less populated areas, in this case island municipalities on the western coast of Sweden, is to sort out a plastic packaging waste and metal packaging waste in differently coloured bags, which are placed in a bigger transparent plastic bag. Paper packaging waste is loosely placed in the bigger bag. Separate containers are used for other packaging waste fractions. The system is called “the recycling bag” and was introduced in Orust municipality during the 1990s. The recycling bag is collected every second week and is manually sorted by the waste contractor. The service is available both for apartment buildings and for single-family homes (Göteborgs stad, 2012).

7.2.2 PET bottles

The system for collection and recycling of PET bottles is separated from other plastic packaging due to SFS 2005:22, *Ordinance on deposit system for plastic bottles and metal cans*. The ordinance is applied on PET bottles sold in Sweden with ready-to-drink beverages apart from bottles containing drinking dairy products, and drinks with a content of juice or vegetable parts exceeding 50 percent. The authority giving approval to deposit systems is The Swedish Agricultural Board (Jordbruksverket, 2013).

The dominating deposit system for PET bottles in Sweden is managed by the private company Returpack, owned by Sveriges Bryggerier, Livsmedelshandlarna and Svensk Dagligvaruhandel (Returpack, 2013b). 97 percent of the PET bottles delivered to Returpack are collected through reverse vending machines (counted and compressed). The rest is taken back manually and sent in to Returpack in plastic bags (uncompressed) to be counted. The fraction from the reverse vending machines is very pure as the machines do not accept other fractions than PET bottles with registered barcodes. 0.28 percent of the total incoming material, including combustible waste generated in the office and contaminants following the bottles and cans, is not delivered to recycling. Material losses in the sorting of PET bottles are unknown, but is significantly lower than 0.28 percent of the incoming material (Returpack, 2013a).

PET bottles are automatically sorted in a transparent fraction and in a coloured PET fraction at Returpack’s sorting facility in Händelö, outside of Norrköping in Sweden. Bottle caps are not removed in the sorting process, but often fall off during sorting. A part of the bottle caps thus

follows the transparent and the coloured PET fractions. Labels either fall off in the sorting process or follow the PET streams. Bottle caps are subject to recycling and labels to energy recovery (Returpack, 2013a).

The transparent and coloured PET fractions are baled and sold to Cleanaway Svenska PET AB; a company specialized in bottle-to-bottle recycling. Cleanaway is situated on the same premises as Returpack making the transportation needs minimal (Returpack, 2013a). The PET bales delivered from Returpack are first separated in a bale separator. Bottle caps are sorted out in a drum sieve. The clean PET fraction is manually inspected, visible contaminants are removed and the PET fractions processed into PET flakes using the UnPET process (Chapter 11.4).

7.2.3 Plastic bulky waste

According to Avfall Sverige (2013), 28 municipalities sort out plastic bulky waste at their recycling centrals. The figure is based on the web-based tool Avfall Web where municipalities report statistics and information about their waste management. The number of municipalities collecting plastic bulky waste can be higher than 28 as Avfall Web is voluntary. According to Avfall Web, the 28 municipalities collected 4,100 tonnes of plastic bulky waste in 2012. The information does not tell how the collected plastic bulky waste was treated.

Swerec annually accepts around 5,000 tonnes of plastic bulky waste from municipal recycling centrals. The 5,000 tonnes originates from 15 municipalities, there among Stockholm and Gothenburg. The fate of the plastic bulky waste sorted out at the remaining municipalities is unknown.

The plastic bulky waste fraction accepted by Swerec consists mainly of PP (50 percent), PE (30 percent) and of miscellaneous combustibles of 10 percent. Swerec sorts the fraction manually or crushes it with a mobile crusher before NIR sorting, the same equipment used for plastic packaging. Swerec observes an increasing interest from municipalities to sort out their plastic bulky waste. There are some restrictions on the plastic bulky waste that the municipalities must fulfill in order for the material to be accepted by Swerec. The list contains of around 30 fractions accepted as plastic bulky waste (by Swerec called "kommunplast") and 30 fractions not accepted. Among the fractions accepted are for example plastic flower pots, plastic garden furniture, plastic toys, buckets, pallets and CD cases (Swerec, 2013b).

Figure 9. Plastic bulky waste delivered to Swerec



Photographer: Swerec.

7.2.4 Non-packaging small plastic items

As there are no designated collection and recycling system for small items of plastic waste other than packaging the fraction ends up in the residual waste fraction collected by the municipality or the municipalities contracted entrepreneurs, and is subject to energy recovery. Non-packaging plastics also ends up in the plastic packaging and plastic bulky waste fractions. In that case they follow the respective stream to recycling if the polymers correspond with the polymers sorted out of the plastic packaging and plastic bulky waste fractions.

7.3 Financing measures

Collection and recycling of plastic packaging does not usually cover its own costs. The recycling system of FTI is not-for-profit and all companies affiliated with the system pay packaging fees in relation to the amount of packaging material they put on the Swedish market. There are different fees according to type of plastic packaging put on the market (Table 9).

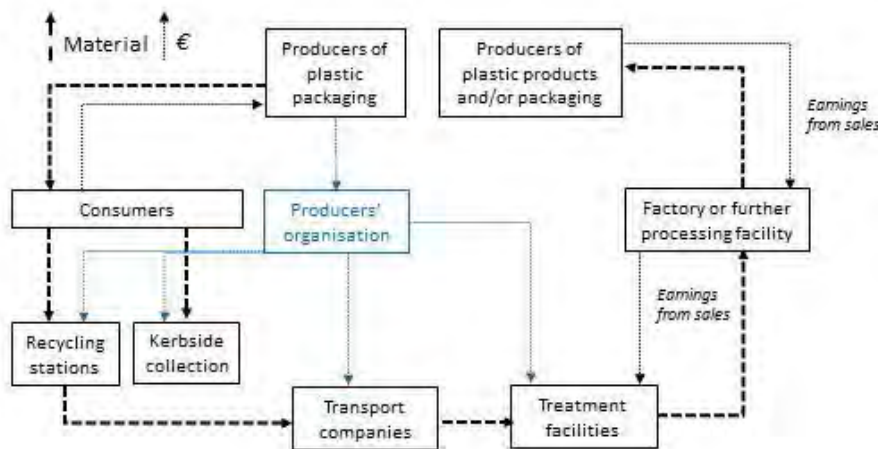
Table 9. FTI's packaging fees

Type of packaging	Packaging fee (EUR/kg)
Consumer packaging	0.19
Business packaging	0.01
Service packaging	0.18

The difference in packaging fee is quite substantial, which according to FTI mainly has to do with the costs for collection. The costs of FTI are primarily related to the collection of packaging waste from households. Producers of these kinds of packaging are therefore charged more than producers of business packaging. Other costs are related to consulting with municipalities and reporting to the Swedish EPA. Producers of business packaging are only charged for the last mentioned costs and not for the collection. The collection is paid by the generator of the plastic packaging waste (FTI, 2013a).

The general cost distribution in the collection and recycling of packaging waste from households is illustrated in Figure 10.

Figure 10. Material and money streams in the collection and recycling of plastic packaging waste in Sweden



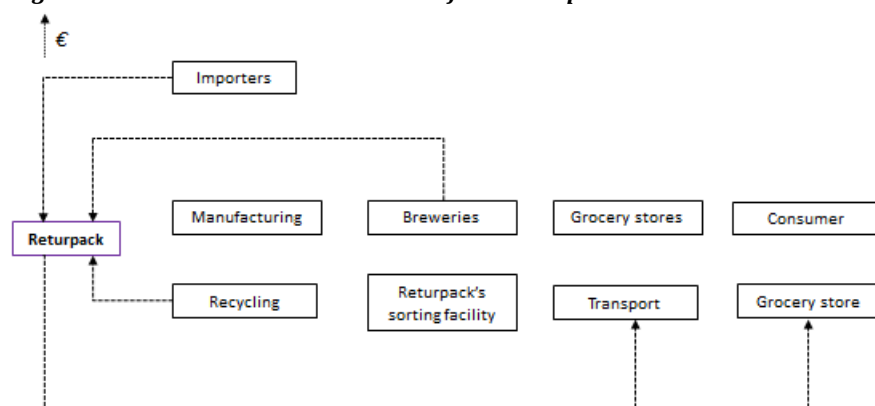
The extra cost for kerbside collection from apartment buildings in collaboration with FTI are financed by the property owner and in turn the residents. The fee for kerbside collection is equivalent to the difference between the cost of collection and the payment from FTI to the collection contractor for the collected material (FTI, 2013d). The same principle applies for kerbside collection for households in collaboration with FTI.

When collection of plastic packaging is organised on behalf of the producers (bring system or kerbside collection), the municipalities have

no legal right to charge the households as part of the waste fee. The municipalities are on the other hand able to charge a service fee for the extra service of kerbside collection for the avoided transport to recycling stations. If the municipalities arrange their own system of kerbside collection they can sell the collected material on a free market and charge through the waste fees. (Avfall Sverige, 2010).

When breweries and importers sell ready-to-drink beverages in PET bottles to grocery stores and shops they charge a deposit per bottle (SEK 1 or SEK 2 depending on the size of the bottle) and an administrative fee.¹² When the consumers buy the ready-to-drink beverages they are charged the deposit and the grocery store is refunded the amount they paid to the breweries and importers. As long as the bottle is not returned to the deposit system, the deposit remains paid by the consumer. The grocery store is compensated by Returpack for the disbursement (Returpack, 2013a).

Figure 11. Financial transactions to and from Returpack



The financial transactions to and from Returpack are illustrated in Figure 11. Apart from the charged deposits and administrative fees from importers and breweries, Returpack finances the collection and recycling system by incomes from selling the sorted PET fractions to recycling. Cleanaway in turn sell the PET flakes to bottle manufacturers. The bottle cap fraction is sold for recycling, both by Returpack and by Cleanaway. The grocery stores own the reverse vending machines (Returpack, 2013a).

¹² Customers of Returpack are also restaurants, associations, offices etc.

The management of municipal recycling centers is financed through waste management fees. The recycling centers pay either for the bulky waste to be incinerated or for the plastic bulky waste fraction to be sent for sorting and recycling.

Collection and incineration of this fraction is financed by the municipalities through the waste management fee. The municipalities have to pay an incineration fee to the heat and power company per tonne of residual waste that is incinerated.

8. Åland

8.1 Key actors

Waste management in Åland is controlled by Act of waste, ÅFS 1981:3. The definition of household waste includes waste generated by households and similar waste generated by businesses. According to the law, the municipalities of Åland are responsible for waste management of private household waste. The producer responsibility for packaging, which is controlled by ÅFS 1998:93 (Decree of packaging and packaging waste), last updated on the 29th August 2013, covers packaging producers in Åland and importers of packaging and packed products to Åland.

Proans (Producentansvar Åland AB) is a service organisation created in 2009 to assist producers and importers of packaging fulfilling their producer responsibility obligations in Åland. Proans is owned by the municipal company Miljöservice på Åland AB (Mise), but the aim is to sell Proans as the more logical owner is the industry (Proans, 2013a). Ålands Problemavfall AB (ÅPAB), which is a subsidiary of Mise, and Ålands Renhållning AB collect packaging waste from the recycling stations and centrals, on behalf of Proans.

Table 10. Key actors and their role in collection and recycling of plastic packaging waste in Åland

Key actor	Role
Importers and producers of plastic packaging	Put plastic packaging on the market in Åland.
Municipalities	Responsible for collection of private household waste. Communication to households about waste management of household waste.
Consumers of plastic packaging	Buy plastic packaging on the market in Åland
Proans	Responsible for the collection and treatment of plastic packaging waste. Reports to authorities.
Ålands Problemavfall AB (ÅPAB)	Collects rigid plastic packaging waste from public recycling stations on behalf of Proans.
Ålands Renhållning AB	Collects rigid source-sorted plastic packaging waste from households at the curb.
Ålands landskapregering	Supervising authority and responsible for reporting to Eurostat

The deposit return system is included in the Finnish system managed by PALPA. The collection and recycling of PET bottles is regulated by Decree (1998:93), last updated in 2013.

According to Decree of waste ÅFS 2011:74 (§§ 7, 8) plastic waste should be collected and recycled. This includes not only packaging, but also other types of waste.

8.2 Collection and recycling

Plastic packaging waste in Åland is most commonly sorted out through traditional bring systems. There are 15 recycling stations in the region of Måne and additional 78 recycling stations in the rest of Åland's nine municipalities. Some of the recycling stations are placed in combination to recycling centrals. The largest commercial harbours, guest harbours, and shipyards are obliged to provide containers for rigid plastic packaging waste (ÅFS 2003:67) and apartment blocks with more than five households are required to have a separate container for rigid plastic packaging waste following the regulations of Måne (Ålands landskapsregering, 2013). In total, there is approximately one public recycling station for households per 300 citizens in Åland.

Households can discard seven fractions of packaging waste and newsprint at the recycling stations: paper and cardboard, aluminum cans, metal packaging, glass packaging, rigid plastic packaging, liquid packaging board ("tetror"), and newsprint (Måne, 2013a). Flexible plastic packaging is not separately sorted out from households. Proans has contracted ÅPAB to manage the collection of rigid plastic packaging waste at recycling stations and centrals, but as they do not have a sufficient number of collection vehicles Ålands Renhållning AB is subcontracted to collect the rigid plastic packaging waste (Ålands Renhållning, 2013).

All municipalities in Åland offer their citizens collection of combustible household waste at the curb. The majority of households can also choose to pay extra for having kerbside collection in eight fractions, the same fractions that are sorted out at recycling stations. Flexible plastic packaging waste is not collected separately, but discarded in a mixed combustible fraction (Ålands Renhållning, 2013a). Around 2,000 households out of 13,100 (ÅSUB, 2013b) in Åland have chosen kerbside collection in eight fractions. The fractions sorted out are combustible waste, food waste, liquid packaging board, rigid plastic packaging waste, newsprint, glass and metal packaging. There is also a possibility to choose a container with two compartments (combustible waste and food waste) or a container for

combustible waste only) (Ålands Renhållning, 2013b). In that case they are directed to sort out recyclable waste fractions at recycling stations. Ålands Renhållning is in charge of the kerbside collection of plastic packaging waste from households (Ålands Renhållning, 2013a).

Figure 12. Kerbside collection of rigid plastic packaging waste in Åland



Photographer: Ålands Renhållning.

The collected rigid plastic packaging waste from kerbside collection and from recycling stations are baled and stored before it is sent to Finland for energy recovery. The rigid plastic packaging waste fraction is used as fuel in the industry. Rigid plastic packaging waste is regarded as a fuel, like any other fuel, and the fraction is therefore not charged with incineration fee in Finland. By sorting out plastic packaging it is possible to obtain a dense, compressed fraction lowering the transportation costs (Ålands Renhållning, 2013a).

The reason not to send the rigid plastic packaging waste fraction to recycling is due to unreasonably higher costs compared to sending it to Finland as fuel. A couple of years ago the rigid plastic packaging waste was sent to Swerac in Sweden. The composition of the plastic packaging waste was good enough, but would be too expensive, much because of transportation costs (Ålands Renhållning, 2013a).

The combustible waste fraction containing flexible plastic packaging waste and small items of plastic packaging waste is transported to Sweden, to Vattenfall in Uppsala, for energy recovery (Ålands Renhållning, 2013a).

In addition to recycling stations there are manned recycling centrals in all except one of Åland's sixteen municipalities. Households can leave bulky waste, hazardous waste, waste under producer responsibility obligations and waste fractions to landfill at recycling centrals. Households can leave plastic bulky waste at recycling centrals for an additional cost (Ålands landskapsregering, 2010). At the recycling centrals there are separate containers for rigid plastic bulky waste. The plastic bulky waste is left at the manned recycling stations and is sent to Finland for further processing and energy recovery (Ålands landskapsregering, 2010).

8.3 Financing measures

Producers connected to Proans pay a fee per kilo plastic packaging material they have put on the market. The current fee (for 2013) is EUR 0.29 per kilo plastic packaging material. Apart from the fee per kilo the producers pay an annual fee of EUR 450 to Proans. Producers producing less than 100 kg packaging are not obliged to report the amounts put on the market, but pay an annual fee of EUR 150 to Proans (Proans, 2013b).

The costs for waste management have in the majority of Åland's municipalities changed from being partly financed by taxes to a financing system based on waste fees inspired by "polluters' pays principle". As an example, the extra cost for having kerbside collection of plastic packaging is paid by the households using this service. However, within Misa the households choosing kerbside collection gets EUR 35 discount on the base fee for the waste management.

One of the reasons to form Proans was to lower the costs for waste management for households. The responsibility for the household waste management is spread out on individual municipalities, even though some municipalities have chosen to act together as a unit. Common public procurement among the municipalities could lower the costs for waste management. The long-term goal of Proans is to obtain a collection system of packaging waste that is entirely integrated with the existing collection system for household waste, where the municipalities are responsible for the planning and operation of the collection system and Proans for the finances. One step in the right direction is the agreement between Proans and ÅPAB (Ålands Problemväfall AB), who collects of plastic packaging waste from recycling stations. New agreements will however be signed with the municipalities of Åland in 2014 (Proans, 2013b).

9. Quantification of known plastic waste streams

Known plastic waste streams are quantified in this chapter. By “known” means official statistics on plastic waste or data reported by the previously mentioned key actors. Estimated plastic waste streams not mentioned in this chapter are found in chapter 10.9.

In Table 11, amounts of plastic packaging and PET bottles put on the market in the Nordic region are presented. The figures represent official statistics of the amount of plastic packaging put on the Nordic market. As a general rule agricultural film is not included in the figures. However, in the Danish and Finnish statistics it is not possible to separate plastic packaging from agricultural film why it is included in the statistics.

In Table 12, the separately collected plastic packaging waste and PET bottles are presented. Table 12 also includes how the separately collected plastic packaging waste fractions are treated without taking into account material losses in sorting and recycling processes. The sources of data are listed beneath the tables.

Table 11. Plastic packaging put on the market in the Nordic region

Country	Plastic packaging (ex. PET-bottles) [tonnes]	Plastic packaging per capita (excl. PET-bottles) [kg]	PET-bottles [tonnes]	PET-bottles per capita [kg]
Denmark	155,909 (2009)	27.8	10,590*** (2009)	1.9
The Faroe Islands	Not available	Not available	Not available	Not available
Finland	117,126 (2011)	21.6	13,300 (2011)	2.5
Greenland	Not available	Not available	Not available	Not available
Iceland	9,002 (2012)	28.0	1,950 (2012)	6.1
Norway	137,479 (2012)	27.2	8,274 (2012)	1.6
Sweden	176,478 (2010)	18.4	21,968 (2010)	2.3
Åland	77 (2012)	Not available	Not available	

*** The figure includes all PET packaging. Approximately 20 percent of the units were covered by PET-bottles washed and reused by the breweries (in 2009).

Sources:

Denmark: (DEPA, 2011).

The Faroe Islands: (Interkommunali Renovatiónsfelagsskapurin, 2013).

Finland: (PYR, 2013b), (PALPA, 2013).

Iceland: (The Icelandic Recycling Fund, 2013b), (Endurvinnslan, 2013).

Norway: (Grønt Punkt Norge, 2013b), (Norsk Resirk, 2012).

Sweden: (Naturvårdsverket, 2012).

Åland: (Proans, 2013a).

Table 12. Separately collected plastic packaging waste and the way of treatment

Country	Separately collected plastic packaging (ex. PET-bottles) [tonnes]	Treatment of separately collected plastic packaging [tonnes]	PET-bottles [tonnes]
Denmark	39,937 (2009)	20,000 to recycling 19.37 to energy recovery (estimated 50% output – 2009)	6,000 (2009)
The Faroe Islands	328 (2012)	328 to recycling	65 (2012)
Finland	53,768 (2011)	29,726 to recycling 25,000 to energy recovery	12,500 (2011)
Greenland	Not available	Not available	Not available
Iceland	2,432 (2012)	1,424 to recycling 1,008 to energy recovery	1,697 (2012)
Norway	54,424 (2012)	54,424 to recycling	4,200 (2012)
Sweden	123,500 (2010)	45,560 to recycling 77,030 to energy recovery	21,968 (2010)
Åland	125 (2012)	125 to energy recovery	Not available

Sources:

Denmark: (DEPA, 2011).

The Faroe Islands: (Interkommunali Renovatiónsfelagsskapurin, 2013).

Finland: (PYR, 2013b), (PALPA, 2013).

Iceland: (The Icelandic Recycling Fund, 2013b), (Endurvinnslan, 2013).

Norway: (Grønt Punkt Norge, 2013b), (Norsk Resirk, 2012).

Sweden: (Naturvårdsverket, 2012).

Åland: (Proans, 2013a).

In Denmark the registration of plastic packaging is partly based on statistical data on supply to the market, partly on waste collection registrations made by waste collectors and waste receivers. From 2010 the waste data collection has been centralized to a national waste database administered by the Danish EPA, the Waste Data System (Affaldsdata-systemet) which will make out the central source of information. Before the change, the municipalities had the responsibility for data collection. However, this new database is not yet considered to be fully reliable because the changes in regulation has caused some erroneous registrations in the first years, why the data collected will have to be adjusted according to European and Scandinavian registrations of plastic waste generation from the different sectors, and according to data collected prior to the change in registrations practice.

The amount of plastic packaging put on the market in the Faroe Islands and Greenland is unknown. Separate collection of plastic waste does not occur in Greenland, or in the Faroe Islands (from households), and there and no statistics on the amount of plastic waste generated could be found.

Separate collection of plastic waste from households does not exist in the Faroe Islands either, apart from PET bottles within a deposit return system. The figure for plastic packaging waste presented in Table 11 come from Interkommunali Renovatiónsfelagsskapurin (2013) and is the total amount of plastic waste delivered to IRF: transparent and coloured flexible plastic packaging, PET bottles, polystyrene (also called flamingo), and remaining of fishing gear. In 2012, 257 tonnes of the total amount of 322 tonnes consisted of flexible plastic packaging waste (both transparent and coloured), and 65 tonnes of PET-bottles. Apart from IRF's plastic waste export, a large producer of fish feed exports plastic waste under private management. The annual amount exported is around 40 tonnes, but is not presented in Table 11. PET bottles returned to the two large importers of PET bottles (Poul Hansen och Poul Mikkelsen) go directly to the Danish deposit return system and should appear in the Danish statistics (Interkommunali Renovatiónsfelagsskapurin, 2013).

In Finland, the plastic packaging put on the Finnish market refers to the registered amounts in the system of PYR (PYR, 2013b). The separately collected plastic waste from households is a mix of plastic packaging waste and non-packaging small plastic waste, and the numbers in Table 12 therefore refers to both. According to Statistics Finland (2013) separate collection of plastic waste from MSW sources in 2012 was 36,127 tonnes; of which 4,451 tonnes (12 percent) was sent to recycling and 31,676 tonnes to energy recovery (Statistics Finland, 2013). Data for PET bottles comes from PALPA.

The Icelandic statistics on plastic packaging are based on data and calculations from The Icelandic Recycling Fund and include separately collected plastic packaging waste from both households and businesses. Endurvinnslan (Recycling Ltd) provides data on PET bottles.

The Norwegian figures for plastic packaging put on the Norwegian market is the total amount of plastic packaging, both put on the Norwegian market, both by registered producers of Grønt Punkt Norge as well as the amount put on the market by producers not taking their producer responsibility. The collected amount of plastic packaging waste in Norway refers to the amount collected within the EPR system of Plastretur on behalf of Grønt Punkt Norge (both from households and businesses). The figures for PET bottles are the amount collected by Norsk Resirk.

According to national statistics the amount of plastic waste generated in Norway in 2011 was 478,000 tonnes, of which 157,000 tonnes originated from households. Total amount of plastic waste in 2011 separated in different types of treatment was: 89,000 tonnes to material recycling, 231,000 tonnes to energy recovery, 52,000 tonnes to incineration without energy

recovery and 25,000 tonnes to landfill. Treatment of the 81,000 remaining tonnes is categorized as unknown in the national statistics. The national statistics do not categorise the plastic waste into different product groups, e.g packaging and non-packaging (Statistics Norway, 2013).

The data for Sweden is based on reported amounts to the Swedish EPA from Plastkretsen AB (part of FTI), Svensk Ensilageplast Retur AB, Plaståtervinning i Wermland AB and TMR AB (Avfall i Sverige, 2010). The data is gathered by the SMED consortium (Svenska Miljöemissionsdata) on behalf of the Swedish EPA. Plastkretsen represents the absolute majority of the reported amounts of packaging put on the Swedish market and the collected and recycled amounts of packaging waste. The Swedish figure on plastic packaging waste is collected plastic packaging both from households and businesses as there are no official statistics available where collected amounts are divided on end-consumer.

The Swedish statistics for PET bottles come from Returpack and is the amount of PET bottles put on the market and the delivered PET bottles to the deposit return system (both from households and businesses) (Returpack, 2013a).

The figures for Åland represent the separately collected amounts of plastic packaging waste within the system of Proans, and the plastic packaging put on the market by the members of Proans. Only rigid plastic packaging waste is separately collected. 90 tonnes of plastic packaging waste was collected within the system of Proans in 2012. This amount includes the collection from recycling stations and centrals, as well as from businesses. 35 tonnes of rigid plastic packaging was collected at the curb from households in 2012. The total amount of collected plastic packaging waste therefore counted to 125 tonnes. There are no figures available on the amount generated by households only. ÅSUB (Ålands statistik- och utredningsbyrå) is responsible for compiling waste statistics on behalf of Ålands landskapsregering.

10. Benchmarking the collection and recycling systems for plastic waste in the Nordics

Facts about the collection and recycling systems in the Nordic countries reveal interesting synergies and differences. These aspects are highlighted in this chapter and the situation in the Nordic countries compared.

10.1 Goals and achievements of goals

The Packaging and Packaging Waste Directive (94/62/EC) (amendments by Directive 2004/12/EC and Directive 2005/20/EC)¹³ include minimum requirements for recycling of plastic packaging waste in the Member Countries. The specific objectives concerning collection and recycling of plastic packaging are:

- a) No later than 30th June 2001 between 50 percent as a minimum and 65 percent as a maximum by weight of packaging waste will be recovered or incinerated at waste incineration plants with energy recovery.
- b) No later than 31st December 2008 60 percent as a minimum by weight of packaging waste will be recovered or incinerated at waste incineration plants with energy recovery.
- c) No later than 30th June 2001 between 25 percent as a minimum and 45 percent as a maximum by weight of the totality of packaging materials contained in packaging waste will be recycled with a minimum of 15 percent by weight for each packaging material.
- d) No later than 31st December 2008 between 55 percent as a minimum and 80 percent as a maximum by weight of packaging waste will be recycled.

¹³ Hereafter referred to "the packaging directive".

- e) No later than 31st December 2008 the following minimum recycling targets for materials contained in packaging waste will be attained:
- (i) 60 percent by weight for glass.
 - (ii) 60 percent by weight for paper and board.
 - (iii) 50 percent by weight for metals.
 - (iv) 22.5 percent by weight for plastics, counting exclusively material that is recycled back into plastics.
 - (v) 15 percent by weight for wood.

Apart from the minimum objectives stated in the directive some of the Nordic countries have national objectives related to plastic packaging or goals to be met within designated collection and recycling systems for plastic packaging (Table 13).

Table 13. National recycling targets for plastic packaging in the Nordic region

Country	National objectives for recycling of plastic packaging waste	National objectives for recycling of PET bottles
Denmark	50% of MSW must be recycled by 2022, including all plastic waste	As high as possible (pt. 92%)
The Faroe Islands	No target	-
Finland	22.5% recycling of plastic packaging (30% in 2016)	80% (90% in 2015)
Greenland	No target	-
Iceland	22.5% recycling of the plastic packaging	-
Norway	Requirements in the EPR agreement: at least 30% recycling at least 50% energy recovery Target for EPS: 60% recovery of which at least 50% recycling	-
Sweden	70% recovery of which 30% recycling	90% recycling
Åland	22.5% recycling of the plastic packaging	80% (90% in 2015)

The Faroe Islands and Greenland have no objectives specifically targeted on plastic packaging. Iceland, Finland and Åland have chosen not to go further than the minimum requirements in The Packaging and Packaging Waste Directive. Sweden has on the other hand a higher national objective than the requirements in the directive, and so is the target within the Norwegian EPR agreement. Denmark has a target for all recyclables not excluding plastics.

The recycling objective for PET bottles varies between 80 percent (Finland and Åland) and 90 percent (Sweden).

No Nordic country has specific targets for collection and recycling of plastics other than for plastic packaging.

10.2 Reaching of recycling targets

The data reported to Eurostat in accordance with the packaging directive is presented in Table 14.

Table 14. Recycling rates for plastic packaging reported to Eurostat

Country	Recycling of plastic packaging (%)	
	2010	2011
Denmark	26.4*	22.3**
Finland	26.2	25.4
Norway	36.4	37.6
Sweden	32.4	34.1

* Estimated number ** Break in time series.
(Eurostat, 2013).

Norway has the highest recycling rate for plastic packaging in the Nordics according to data reported to Eurostat. Sweden and Finland meet the target, but Denmark is slightly below in 2011.

Comparison between recycling rates based on Eurostat data should be done with precaution as differences in methodologies might give biased results. This is a common obstacle in comparing waste statistics between countries, also emphasised in other studies such as in Hanssen *et al.* (2013) (published within the EU project FUSIONS). Member States are free to use methods of their choice as long as the Eurostat instructions are followed, and the data is therefore coming from various sources, such as national statistical institutes and administrative sources e.g. municipalities, producer compliance schemes etc. (Eurostat, 2013).

According to Eurostat metadata, the recycling rate for plastic packaging waste should be calculated as the total quantity of recycled packaging waste, divided by the total quantity of generated packaging waste. Packaging waste generated in a Member State may be deemed to be equal to the amount of packaging placed on the market in the same year within the Member State. In addition, the weight of recovered or recycled packaging waste shall be the input of packaging waste to an effective recovery or recycling process. If the output of a sorting plant is sent to effective recycling or recovery processes without significant losses, it

is acceptable to consider this output to be the weight of recovered or recycled packaging waste (Eurostat, 2013).

National recycling targets

The attainments of the national targets are listed in Table 15. PET bottles are excluded apart from the statistics for Denmark and Åland. Agricultural film is excluded when possible (not excluded in the Danish and Finnish statistics). Statistics for 2012 is not yet official for all countries why the most recent data is presented.

Table 15. Reaching of national recycling objectives for plastic packaging in the Nordic region (excl. PET bottles and agricultural film when possible)

Country	National objectives for recycling of plastic packaging waste	Reaching of national recycling objectives	Is the national recycling target for recycling of packaging waste reached?
Denmark	50% of MSW and hereunder plastic recycled in 2022. The remaining waste fraction must be energy recovered to heat and energy	2011: 22% recycling and 75% energy recovery (including PET bottles)	NO
The Faroe Islands	No target	-	-
Finland	22.5% recycling of plastic packaging (30% in 2016)	2011: 25% material recycling and 21% energy recovery (industrial packaging)	YES
Greenland	No target	-	-
Iceland	22.5% recycling of the plastic packaging	2012: 16% recycling, 11% energy recovery	NO
Norway	Requirements in the EPR agreement: 30% recycling and at least 50% energy recovery. Target for EPS: 60% recycling of which 50% material recycling	2012: 40% recycling 53% energy recovery	YES
Sweden	70% recovery of which 30% recycling	2010: 26% recycling (28% for 2011) ¹⁴ 18% energy recovery, 44% total recovery	NO
Åland	22.5% recycling of the plastic packaging	2012: 18% recycling (PET bottles) 82% energy recovery	NO

Sources:

Denmark: (DEPA, 2013b), (Eurostat, 2014).

Finland: (PYR, 2013b).

Iceland: (The Icelandic Recycling Fund, 2013b).

Norway: (Grønt Punkt Norge, 2013b).

Sweden: (Naturvårdsverket, 2012).

Åland: (Ålands landskapsregering, 2013).

¹⁴ As detailed data as for 2010 is not available.

As presented in Table 15, the national targets for plastic packaging waste are met in Norway and Finland, but not in Sweden, Iceland and Åland. However, the recycling rates calculated to follow-up the national objectives for recycling of plastic packaging waste differ between the Nordic countries. This will be further discussed in Chapter 10.8.

There is no recycling target for PET bottles in Norway, but for removing the environmental fee a goal of 95 percent collection rate was set. In 2012 this target was obtained (97 percent for PET), resulting in the removal of the environmental fee on cans and bottles. In Sweden, the target was nearly reached in 2010, 86 percent (Naturvårdsverket, 2012). In Denmark the target is to have a recycling rate which is as high as possible. Currently, the recycling rate is 89 percent, and seemingly this is a stable recycling level. The current target in Åland and Finland is 80 percent (90 percent from 2015).

10.3 Collection of plastic waste

Collection systems in place for plastic packaging, plastic bulky waste and non-packaging small plastic waste from MSW sources in the Nordic region are presented together in Table 17 for an easier comparison.

10.3.1 Plastic packaging waste (excl. PET bottles)

Two strategies of separate collection of plastic packaging waste can be distinguished in the Nordic region. One is to focus on separate collection and recycling of plastic packaging waste from MSW sources (Denmark, Norway, Sweden and Iceland). The other strategy is to separately collect plastic packaging waste for energy recovery as a fuel of high calorific value (Finland and Åland). Central sorting of mixed MSW waste in order to obtain plastic packaging waste and other recyclable fractions is not practiced in the Nordic countries, although a number of municipalities in Norway are planning a central sorting plant (see Chapter 13). Rigid and flexible plastic packaging is collected together throughout the Nordic region apart from Finland and Åland. In Finland packaging and non-packaging plastic waste is collected and treated together and in Åland only rigid plastic packaging waste from MSW sources is source-sorted and separately collected. The strategies are summarised in Table 16 below. “Yes” means that collection systems are in place, without taking

into account the amounts of generated plastic packaging waste that are collected within the systems.

Important to remember is that there are differences within a country depending on several things, for example the type of housing is important – kerbside collection is more common in more densely populated areas.

Table 16. Summary of the availability of collection systems for plastic packaging waste from MSW sources (ex. PET bottles)

Country	Separate collection of plastic packaging waste from MSW sources	Recycling of plastic packaging waste from MSW sources
Denmark	YES	YES
Finland	YES	NO
The Faroe Islands	NO	NO
Greenland	NO	NO
Iceland	YES	YES
Norway	YES	YES
Sweden	YES	YES
Åland	YES	NO

Table 17. Collection of plastic waste from households in the Nordic region

Country	Plastic packaging		Plastic bulky waste	Non-packaging small plastic items	PET bottles
	Apartment buildings	Single-family homes			
Denmark	Separate collection is starting in some municipalities; the majority of plastic waste still ends up in mixed waste.	Separate collection is starting in some municipalities; the majority of plastic waste still ends up in mixed waste.	Recycling centrals, no separate collection of plastic bulky waste.	Non-plastic packaging items end up in the mixed combustible fractions.	Deposit return system for PET bottles in place.
The Faroe Islands	No separate collection of plastic packaging waste from MSW sources. Plastic packaging waste ends up in mixed waste fractions.		Recycling centrals, no separate collection of plastic bulky waste.	Non-plastic packaging items end up in the mixed combustible fraction.	Deposit return system for PET bottles in place.
Finland	<i>Sorted:</i> Bring system with manned recycling stations with (plastic and) energy waste collection. Collection points for plastic bag collection. <i>Unsorted:</i> Kerbside collection of energy waste. <i>Unsorted:</i> Kerbside collection of mixed waste.	<i>Sorted:</i> Bring system with manned recycling stations with (plastic and) energy waste collection. Collection points for plastic bag collection. <i>Unsorted:</i> Kerbside collection of mixed waste.	Manned recycling stations with (plastic and) energy waste collection. No separate collection of plastic bulky waste.	Manned recycling stations with (plastic and) energy waste collection. No separate collection of small non-packaging plastic items.	Deposit return system for PET bottles in place
Greenland	No sorting or collection of plastic waste in Greenland. Plastic waste ends up in mixed waste fractions, which are subject to incineration or landfilling.				
Iceland	Bring system or kerbside collection accompanied with a central recycling central.	Bring system or kerbside collection accompanied with a central recycling central.	Recycling centrals, no separate collection of plastic bulky waste.	No separate collection	Deposit return system for PET bottles in place
Norway	Kerbside collection and bring system. 90% of the population has access to kerbside collection.	Kerbside collection and bring system. 90% of the population has access to kerbside collection.	Recycling centrals, no separate collection of plastic bulky waste.	Non-plastic packaging items end up in the mixed combustible fraction.	Deposit return system for PET bottles in place
Sweden	Bring system with around 6,000 recycling stations for packaging waste (producers' system). Around 50% of households in apartment buildings has access to kerbside collection.	Around 40 municipalities offer kerbside collection (mostly multi-compartment bins) for single-family homes, otherwise recycling stations. In total 5% of single-family homes have kerbside collection of packaging and newsprint.	Around 600 manned recycling centrals for bulky waste. At least 28 municipalities have separate containers of plastic bulky waste at recycling centrals.	Non-plastic packaging items end up in the mixed combustible fraction.	Deposit return system for PET bottles in place
Åland	Collection of rigid plastic packaging waste at around 95 unmanned recycling stations as well as kerbside collection. Flexible plastic packaging waste in mixed combustible waste fractions.	Collection of rigid plastic packaging waste at around 95 unmanned recycling stations as well as kerbside collection. Flexible plastic packaging waste in mixed combustible waste fractions.	Recycling centrals, no separate collection of plastic bulky waste.	Collected as part of the combustible waste fraction.	Deposit return system for PET bottles (expansion of the Finnish system)

Bring systems are the most common way to separately collect plastic packaging waste from MSW sources in Denmark, Iceland, Sweden and Åland, as opposed to Norway where kerbside collection is dominating. The bring systems are supplemented by different kinds of kerbside collection.

The percentage of the population having access to kerbside collection in these regions is difficult to estimate. In Iceland around 11 percent of the population lives in municipalities offering kerbside collection of plastic packaging waste, but there are no figures available on how many households that are actually using the service. In Sweden 8–9 percent of the single-family homes and around half of the apartment buildings have kerbside collection of packaging and newsprint. In Norway the figure is 70 percent. In Åland 2,000 households out of 13,000 have kerbside collection of rigid plastic packaging waste. The trend towards increased kerbside collection has been obvious in the project work.

Practical solutions to increase the collection of plastic packaging waste

Both bring systems and kerbside collection of source-sorted plastic packaging waste is common in the Nordic region. As we have seen, especially kerbside collection can take its form in different ways. It is tempting to compare collection rates or collected amounts of plastic packaging waste per citizen with practical solutions in place, and try to find a pattern of best practice, i.e. which collection system that generates a high collected rate compared to others. This is easier said than done as there are several factors influencing the collection rate such as the number of waste fractions sorted out and for how long source sorting has been implemented, as well as how much plastic packaging waste there is available for sorting. As an example, results from a Swedish study reveal that the amount of unsorted plastic packaging waste discarded in combustible fractions (corrected for moisture and dirt) is lower for single-family houses with separate collection of food waste than for households without separate food waste collection (Avfall Sverige, 2011). The results indicate that separate sorting and collection of plastic packaging waste is facilitated by separate sorting and collection of food waste.

The waste management system must be looked at from different angles, not only considering the collected amounts. Also the plastic packaging waste present in other waste fractions should be taken into account when calculating more accurate collection rates, which often requires detailed and costly analysis. The sources of information applying this approach are scarce.

Some Swedish studies have, however, looked deeper into the collection rates of packaging waste dependent on collection method. The stud-

ies show that the collection rate for packaging waste per citizen is higher with kerbside collection compared to bring systems (IVL Swedish Environmental Research Institute, (2006); Bisaillon *et al.* (2009)). Results from Dahlén *et al.* (2013), a study focusing particularly on plastic packaging, show that in average twice as much plastic packaging waste is collected in municipalities with fully developed kerbside collection of plastic packaging waste compared to the national average. Unsorted plastic packaging waste in combustible waste fractions is taken into account. In another Swedish study, from 2011 where waste samples from 31 municipalities were analysed concluded that households with kerbside collection source sort a higher percentage of their generated plastic packaging waste (29 percent) compared to households using bring systems (11 percent) (Avfall Sverige, 2011).

In the project SHARP (Sustainable Households, Attitudes, Resources and Policy) the attitudes of households and their response to policy instruments within the field of waste was investigated. Drawn conclusions were, among others that households sort out more packaging waste when they have kerbside collection in comparison to the traditional system bring system. Another conclusion was that in municipalities offering kerbside collection of plastic packaging waste, more plastic packaging waste was sorted out per citizen in comparison to other municipalities and in municipalities applying weight-based residual waste fees the collection of plastic packaging waste was also higher (Hage *et al.*, 2008).

Kerbside collection of plastic packaging waste is most common in Norway and Sweden, especially in Norway. Information on a sufficient level of detail in order to compare different kinds of kerbside collection of plastic packaging waste in Swedish and Norwegian municipalities has not been obtained within this project phase.

Bearing in mind the constraints of comparing collected amounts of plastic packaging waste, it is nevertheless interesting to compare the amount of plastic packaging waste collected per capita in different municipalities. The national average in Sweden was 4.87 kg per capita in 2012, but this figure is only valid for the municipalities cooperating with FTI.

The five Swedish municipalities collecting the highest amount per capita in 2012 were (FTI, 2013d):¹⁵

¹⁵ Based on figures from FTI. Includes collected amounts at recycling stations and through kerbside collection in collaboration with FTI.

Municipality	kg/capita	Collection system
Borgholm	17.4	Bring system
Gotland	18.3	Bring system
Munkfors	16.3	Bring system
Vilhelmina	17.8	Bring system
Åre	15.6	Bring system

The municipalities are small with a population under 20,000 inhabitants (apart from Gotland with a population over 50,000). The figures do not give a complete picture, as many municipalities having kerbside collection in multi-compartment containers are managing the kerbside collection without FTI. The reason why the numbers are high is as mentioned previously most likely manifold, but one factor known to boost the source sorting of packaging waste is the presence of weight-based waste fees. Notably, three of the five mentioned municipalities have implemented weight-based waste fees for combustible waste (Borgholm, Gotland and Vilhelmina). Another factor probably influencing the per capita numbers is the fact that Borgholm, Gotland and Åre are popular tourist destinations meaning that they will have more people generating waste than actual inhabitants counted for.

Statistics from municipalities with collection of packaging waste in multi-compartment bins for single-family homes indicate that around 12 kg/capita plastic packaging waste is collected in the municipalities (based on results from five municipalities in the south of Sweden) (Göteborgs Stad, 2012). This is remarkably higher than the national average calculated by FTI, but lower than the five municipalities listed above. The results are contradictory as kerbside collection of packaging waste in multi-compartment bins tend to be marketed as a system generating comparatively high numbers of collected packaging waste per capita. The statistics on collected amounts of plastic packaging waste per capita needs further analysis in order to draw more profound conclusions.

According to Avfall Norge (2013), the best practice of household plastic packaging waste is achieved by kerbside collection as both the amounts and quality of the collected plastic waste improve compared to bring systems. Based on these arguments, all municipalities should consider kerbside collection (Avfall Norge, 2013).

The regions collecting the most plastic packaging waste in Norway in 2012 were (Statistics Norway, 2013):

Region	kg/capita	Waste treatment systems
Telemark/Indre Aust-Agder	14.7–18.9	Collection at home in plastic bags
Hamar-regionen	13.4–15.7	Collection at home in plastic bags
Søndre-Helgeland	13.4–13.8	Collection at home in plastic bags, optical sorting
Vestfold	13.2–13.4	Collection at home in plastic bags
Nordre Gudbrandsdal	12.8–13.0	Kerbside collection
Øvre Romerrike	12.6–12.9	Collection at home in plastic bags

The indicator is kg of plastic packaging waste sorted out for material recycling per inhabitant (permanent and cottages) in the municipalities. It is shown on regional level because the figures cover several municipalities within a common collection organisation. As seen most regions have home collection systems in plastic bags which are collected every third or fourth week. Most of the regions have had this type of system for a number of years. Only one region (Nordre Gudbrandsdal) has a system where the inhabitants must bring plastic waste to a recycling station.

Quality of collected amounts of plastic packaging waste

The variation in quality of source-sorted plastic packaging waste from different collection systems are hard to analyse, and as far as known there are no study systematically comparing the quality of the collected plastic packaging waste based on the way the fractions were collected. Differences within a collection method, e.g. bring systems, have proven to vary substantially, such as from one recycling station to another.

(Dahlén *et al.*, 2013) analysed the purity of source sorted plastic packaging waste from households, as well as the difference in purity between collections systems in five Swedish municipalities. In the study it was concluded that the purity of the collected plastic packaging waste was higher (less non-plastics) from kerbside collection than from the bring system (10 percent non-plastic vs. 15 percent). The highest purity was obtained by kerbside collection from single-family homes (multi-compartment bins) (6.5 percent non-plastics). The results for kerbside collection for apartment buildings compared to recycling stations were not as clear as for kerbside collection from single-family homes, and no conclusions were possible to make.

No comprehensive studies have been carried out of the purity of collected plastic packaging waste in Iceland. The Icelandic Recycling Fund does not monitor the purity or the composition of the waste on a regular basis, but some samples have been analysed in cooperation with other actors as this type of information is useful when designing or revising parts of the system. The purity differs a lot between different categories of packaging. Wasted plastic films, for instance, tend to contain a negligible amount of impurities, while mixed plastic packaging waste from

households (kerbside collection or bring systems) may contain up to 40 percent of other materials. Impurities should preferably not exceed 10 percent of weight on average according to IRF, but in Iceland this ratio may be closer to 20 percent.

10.3.2 Costs for different kinds of collection

Costs for collection of packaging waste include investments in vehicles and containers, operation and maintenance, as well as administration and communication. On the credit side is lower costs for energy recovery and/or landfilling and possible income from the collected material. Depending on country and system in place these costs and incomes are divided onto various actors involved in the collection and recycling of plastic waste.

Costs for different kinds of collection of plastic packaging waste are a complicated area as it is difficult to relate the costs to a specific waste fraction, in this case plastic packaging waste. With separate collection of plastic packaging waste follows collection of other recyclable waste fractions. Another obstacle is that waste management fees in general are not as specified as needed in this context. An example is the municipality of Borgarbyggð in Iceland. Plastic packaging waste is collected at the curb and the municipality has a contract with a waste management company collected, which apart from collection includes purchase of two containers per household, one black container for combustible waste and one green container for recyclable waste fractions. Even though, the cost for collecting the green container was known it would not be possible to allocate the cost on the different recyclable waste fractions. To make it even more complicated The Icelandic Recycling Fund compensates the “service provider”, i.e. the contracted waste management company (see Chapter 5) making it possible for the contracted company to offer the collection to a lower cost. The costs for the municipality are invoiced the households through the waste management fees.

In Sweden, kerbside collection in multi-compartment containers is more expensive than bring systems (single-family homes) (Göteborgs stad, 2012). In Åland a household choosing a multi-compartment container (eight fractions) pay EUR 44.50 per month (two containers of 370 liters: collection of one container twice a month and of the other container once a month) and EUR 29 per month for a container with two separate compartments, one for food waste and one for combustible waste (Ålands Renhållning, 2013b).

Even though no literature sources have been found for other Nordic countries, the principle of kerbside collection is the same although prac-

tical solutions vary. Kerbside collection requires special containers or a higher number of containers, increased transport due to a higher number of collection points and might require special equipment for the collection vehicles. The difference compared to bring systems decreases when the avoided amount of combustible waste is taken into account as well as possible income from the collected material (Göteborgs Stad, 2012). Kerbside collection from apartment buildings is generally cheaper than kerbside collection from single-family homes per household as several households share the extra cost for collection and containers. The logistics is more efficient with fewer containers to collect. Once again, it is challenging to allocate an extra cost to plastic packaging waste, which needs deeper analysis and background information.

Collection of waste in rural or more sparsely populated areas is more costly than collection in urban cities. This is not surprising as the transportation costs naturally increases with longer distances, both between households and to treatment or sorting facilities. Plastic packaging waste is even more sensitive to transport distances as the fraction is voluminous and the transport work per tonne of transported material is less efficient than for many other waste fractions. Lack of recycling facilities in many areas in the Nordic region increases the transportation costs even more as both collection vehicles, loading and shipping might be necessary.

10.3.3 PET bottles

PET bottles are collected and recycled through separate deposit return systems in the Nordic region apart from Greenland. Åland and Finland have a joint deposit return system whereas there is one deposit system for each region in the rest of the Nordics.

10.3.4 Plastic bulky waste and non-packaging plastic waste

Plastic bulky waste and non-packaging small plastic waste items are not subject to any dedicated, nationwide collection and recycling systems in the Nordics, but an increased trend of collecting plastic bulky waste at municipal recycling centrals is observed in Sweden and in Denmark. The collection is based on initiatives between municipalities and waste management companies. As far as known pilot projects also take place in Norway.

Small plastic waste other than packaging is taken care of in a similar manner in the Nordic region. The fraction is collected together with other types of waste and commonly sent to energy recovery or even landfill. The only difference is the case of Finland where separately collected

plastic waste, both packaging and non-packaging small plastic waste, is collected together based on material rather than on product type.

10.4 Sorting and recycling of plastic waste

The collected amounts of plastic packaging waste in Norway and Sweden follow the same sorting and recycling route. FTI and Grønt Punkt Norge have from 2014 four contracted sorting facilities for their collected plastic packaging waste, one operator in Sweden and three in Germany. Swerec accepts around 30,000 tonnes of plastic packaging from FTI and around 10,000 tonnes from Grønt Punkt Norge per year. According to Swerec approximately 11 percent of the incoming material consists of non-plastic contaminants. Around 75 percent of the remaining 89 percent is sold for recycling (Swerec, 2013a).

The incoming material consists of both plastic packaging waste and contaminants that are incorrectly part of the plastic packaging waste stream. The plastic packaging waste consists of both polymers that are sorted out at the facility, and polymers that the facility is not adapted for. The polymers sorted out are LDPE, HDPE, PP and PET. This means that other types of polymers, for example polystyrene (PS), are currently not sorted out and not subject to recycling. The reason for not sorting out other polymers than the ones mentioned above is due to the fact that the facility is adjusted for accepting plastic packaging waste and that plastic packaging mostly consists of PE, PP and PET. The obstacle is not the sorting technology. Process losses do also occur, i.e. the efficiency of sorting out plastic waste fraction is not complete. The sorting is based on polymers rather than on product category meaning that non-packaging plastic waste of PP, PE and PET follow the plastic packaging waste stream.

The incoming material also includes dirt, and rests of food and liquid. This fact together with the factors described makes it understandable that the total amount of incoming material is not possible to recycle. Contaminants such as dirt or food waste are not a problem for the sorting process, as the polymers after the sorting is washed and cleaned (Figure 13). The contaminants can however cause unpleasant odours in the collection. Plastic waste with a potential content of hazardous substances is not detected and sorted out.

The incoming plastic packaging is to 50 percent rigid plastics and to 50 percent flexible plastics (LDPE) (Swerec, 2013a). The sorting of plastic packaging waste (Figure 13) starts with manual sorting of large fractions (exceeding five liters) and flexible plastics on a conveyor belt. The flexible

plastics are after that sorted out by a suck and blow system. The next sorting step is NIR (near infrared) technique for the rigid plastics where four optical readers sort out PP, PE and PET. The last reader sorts out the remaining PP, PE and PET in the stream. Depending on the customer the fractions can be baled and transported only, or also milled and washed. There is also a possibility to pelletize the PP fraction after milling and washing through collaboration with a Dutch company (Swerec, 2013a).

Figure 13. Schematic view of the sorting of plastic packaging waste at Swerec

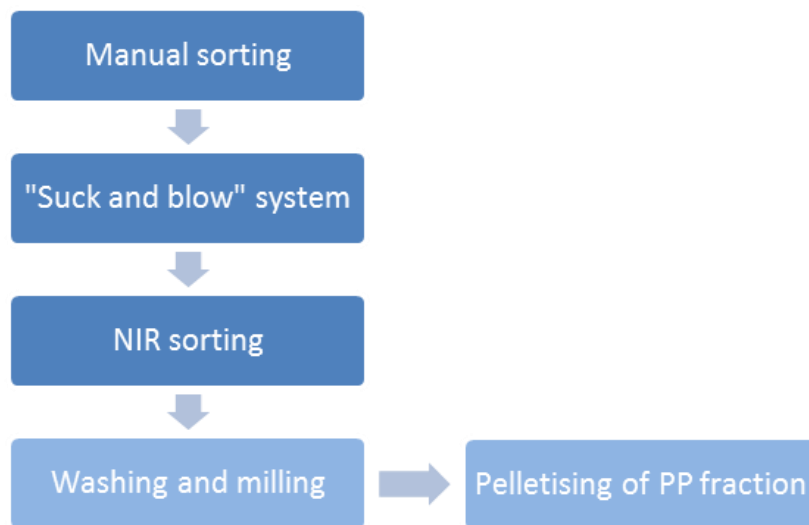


Figure 14. Baling of sorted plastic packaging waste at Swerec's facility in Lanna, Sweden



Photographer: Swerec.

The plastic packaging waste sent to the German facilities go through similar sorting technique as the plastic packaging waste sent to Swerec. Apart from flexible plastics, HDPE, PP and PET, polystyrene (PS), a mixed plastic fraction for recycling as well as a bucket and a canister fraction are sorted out. In 2012,¹⁶ around 20 percent of the incoming amount was sorted out as flexible plastics, 32 percent as rigid plastics, and 29 percent as mixed plastics for recycling and 18 percent for energy recovery (FTI, 2013b).

In the case of Iceland a majority of the collected plastic packaging waste is exported to The Netherlands where it is mixed with similar waste from other countries and thus not traceable. The separately collected rigid plastic packaging waste generated in Finland and Åland is subject to energy recovery within the industry sector.

¹⁶ At sorting facilities of Alba GmbH and Dela GmbH (contractors of 2012).

10.4.1 PET bottles

PET bottles in Denmark, Norway, Sweden, Finland and Åland are returned through reverse vending machines. An example of machines is the ones provided by TOMRA, for example used within the Finnish system. TOMRA's Sure Return™ Technology utilises cameras for identification and sorting (TOMRA, 2013).

When PET bottles are returned they are sorted and subject to bottle-to-bottle recycling. One of the most common methods used in Europe is the URCC (United Resource Recovery Corporation) UnPET process where the PET fractions are processed into PET flakes.

The process can be explained in ten steps, briefly described below (Cleanaway Svenska PET, 2013):

1. The PET fractions are milled into flakes.
2. The flakes are washed in hot water and labels, drink residues and dirt are removed by an alkaline solution.
3. Bottle caps (HDPE and PP) are separated from PET by a sink and float system based on density separation. HDPE and PP float and PET sinks. The bottle cap fraction is sent to material recycling.
4. The PET flakes are dried.
5. Small foreign particles such as film or labels are removed by an air classifier. A PET fraction for non-food applications is taken out.
6. The rest of the PET flakes go through caustic soda treatment. A special device moisturises the washed flakes with caustic soda to later achieve a "peeling effect" on the exterior of the flakes. These flakes are later used for food-grade applications.
7. The PET flakes for food applications are dried and the surfaces sterilised by vacuum treatment in a rotary kiln. A salt is formed. Odorants are removed.
8. The salt formed during the vacuum treatment is removed and the flakes sieved, rewashed, neutralised and dried.
9. The food-grade flakes are sieved and the oversized and fine particles removed. A laser sorting system separates any remaining colour PET flakes and foreign particles from the transparent fraction.
10. The PET flakes are loaded into big bags.

10.5 Market

The product manufacturers producing plastic products out of secondary plastic raw material from collected plastic packaging waste are diverse and hard to track as the trading chain include several actors. There is for example no reliable information on the end-consumer of secondary raw material from collected plastic waste in Iceland.

Swerec sells about half of the flexible plastics to the Nordic market. Almost all rigid plastics are sold to the European market, but all of it is not subject to recycling within the EU. Less than 5 percent of the rigid plastics are sold to the Nordic market. The secondary raw material from rigid plastic packaging waste is commonly recycled into plastic products and not back into plastic packaging. Flexible plastic packaging waste is often recycled back into packaging in the form of plastic bags (Swerec, 2013a).

The plastic bulky waste is taken care of by the same sorting equipment as the plastic packaging waste at Swerec. The market possibilities are therefore similar (Swerec, 2013a). PET bottles are mainly recycled into new bottles (Cleanaway Svenska PET, 2014).

10.6 Nordic cooperation

Nordic cooperation within the field of plastics collection and recycling exists, but could be further developed. It is difficult to map relations between specific companies, especially if the cooperation is on a small scale. These relations, and the outcome of the relations, could also be seen as sensitive information. Identified cooperative work within plastics recycling in the Nordics is the collaboration between Grønt Punkt Norge and FTI in Sweden. They have launched a cooperation based on a joint procurement for sorting of the plastic packaging waste generated within the respective producer responsibility scheme. The generated plastic packaging waste is sorted at the same sorting facilities in Sweden and in Germany. The collected PET bottles in the Nordics are also partly following the same track. Cleanaway Svenska PET accepts PET bottles from both Sweden and Norway.

In Finland, the producer responsibility for plastic packaging is to cover household packaging. There are indications that Finland is interested to join the Swedish-Norwegian collaboration when they are ready. If agreements are made and contracts signed it must be clarified that a certain amount of plastic packaging waste of a certain quality could be delivered to the contracted sorting facilities during several years. If this will be the

case one solution to reach larger volumes might be to also include the packaging from Åland that is now sent to Finland for incineration.

By cooperating the Nordic countries would have larger volumes which would then possibly make it more interesting to have more sorting and recycling within the Nordics.

10.7 Responsibilities for collecting and recycling plastic waste

Municipalities are responsible for collecting plastic packaging waste in the entire Nordic region (including regions where plastic packaging waste is not subject to separate collection), apart from in Sweden. In Sweden the producers are responsible for collection and recycling of plastic packaging waste discarded in the collection and recycling systems they provide (not unsorted plastic packaging waste).

The responsibility for recycling of plastic packaging waste rests on the producers in the countries with producer responsibility (in Finland only from industries).

The Nordic municipalities are responsible for plastic bulky waste from MSW sources, as well as plastic waste e.g. non-packaging small plastic items ending up in mixed MSW fractions.

10.7.1 *Producer responsibility*

Five of the studied Nordic regions have implemented producer responsibility obligations on packaging and packaging waste, including plastic packaging. Sweden, Finland, Åland and Iceland have a legal form of producer responsibility, whilst Norway has chosen a different approach in the form of a voluntary producer responsibility. Denmark has chosen not to implement producer responsibility. The packaging directive has been implemented without use of a producer responsibility scheme.

The producer responsibility is valid independently on the end-consumer of the plastic packaging in Sweden, Iceland, Norway, Åland and Sweden, but in Finland the producer responsibility is currently covering plastic packaging generated from the industry only (the producer responsibility legislation is currently being updated to cover plastic packaging from households as well).

Legislative producer responsibility in Sweden, Finland, Åland and Iceland

In Sweden, Finland and Åland there are legislative producer responsibility for importers or producers of packaging, there among for plastic packaging. The producer responsibility is however created differently in the three countries. In Sweden, producers are obliged to take producer responsibility independently of the size or turnover of the company. In Finland and Åland only producers with a turnover exceeding EUR 1 million yearly are obliged to take producer responsibility for their packaging put on the market. This means that the costs for collecting and recycling the plastic packaging waste put on the market by relatively small actors, are spread out onto larger companies.

Another difference is the financing of the collection and recycling of the plastic packaging waste. In Finland, Norway, Sweden, Åland and Iceland the collection and recycling of plastic packaging waste is mainly financed through packaging fees. There is, however, a significant difference in the size of the packaging fee. In Sweden, Plastkretsen makes a distinction between different kinds of packaging, based on assumed end-consumer, and the packaging fees vary accordingly. Norway makes a distinction between EPS plastic and other polymers, whilst the fee in Iceland is fixed per kilogram, as decided by law. In Table 18, the packaging fees in the Nordic region are listed in EUR per kg (excluded VAT), as well as what the packaging fee is covering in the collection and recycling of plastic packaging.

Åland has the highest plastic packaging fee in the Nordics, but also the most recently implemented producer responsibility (in 2009). The packaging fee in Finland covers the treatment of plastic packaging waste from the industry, not from households. Collection is not covered. When collection and recycling of plastic packaging waste from households will be implemented in the producer responsibility the fee is likely to increase.

Table 18. Plastic packaging fees in Finland, Iceland, Norway, Sweden and Åland for 2013

Country	Plastic packaging fee (EUR/tonne ex. VAT)	Covered by the fee	Producer coverage
Finland	21	Treatment of plastic packaging (currently only packaging from the industry, but soon also collection and treatment from households will be included)	Producers and importers with a turnover > EUR 1 million
Iceland	70	Collection, sorting, transportation and recycling	All producers and importers
Norway	Plastic packaging: 10 EPS: 30	Sorting and recycling, in addition transport from central collection points. Administration and information.	All producers and importers
Sweden	Household packaging: 190 Business packaging: 10 Service packaging: 180	Consumer and service packaging: 6,000 recycling stations, compensation to contractors for collecting plastic packaging at the curb, reporting of data to the Swedish EPA, costs for transporting and sorting sorted plastic packaging waste. Business packaging: information and reporting	Producers and importers with a turnover > EUR 57,000
Åland	290	The costs for collection of plastic packaging waste at the curb by ÅPAB.	Producers and importers with a turnover > EUR 1 million

Voluntary producer responsibility in Norway

The Norwegian EPR agreement for plastic packaging is a so called voluntary negotiated agreement as described in (Bauer and Fischer-Bogason, 2011). This means that membership is voluntary, and the motivation for participating is the “threat” that if the agreed goal is not obtained, the authorities can use other types of regulatory measures. Calculations done by the Confederation of Norwegian Enterprise (NHO) in 1994 showed that law enforced environmental taxes would cost the Norwegian business sector up to 10 times as much as what is paid in the current voluntary agreement system and where the economic resources are part of the total state budget and not user specifically for developing and maintaining recycling systems, information campaigns etc. (Grønt Punkt Norge 2013c).

Due to the fact that the EPR system is voluntary, the system is dependent on minimising the amount of free riders. The collection system does not separate between plastic packaging from importers and producers with or without membership. Hence costs for collection and recycling of plastic packaging from free riders are covered by members.

It is a challenge that possessors of large amounts of plastic packaging waste wish to bypass the existing collection systems and send their amounts directly to recyclers. This is a challenge for the rural areas, because the most attractive plastic packaging amounts are taken (cherry-

picked) and small amounts distributed over large distances are left for the common system to collect, making the system more costly.

The producers and importers of plastic packaging or products with plastic packaging are expected to participate, and there are some self-initiated incentives to get rid of free-riders among actors. Experience shows that the amount of free riders is relatively low.

10.7.2 Other instruments in place

Apart from producer responsibility obligations and targets related to recycling of plastics analysed in the previous sections there are other incentives in place in the Nordic region. Legislative instrument in place varies from having no target at all related to recycling, to having producer responsibility, landfill bans and targets focusing on plastic packaging waste recycling.

In Sweden and Norway there is a landfill ban on organic waste (with a TOC higher than 10 percent).¹⁷ The ban was implemented in 2005 in Sweden and in 2009 in Norway. In Norway this ban covers only easily biodegradable, organic waste. Plastic is not considered easily biodegradable and can be landfilled. In Sweden, there is also a ban on landfilling sorted combustible waste since 2002. In Finland a landfill ban on organic waste will be implemented from 2016. In Denmark it is forbidden to landfill waste suitable for incineration since 1997.

Municipalities have the possibility to construct the waste management fees in order to direct waste flows and increase recycling. Waste fee construction is a broad area not possible to dig deeper into within this part of the project, but an example is to use weight-based fees for mixed combustible waste fraction to create an incentive to sort out packaging and newsprint. Other possible waste fee constructions might help recycling of packaging waste, there among plastic packaging waste, by making it less economically attractive to throw plastic packaging waste in the mixed household waste fraction.

Another area that might favour the change of consumer behaviour is communication.

¹⁷ Total Organic Carbon.

10.8 Statistics and calculation of recycling rates to follow-up national objectives

The national recycling rates for plastic packaging are calculated differently in the Nordic region. The basis for all calculations is the separately collected amount of plastic packaging waste divided by the amount of plastic packaging put on the market by the producers registered to producer compliance schemes. Grønt Punkt Norge estimates the total amount of plastic packaging put on the Norwegian market i.e. both for their registered members and estimations for producers not taking their producer responsibility, so-called free-riders, and for private import. In Sweden no such estimations are made.

In Finland, Denmark and Åland PET bottles are included in the separately collected amounts whereas they are not in the Swedish, Norwegian and Icelandic figures. For Finland and Åland this makes an important difference as hardly any plastic packaging from households apart from PET bottles is subject to recycling. Another difference is the inclusion or exclusion of plastic waste from the agricultural sector in the statistics.

To follow-up national objectives on energy recovery FTI in Sweden reports source-sorted packaging that is sent directly to energy recovery. The plastic packaging waste present in mixed combustible waste fractions are not included in the statistics. Grønt Punkt Norge makes the opposite. They include the plastic packaging waste present in mixed combustible waste fractions in the energy recovery rate, resulting in a very high energy recovery rate compared to Sweden.

Sweden is the only country taking moisture, contaminants and plastic waste other than packaging into account in order to get closer to how much that is actually recycled in reality. The correction factor, based on drilling tests, is applied on the total collected amounts within FTI. FTI's figures are based on reported collected amounts from the contracted transporters and reported amounts put on the market from the registered producers. For the business flow through private actors, FTI collects data from trade associations. Moisture is according to FTI probably taken into consideration for the business packaging, but the business packaging flow is very clean in comparison to the household packaging flow. Consumer packaging ending up in the business flow is negligible in comparison to the rest of the business flow, making it unnecessary to correct for moisture, contaminants and non-packaging (FTI, 2013a).

All these above mentioned factors make it doubtful to compare the different national recycling rates, and a comparison has to be made with pre-

caution. The way of calculating national recycling targets are summarised in Figure 15.

Figure 15. Calculation of recycling rates in the Nordic countries

$\frac{\text{Separately collected amounts sent to recycling}}{\text{Amount of collected packaging waste}}$ <ul style="list-style-type: none"> • PET bottles included 	Denmark 
$\frac{\text{Separately collected amounts sent to recycling}}{\text{Amount of plastic packaging put on the market by registered producers}}$ <ul style="list-style-type: none"> • PET bottles included 	Finland 
$\frac{\text{Separately collected amounts sent to recycling}}{\text{Amount of plastic packaging put on the market by registered producers}}$ <ul style="list-style-type: none"> • PET bottles excluded 	Iceland 
$\frac{\text{Separately collected amounts sent to recycling}}{\text{Total amount of plastic packaging put on the market}}$ <ul style="list-style-type: none"> • PET bottles excluded 	Norway 
$\frac{\text{Separately collected amounts sent to recycling}}{\text{Amount of plastic packaging put on the market by registered producers}}$ <ul style="list-style-type: none"> • PET bottles excluded • Moisture, contaminants and non-packaging are accounted for 	Sweden 
$\frac{\text{Amount of collected plastic packaging waste sent to recycling}}{\text{Amount of collected plastic packaging waste}}$ <ul style="list-style-type: none"> • PET bottles included 	Åland 

10.8.1 Best practice

It is challenging to define best practice in collection and recycling of plastic packaging waste as comparisons are risky to make in the Nordic region as the statistics and the calculation of recycling rates are varying. Best practice in terms of recycling rates can be looked at from different angles. Following the reporting to Eurostat it is Norway that achieves the highest rate (37.9 percent in 2011) followed by Sweden.

When looking at national recycling targets it is in fact Norway again that obtains the highest recycling rate, 43 percent in 2012 within the EPR agreement of Grønt Punkt Norge. The figure for FTI in Sweden in 2012 was almost 27 percent (FTI, 2013c).¹⁸ As previously mentioned, FTI makes a correction for moisture, non-packaging and contaminants as opposed to Grønt Punkt Norge resulting to a somewhere higher recycling rate for the system of FTI if this was not considered.

¹⁸ The national recycling rate is not yet available. The figure represents the recycling rate for the producers connected to the system of FTI.

Norway also demonstrates the highest recycling rate for PET bottles, 97 percent in 2012. Recycling rates for PET bottles are easier to compare between countries as they are all part of a deposit return system that only accepts PET bottles with registered bar codes.

Nordic countries that have implemented producer responsibility of plastic packaging seem to obtain higher recycling rates, shown both the data reported to Eurostat and the national statistics.

10.9 Potential for increased recycling

The potential for increased recycling both deals with collection of plastic waste, i.e. to get hold of the material, and of possible technical improvements in the sorting and recycling processes. Both issues are taken into consideration in the chapter, and it starts off by looking at the amount of unsorted plastic waste in mixed waste fractions.

The quantified theoretical potentials in the form of plastic waste in mixed MSW fractions are summarised in Table 19. The total sum is estimate to be around 690,000 tonnes, although the uncertainty should be noted. The total amount is divided into plastic packaging waste and non-packaging small plastic waste. The share between packaging waste and non-packaging waste for Norway and Sweden is the same, non-packaging plastic waste counts to around 20 percent of the total amount of packaging and non-packaging plastic waste in mixed MSW fractions.

For Finland the figure is a combination of both packaging and non-packaging, but by applying the same share of 20 percent of non-packaging plastic waste

The figures are theoretical in the way that the total amount of plastic waste in mixed MSW fractions is presented, the realistic potential is not considered, i.e. the amount of generated plastic waste available for recycling, which is likely to be significantly lower. The presence of potential hazardous substances undesired in the recycling system is one factor that decreases the potential for recycling.

Table 19. Summary of the quantified potentials for plastic packaging waste present in mixed MSW waste as well as non-packaging small plastic items present in mixed MSW waste

Country	Plastic packaging waste	Non-packaging small plastic waste	Plastic waste (both packaging and non-packaging small plastic items)
Denmark	52,000	63,000	115,000
The Faroe Islands	Unknown	Unknown	Unknown
Finland ¹⁹	216,000	54,000	270,000
Greenland	Unknown	Unknown	1,200
Iceland	7,500	Unknown	7,500
Norway	79,000	21,000	100,000
Sweden	151,000	42,000	193,000
Åland	Unknown	Unknown	Unknown

An indicative analysis of the above mentioned figures makes it possible to observe that a main obstacle for recycling of plastic packaging waste seems to be based on getting hold of the plastic packaging, i.e. getting the plastic packaging put on the market back in the system and avoids plastic packaging waste in various mixed waste fractions. This is a symptom likely caused by insufficient motivation and availability of collection systems.

The estimations of the theoretical potentials are further explained and described in the following section. The potentials for plastic packaging and non-packaging plastics are separately described for the respective country.

10.9.1 Unsorted plastic packaging waste in mixed MSW fractions

Data on the amounts of plastic packaging waste and non-packaging plastic waste present in mixed waste fractions for the Faroe Islands was not found.

Denmark

Based on measurements of the content of fossil carbon from flue gas emissions, it has been estimated that approximately 10–12 percent of the waste incinerated in Copenhagen is plastic, which indicates that a considerable potential for increasing recycling exists, though the sources, plastic types, and products contributing with the plastic to the incinerated waste are unidentified (Larsen & Skovgaard 2012; Astrup 2012).

Investigations of the composition of household waste indicate that household waste from households in single detached dwellings in Den-

¹⁹ The amount of plastic packaging waste and non-plastic packaging waste are not known, but non-packaging plastic waste is assumed to represent 20 percent of the total amount, as seen in Norway and Sweden.

mark in average produces 468 gram of plastic packaging and 571 gram of other plastic waste per household per week (Miljøstyrelsen 2012), confirming 12 percent of the waste being plastic. The different types of plastic packaging waste found in residual waste from single-family households in Denmark is presented in Table 20. The dominating types of plastic packaging is cans and jars for chemical-technical products, and tins for food, plastic trays for meat and plastic boxes (for fruit, pastries etc.) (Miljøstyrelsen, 2012).

Table 20. Types of plastic packaging in residual waste from single-family houses nationwide evaluated to be recyclable

Fraction – plastic packaging	Distribution %	Volume (tonnes)
Plastic bottles for beverages	3.4	
Canisters to vinegar, washer fluid and the like.	0.4	
Cans and jars for chemical-technical products	14.4	
Plastic trays for other foods	4.9	
Flower pots, plastic	5.6	
Plastic lid	2.1	
Heavy film for wrapping	4.3	
Plastic bottles for food	8.3	
Cans and tins for food	12.0	
Cans and jars of chemicals	1.0	
Plastic trays for meat	11.8	
Plastic boxes (fruit, pastries, etc.).	11.3	
Other hard packaging	3.7	
Blisters	1.5	
Cups of butter and margarine	3.3	
Laying seals	11.2	
Plastic laminates	1.0	
Total	100.0	36,912

(Miljøstyrelsen 2012).

Table 21. Other plastic waste in residual waste

Fraction – other plastics	Distribution %	Volume (tonnes)
Shopping bags	16.6	
Garbage bags	10.7	
Films and other bags	62.9	
Cover sheets	2.8	
Hangers	0.1	
Toys	0.5	
Kitchenware Plastic	1.1	
Articles for everyday use of plastic	1.1	
FlexiblePVC	0.4	
Rigid PVC	1.2	
Other hard plastic	0.5	
Other plastics	2.2	
Total	100.0	45,073

(Miljøstyrelsen 2012).

The number of single-family house households is approximately 1.5 million, and the number of households in apartment buildings approximately 1 million. The waste generation from households in apartment buildings is generally lower compared to single-family house households, and therefore it is estimated that the volume of plastic waste from packaging and other types of plastic is approximately 40 percent higher than the figures for the total volume in (Miljøstyrelsen 2012).

Table 21, i.e. 52,000 tonnes of plastic packaging waste evaluated to be recyclable and 63,000 tonnes of other plastic waste.

Finland

The generation of MSW in Finland was approximately 2.7 Mt in 2012 of which 1.2 Mt was collected as source-separated and the remaining as mixed waste. Household plastic waste (excl. PET bottles) is mainly collected as mixed waste. The mixed MSW contains in average 18 percent of plastics (HSY, 2012). A rough estimation on the total amount of plastic waste in the generated mixed MSW therefore counts to 270,000 tonnes. This number refers both to plastic packaging waste and non-packaging small plastic waste. No figures on the percentage of plastic packaging waste in the mixed waste fractions were obtained.

Suomen Uusiomuovi Oy (2013) estimates that it would be possible to collect approximately 20,000 tonnes of plastic packaging waste from households for recycling in Finland.

Greenland

Eisted and Christensen (2011b) estimate the total amount of waste generation in Greenland to 50,000 tonnes per year. This is an estimation of the total generation of solid waste (all categories) as there are no statistics on generated amounts of household waste. However, the composition of the household waste was for the first time analysed in 2009. A total amount of 2,067 kg of household waste in 285 waste bags, representing 15 percent of the weekly collected waste in the town of Sisimiut was analysed. The results of the manual sorting showed that the majority of the weight was represented by biowaste (43 percent) and to combustibles (30 percent). The household waste composed of paper to 8 percent and of glass to 7 percent. The remaining 10 percent was steel, aluminum, plastics, non-combustibles and hazardous waste. The plastics sorted out were items with an identity mark showing the type of plastics, other plastics was sorted into combustibles. The results of the analyses are summarised in Table 22. Based on the composition the amount of plastic waste in the total amount of generated waste in Greenland is

estimated to 1,200 tonnes per year. The estimation is rough as it is assumed that the waste generated in Greenland has the same composition.

Table 22. Composition of household waste in Greenland

Fraction	Composition (weight %)
Biowaste	42.8
Combustibles	30.4
Non-combustibles	1.8
Glass	7.1
Paper and cardboard	11.4
Plastics	2.4
Steel	1.5
Aluminum	0.5
Wood	1.0
Hazardous waste	1.2

(Eisted och Christensen, 2011b).

Iceland

In Iceland, the total amount of generated mixed household and industrial waste in 2011 was 127,000 tonnes according to data from the Icelandic EPA (Umhverfisstofnun) (Ministry for the Environment and Natural Resources, 2013). Thereof some 52,000 tons (51,000–53,000) were of household origin. Sorpa, the municipal waste company owned and operated by the municipalities in the capital area, has for several years carried out an annual study of the composition of unsorted household waste. According to a sample study made in November 2012 some 14 percent of unsorted household waste is made up of plastic packaging waste. If the same percentage is applied to all household waste in Iceland, this equals a total of 7,300 tonnes per year. This estimate, however, has to be seen as indicative as several factors may increase the level of uncertainty. These factors include a small sample size, possible seasonal fluctuations, and different waste management practices in different parts of Iceland etc.

Norway

Grønt Punkt Norge reported in 2012 that around 52 percent of the plastic packaging waste was recovered as energy. This percentage is based on compilation of results from analyses of the content of plastic packaging waste in residual waste fractions (both from municipalities and industry). 52 percent equals an amount of around 79,000 tonnes of plastic packaging waste currently subject to energy recovery.

Sweden

According to Jensen *et al.* (2011) the plastic packaging waste in mixed household waste (often called residual waste in Sweden) together with plastic packaging in the food waste fraction (from households) is estimated to 152,500 tonnes.²⁰ The total amount of source-sorted plastic packaging waste counted to 45,500 tonnes (both from households and from businesses). According to Dahlén *et al.* (2013) 60–90 percent of the plastic packaging put on the market in Sweden is not subject to recycling.

Åland

Apart from the potential for rigid plastic packaging waste there is a potential in flexible plastic packaging waste that today ends up in combustible waste fractions. The possibility to have another compartment for flexible plastic waste in the waste bins is one option. Another option is to sort out both rigid and flexible plastic waste together (Ålands Renhållning, 2013). This is confirmed in the waste management plan of Åland where it is stated that the general public sometimes has difficulties with dividing flexible plastics from rigid plastics in a sufficient way. In the long-term it would benefit the recycling of plastics to mix the two fractions together (Ålands landskapsregering, 2010).

In Åland, 3 percent of the combustible waste fraction in containers with eight compartments consists of rigid plastic packaging waste, and 11 percent in containers with one-or two compartments (Mise, 2013). The generated amount of combustible waste from households with eight compartments and households with one or two compartments is not known, but the total amount of generated household waste in Åland was 10,700 tonnes in 2012 (ÅSUB, 2013). The amount of generated combustible household waste is unknown, but potential for increased recycling of rigid plastic packaging waste in Åland from combustible household waste is likely to have little effect on the total potential for plastic packaging waste in mixed MSW fractions in the Nordics.

10.9.2 Non-packaging small plastic waste

In Iceland, data on plastic waste other than packaging waste is not being collected for the time being. According to Sorpa's sample study in November 2012 plastic waste other than packaging makes up some

²⁰ Corrected for non-plastics by factor 0.56. (Jensen *et al.*, (2011).

3.5 percent of unsorted household waste. The total annual amount of unsorted waste in Iceland is close to 127,000 tons, including waste from companies. There is no information available on the amount of plastic waste from companies, but assuming this is close to 3.5 percent as well, bearing in mind that the IRF-related incentive is missing in this case, some 4,400 tons of small items of plastic waste other than packaging may be generated and sent to landfills per year.

In Norway, non-packaging small plastic waste from MSW sources (toys etc.) are estimated to 21,000 tonnes per year, based on a content of non-packaging small plastic waste of 5 percent (Mepex, 2013).

In Sweden, around two percent of the residual waste fraction consists of non-packaging plastics. This counts to around 42,000 tonnes (Jensen *et al.*, 2011).

10.9.3 PET bottles

The recycling targets for PET bottles are significantly higher than for other plastic packaging, and so are the achieved recycling rates. This is not surprising as the deposit return systems provide economic incentives to consumers to bring back the empty PET bottles as well as the fact that the deposit return schemes have existed for a long time. Compared to plastic packaging waste the PET bottle fraction is very pure as the deposit return systems only accept registered bottles. Problems with contaminants are therefore much less obvious than for other plastic packaging waste fractions. PET bottles are more often closed loop recycling compared to other plastic packaging, and the majority of the PET fractions are used in new bottle manufacturing. However, potentials for increased recycling exist. Returpack will for example will focus there marketing even more on trying to change consumer behaviour and attitudes towards recycling of PET bottles and will focus on the targets groups “urban cities” and “young adults” (Returpack, 2013a).

10.9.4 Plastic bulky waste

Sweden and Denmark are the only countries where plastic bulky waste is collected separately at some of the manned recycling centrals. Swerec receives around 5,000 tonnes of plastic from bulky waste from 15 municipalities. Some initiatives have also started up in Norway. Even though the two largest municipalities Gothenburg and Stockholm are represented there, the recycling of plastic bulky waste represents a significant potential as Sweden has 290 municipalities. To sort out the plas-

tic waste at recycling centrals is a low-hanging fruit and it is surprising that it has not been done until now (Swerec, 2013a).

In Sweden, the potential amount of plastics in bulky waste was estimated to 36,000 tonnes based on the share of plastic waste in the combustible bulky waste fraction (Jensen *et al.* 2012). The estimation should be seen as insecure. The accepted amounts of plastic bulky waste accepted by Swerec of 5,000 tonnes from 15 municipalities (Swerec, 2013a) indicate that the figure is much higher in reality.

In Iceland there is also a big potential for increased recycling of plastic bulky waste, where the recycling rate can be expected to be close to zero. A first step to harness this potential seems to be to sort out this waste at recycling centrals. Certain plastic waste categories may be more feasible than others in this respect, such as garden furniture etc., i.e. categories of homogenous waste suitable for recycling. Financial input, such as from IRF, would not be needed in these cases, due to a relatively high market value. For most other categories some financial input, such as from IRF, would most likely be needed as the extra costs related to the collection, sorting and transporting of this waste would otherwise make it too tempting to send this waste to landfill at much lower costs. Furthermore, many plastic products are made of a mixture of materials, plastic and non-plastic, which may hamper recycling.

10.9.5 Identified potentials of a more general kind

Independently on the magnitude, identified potentials of a more general kind are related to the fact that:

- Plastic waste is still landfilled in the Nordics, e.g. in Iceland 6,570 tonnes of plastic packaging waste seem to end up in landfills according to IRF's statistics. In Greenland, the majority of generated mixed MSW is subject to landfilling, as well as MSW generated in Finland.
- Source-sorted plastic packaging waste in Åland and Finland is not subject to recycling, but to energy recovery.
- Recycling of non-packaging small plastic items is negligible in the Nordics. There are no designated collection and recycling systems for this fraction and the fraction is not included in the plastic packaging waste flows, apart from in Finland, although the fraction is not subject to recycling. However, some non-packaging plastic items end up in the plastic packaging waste flow or as part of plastic bulky waste at the recycling centrals offering this service.

- The absolute majority of plastic waste other than packaging is furthermore not covered by any specific legislation or producer responsibility and there are no objectives focusing on this fraction in particular.
- Statistics on plastic bulky waste in the Nordic region is scarce why the theoretical potential is not possible to estimate. Presumably, the potential is minor compared to the potential in plastic packaging, but represents an area where no particular efforts have yet been made.
- Technique-wise, there are possibilities for improvements in sorting facilities. As mentioned in chapter 11.4 four different polymers are currently sorted out at Swerec (LDPE, HDPE, PP and PET), but a higher number of readers, enabling sorting of a higher number of polymers would be possible, such as polystyrene. This fraction is currently sorted out at the German sorting facilities. Black plastics are not possible to sort out with NIR technology and small pieces of plastics (smaller than around 3 centimeters) are currently not sorted out in the sorting process at Swerec (Swerec, 2013a).

10.9.6 Hazardous substances

Plastic is a diversified material and plastic packaging and plastic products not only contain different types of plastics, but also different kinds of additives. Some of them being harmless to the environment and/or health but others can be hazardous and therefore not desirable to recycle due to the risk of spreading the hazardous substances to the new material or to the environment. This issue affects the potential for general plastics recycling and with higher demands on increased recycling this need to be dealt with. It is also important to remember that the waste streams of today reflects the society of yesterday, so to erase the problem it is of high importance to limit the amounts of hazardous substances used in today's product. The problem will then diminish in the future.

Examples of hazardous substances are: lead/cadmium (historically used as red or yellow pigment), isocyanates and brominated flame retardants (most common in WEEE). A detailed description of different additives in plastics is found in Hansen *et al.* 2013.

The obstacles with recycling plastics might be divided as follows (Naturvårdsverket, 2014):

- Hazardous substances being recirculated in to the new material either as degradation products from already added substances in the recycled plastic or because of hazardous substances existing in plastics that are wrongly sorted.
- Need for more additives in the recycled plastics to compensate for weaknesses in the recycled material.
- Degradation products due to age of the plastic.

The major problem is the difficulty to know in what pieces of plastics hazardous substances are present, and also the type of hazardous substances it might be (Bibi *et al.* 2012). In plastic packaging in general (both food packaging and other packaging) there is little hazardous substances used, however also non-hazardous substances added might be a problem since they will be enriched in the recycled material and that might affect the quality. In other types of plastic products hazardous substances are more common and harder to keep track of.

The plastic waste streams dealt with in the project might be looked upon as in Table 23:

Table 23. Overview of hazardous content in the plastic waste streams covered by the project

Plastic waste stream	Hazardous content
Plastic packaging	Low or none
Plastic bulky waste	Depending of the composition (Bibi <i>et al.</i> 2012) Construction & demolition waste might contain flame retardants Old PVC might contain phthalates and also cadmium In general PET and HDPE are of little concern.
Non-packaging small plastic waste	Vary depending on the product. Much debate on content but not so much research done on the effect for recycling.

In WEEE and ELV hazardous substances might be a problem, but these waste streams are not dealt with within this project.

Separate collection might help to keep flows that are known to be free from hazardous substances separated from flows that might contain hazardous substances. However it is hard for the consumer to keep track of products that might contain hazardous substances. Sorting facilities for plastic packaging (e.g. Swerec) are not always able to detect hazardous substances.

In MEPEX (2011) three suggestions are lifted:

- Plastics containing hazardous substances should not be recycled one reason being that this might hinder the substitution of hazardous substances.
- Plastics containing hazardous substances should not be recycled in a way that the hazardous substance could transfer to other material.
- Plastics containing hazardous substances might be recycled to the same product with the same hazardous substance present.

The safest way of these alternatives is of course not to allow any recycling of plastics containing hazardous substances. This will not only prevent them from being spread in society but also as stated under point 2 above, give incentives to substitute the hazardous substances. As described above the problem is to find out what products that are containing these hazardous substances.

To be able to sort out plastics with hazardous substances sorting techniques is needed. In Bibi *et al.* (2012) the possibilities of NIR (Near infrared) – or XRF (X-ray fluorescence)-scanning and sink-float techniques are used among material recyclers to detect plastics with hazardous content. It is also stressed that the people working at the facilities in general have vast knowledge on what plastic-parts that should be sorted out.

10.10 Towards 50 percent recycling of plastic packaging?

The European countries obtaining the highest recycling rates according to Eurostat statistics report a recycling rate of around 50 percent, there among the Netherlands, Germany, Czech Republic, Slovakia and Ireland (Eurostat, 2013b). Would this be possible in the Nordic countries in 2020? Looking at the estimated theoretical potentials for the Nordic countries it is possible to make a very rough and indicative example. By assuming that 25 percent of the plastic packaging waste currently ending up in mixed MSW fractions instead would be possible to sort out for recycling it would be possible to reach a recycling rate of 50 percent. The estimation is based on the total amount of plastic packaging waste estimated to end up in mixed residual waste and the amount known to be put on the Nordic market. However, this estimation should be regarded as an example only with emphasis on the difficulties with comparing national statistics and dividing statistics on MSW flows and businesses

flows (e.g. plastic packaging put on the market). One uncertainty is for example whether contaminants (e.g. moisture and food waste) are accounted for when assessing the percentage of plastic packaging waste in mixed MSW waste fractions. Secondly, the amount of plastic packaging put on the Nordic market is likely to be underestimated as all countries do not include private import and amounts put on the market by producers not taking their producer responsibility.

Evaluation of the possibility and probability to reach a 50 percent recycling rate of plastic packaging from MSW sources in 2020 needs deeper and more thorough analysis.

10.10.1 Challenges for increased recycling

Basic practicalities

Plastic waste is voluminous and has a relatively low density compared to other types of waste. This results in high transportation costs, and could also have an influence of people's tendency to source sort the plastic waste as it is difficult to compress the fraction at home.

Communication and trust

There is still a misbelief about collection and recycling of plastics. The systems struggle with low trustworthiness and misconceptions, which could be one of several factors contributing to low collection and recycling rates, and an obstacle for improved consumer behavior. The efforts to show good examples of end-uses of secondary plastic raw material from a resource use perspective need to improve (FTI, 2013a).

Sorting capacity

Plastic packaging waste fractions separately collected from MSW sources in the Nordic region need sorting and processing due to contaminants and mixed polymer types.

The current sorting capacity is about to reach its limit as there is at present only one sorting facility in the Nordics accepting high volumes of plastic packaging waste. The aim is to increase the collection and recycling of plastic waste in the Nordics, but with a limited sorting capacity available the equation does not solve. Plastic packaging waste is to a certain extent already subject to sorting outside of the Nordic region. The authors of the report puts no opinion into this, but think it is important to highlight that planning for possible solutions are needed if the collection and recycling rates are aimed to increase.

Costs

An important bottleneck of increased plastics recycling is not the lack of existing technology, but the commonly related high costs compared to other waste management alternatives. Stakeholders are accustomed to profitable recycling of high-value materials (e.g. paper and metals) and respond negatively to the high cost of plastics recycling. Although the producers are the ones to pay for the recycling of packaging waste; the consumers will be the ones to pay in the end. However, producers will aim at keeping prices as low as possible and therefore are quite reluctant to increased recycling targets for plastic packaging. The Nordic countries have a scattered population and long distances to transport plastic waste although it is compressed to minimize volumes. This leads to a substantial cost related to transportation. Examples of costly logistics are transportation of plastic waste from Iceland, Åland, Greenland and the Faroe Islands to the more populated Nordic regions or to other countries in Europe. In Åland plastic packaging waste is not recycled due to unreasonably higher costs compared to using it as fuel in Finland.

It is also important to bear in mind that due to lack of economies of scale recycling of plastic is not likely to be feasible everywhere in the Nordic region to any significant extent and the need for efficient logistics to keep down costs is essential.

Price of virgin materials is a fundamental factor. As long as the price for virgin material is relatively low, secondary raw materials will be in a disadvantageous position as the benefits will be perceived as marginal or non-existing.

According to IRF in the Faroe Islands, it has to be said that increased recycling will only happen if and when the needed incentives are in place, in particular financially. Both IRF's and KOB's incinerators have been expanded, but IRF is unable to sell all the produced heat and needs to buy electricity for cooling of some of the produced heat. Both incinerators will expectedly be outdated within the next decade or so, and increasing volumes of waste will make it interesting to search for financially viable alternatives to build completely new incinerators.

Quality of the collected material

It is important not just to focus on collected quantities, but also to think about quality aspects. The quality of the waste dictates the possible recycling possibilities. The impurities and heterogeneousness of household plastic waste impacts the characteristics of the material, thus, preventing recycling. The quality of the secondary plastic raw material is not as high as for virgin materials. There is a need of companies able to upgrade the plastic waste to qualities more comparable to virgin raw materials.

Plastic bulky waste is a very heterogeneous fraction and commonly contains other kinds of waste and non-recyclables why the fraction not always is perceived as attractive to recycle. There are few innovative actors on the market trying to collect this fraction and it is a question of logistics, capacity and economics.

Small items of plastic waste other than packaging are even more heterogeneous than plastic packaging waste and could contain a higher variety of additives that might not go well with recycling.

Product design

There are many different polymers present in the plastic packaging waste flows. A more uniform packaging design would facilitate the sorting and lower the sorting costs. For instance, black plastic waste is not sorted out by the NIR technology, which is a weakness as well as the lack of communicating this fact to the producers of black plastic packaging to the general public. Another aspect linked to product design is the use of several polymers in one plastic product. This hampers the recycling potential. Polymers in plastic packaging are dominated by three different polymers, but polymers in plastic products are more diverse. Decreasing the variety of polymers present in the plastic waste flows would facilitate for obtaining higher recycling rates, coming back to the importance of product design and collaboration between industry, consumers, collectors and recyclers.

Market demand

Demand for plastic waste from recyclers and in turn from the product manufacturers is a criterion for increased recycling of plastic waste. European recyclers have over the last years maximised their capacity due to increasing amounts of source separated plastics in Europe. When possessing relatively small amounts, it may be a challenge to establish appropriate agreements with recyclers. Nevertheless over the last years the amount of European plastics sent to Asia for recycling has decreased and it is a trend that most of the share of the plastic waste resources is kept in Europe. On the other hand there are indications that the market is saturated and that the demand is lacking.

Recycling objectives and other incentives

Existing recycling targets might be perceived as too low not creating enough incentives to increased collection and recycling of plastic packaging waste. 100 percent recycling may not be a viable target, but there are European countries reaching significantly higher recycling targets than the Nordics. Some regions in the Nordics have no legislation or formal incentive that requires recycling at all.

11. Success criteria

The list of success criteria for obtaining increased collection and recycling of plastic waste in the Nordics has been created based upon the facts and information gathered when comparing the situation for plastic waste in the Nordic countries, as well as the outcome from workshop discussions. The list presents the project view on important issues to boost the recycling of plastics in the Nordics.

Taking the entire value chain into account

Boosting recycling of plastics is about improving the collection of plastic waste taking into account both amounts and quality, collection and logistics such as size of bins, collection frequency, way of transportation, improved sorting and recycling technology aiming for less reject, and about incentives and regulatory issues. There are more aspects to be added, but the key point is to regard collection and recycling of plastic waste as a chain of activities and not as separate events.

A higher market demand

A demand for recycled plastics is vital in order to motivate collection and sorting of plastic waste. During Part 1 of the project there have been indications that the Nordic and European market is saturated and fluctuating, and that boosting the market for recycled plastics is key for obtaining higher recycling rates. This is also emphasised in *Analysis of the public consultation of the green paper "European Strategy on Plastic waste in the Environment"* prepared by Bio Intelligence Service. The market for recycled plastics needs financial encouragement e.g. reduction of value added tax for products containing recycled plastics (Bio Intelligence Service, 2013). Possible measures to increase the market demand for plastics could be certifications, product declarations of secondary plastic raw material and economic incentives for use of secondary plastic raw material in new products.

Practical solutions motivating sorting of plastics at the source

A notable potential for higher recycling rates lies within getting hold of the plastic waste fractions e.g. the availability for consumers to sort out plastic waste for recycling. A significant share of the plastics put on the Nordic market ends up in various mixed waste fractions subject to ener-

gy recovery or even landfilling. Practical solutions that motivate the public to sort out plastic packaging waste to a higher extent is therefore important as well as to introduce collection schemes and systems making this possible. Kerbside collection of plastic packaging waste has proven to increase the collected amounts of plastic packaging waste compared to other collection systems.

Communication

The benefits of plastics recycling, as well as demonstrating good examples of the use of secondary raw materials in new products are important to gain higher public acceptability and to change consumer behaviour in favour of increased collection of plastic waste.

Increased sorting and treatment capacity in the Nordic region

With the aim to collect and recycle more plastic waste in the Nordic region there is also need for more treatment capacity and thus for investments. Focusing too much on collection may lead to the risk of not having enough capacity to take care of the collected amounts, which could in turn prevent increased recycling.

Improved product design through dialogue between the actors in the value chain

Obtaining high-quality secondary plastic raw materials able to compete with virgin materials requires collaboration in the whole value chain, from the producers of plastic products and packaging to waste collectors and processors to recyclers. The quality is determined by the purity of the collected plastic waste, but also of the design of the products before wasted e.g. the material composition, the polymers used and how this design complies with the sorting technology for the plastic waste.

12. Alternative possible future solutions

The possible future solutions presented here are suggested solutions studied to a varying extent in the Nordic region. The possible solutions explained in the chapter include collection of plastic packaging in mixed waste fractions or in mixed packaging waste fractions followed by central sorting, collection in material streams, the use of weight-based waste fees, and possibilities for increased Nordic cooperation.

12.1.1 Collection of packaging waste in mixed waste fractions followed by central sorting

Source separation by consumers has been the traditional way of placing the different materials into the different waste treatment streams. In parallel new technologies for automatic sorting, or central sorting have been developed. These sorting technologies may replace or serve as a substitute to source separation by consumers. There are different kinds of central sorting, so called Mechanical biological treatment (MBT-plants) where mixed municipal waste (including bio-waste) is sorted and more advanced ones where only dry packaging is collected in a mixed fraction and sorted. The later has more potential in generating clean fractions. When it comes to (MBT) cleaning of the plastic is necessary before recycling, and there are uncertainties related to the purity and quality of the sorted plastic. Grønt Punkt Norge (2013) have stated that the purity of central sorted plastics when the organic waste fractions are not separated in the household is potentially non acceptable for the current recycling system.

Central sorting may be a driver and a challenge for the existing plastic collection and recycling system. Central sorting has been evaluated as an option instead of source separation in the households by several Norwegian municipalities. However, the quality, purity and composition of such central separated plastics are not known, since there are currently no Norwegian finalised central sorting facilities. According to Avfall Norge (2013) the central sorting projects are defined as challenging and the major question is whether or not the potentially increased amounts of sorted

plastics occurs at the expense of the quality and purity and the amounts that have sufficient quality to subsidize virgin plastics.

There is also a debate that the pedagogic value of source sorting, using that as a good way to educate the inhabitants and increase the environmental awareness is lost if central sorting is implemented.

Currently two intermunicipal waste companies in Norway are building or planning to build a NIR (near infrared) sorting facility. The organic waste (and paper) is then source separated in the households, while the “dry” mixed waste goes through central sorting. The facilities will be able to do more detailed sorting than household source separation, and may separate different plastic types. This technology is similar to sorting technology at the plastic sorting plants and will increase the value of the plastic collected as the high value plastic materials are separated from the mixed plastic waste. According to Mepex (2013), the sorting rates for this type of solution may be higher than source separation by households.

As far as known there are no as far-reaching plans for central sorting in the rest of the Nordics as in Norway. Within a Swedish project called “The yellow waste bin” joint source-sorting of packaging and newsprint was analysed in order to increase the knowledge about kerbside collection of discarded newspaper and packaging in a mixed fraction (Jensen *et al.*, 2013). The Swedish project was carried out in 2013 and included analysis of collection rates, purity of the collected material and consumer experience through practical tests. Around 180 households in Halmstad municipality in Sweden in both single-family houses and in apartment buildings sorted out used newspaper and packaging (plastic-, metal-, glass- and paper packaging) in a mixed fraction instead of traditional source sorting in separate fractions. The mixed waste was sorted manually into the respective recycling fraction and in an incorrectly sorted waste fraction. The amount of each sorted fraction (which was related to the number of residents) and the results from the sorting analyses of the residual waste were the basis for evaluating what impact the studied collection system had on collection rates.

The results from the project indicate that the main benefit of “The yellow waste bin” compared to other collection systems with respect to amounts collected and amounts left in the residual waste is the ability to be able to dispose newspaper and packaging in close proximity to the properties. This is the main benefit, rather than not having to separately sort out newspaper and packaging. This general conclusion is based on an increase in collected amounts of newspaper and packaging and a decrease of newspaper and packaging in the residual waste when “The yellow waste bin” was compared to the traditional bring system in Swe-

den. No corresponding improvement for “The yellow waste bin” could be measured compared to other kerbside collection systems. However, in the performed behavioural study the households emphasize that it is a great advantage to avoid sorting of the waste.

The potential achieved quality of the fractions generated by an industrial sorting facility processing mixed newspaper and packaging was not included in the project scope, which is needed in order to make the system fully comparable to other collection systems.

12.1.2 Collection in material streams

The Swedish EPA concluded in 2007 that collection of waste in material streams should be considered, and that the materials of main interest should be plastic and metal. Collection in material streams, instead of in packaging streams, was mainly advocated due to the fact that it would lead to a more accessible for system for households. The conclusions indicated that many households sort their waste based on material already, not based on packaging or non-packaging. Another conclusion was that a change in the legal framework about responsibilities and financing between producers and municipalities will most likely create an administrative burden. This is why increased cooperation between municipalities and producers was seen as the most favourable option, avoiding change in the legal framework (Naturvårdsverket, 2007).

Results from a pilote study in Eskilstuna, Sweden within the SHARP project, where plastic waste was collected based on material show that a third of the households already sort waste based on material. The households participating in the project were positive towards collection in material streams, as it became more logical and comprehensive. In the project it was therefore concluded that collection in material streams would lead to more engaged households, as well as increased trust for source separation and recycling, why this was recommended. The quality of the plastic waste was considered of sufficient quality to be recycled and in the assessment there were no major technical obstacles against collection of plastic in material streams (Naturvårdsverket, 2009).

Dahlén *et al.* (2013) concludes that households tend to sort out plastic waste other than packaging in the plastic packaging waste fraction.

The Norwegian waste strategy also suggests an attempt to include other non-packaging plastic products from agricultural sector and households in the collection systems, such as solid plastic products. It is argued that these products to a large extent is produced from the same plastic types as plastic packaging and hence is suited for the existing

collection and recycling infrastructure (Norwegian Ministry of Environment, 2013). Avfall Norge (2013) supports the strategy of including other plastic waste types in the collection system, mainly because this would make the communication to the inhabitants easier. In the current system it may be hard to communicate to the consumers that only the defined packaging plastic waste shall be separated.

12.1.3 Weight-based waste fees

Finnveden *et al.* (2013) recommend weight-based waste fee in combination with information and well-developed bring systems to assure a more sustainable waste management. According to Nilsson (2004) a weight-based waste collection scheme encourages source separation to a greater extent than a system based on volume rates as waste charged by weight creates more incentive to reduce the amount thrown in the bin. Several reports have proven that the amount of mixed household waste decreases in municipalities with weight-based collection schemes. The most recent Swedish reports show a decrease of mixed residual waste with approximately 31 percent. Ålander (2013) based this result on statistics from 20 municipalities with weight-based system and 20 with volume-based system, during the years 1992–2012. Stare and Sundqvist (2013) got the same result when evaluating the amount of waste in Stockholm 2012 and 2013, before and after the introduction of the weight-based system.

Besides reducing the mixed waste a study by Schmidt *et al.* (2012) showed that households with weight-based fee increased their source-separation of packaging material (including plastic packaging). The same study could not prove whether this behavior was due to the charging system, to the increased information campaign carried out by the municipality in connection to the new system or to a combination of both.

Furthermore, when Hage *et al.* (2010) examined the relationship between weight-based charges and recovery, they found that Swedish municipalities with weight-based fee had higher collection rate of plastic packaging compared to municipalities with volume fee. The study was based on data from 2005 and included data from 282 municipalities. Also a study by Constantino (2008) shows tendencies that the amount of sorted plastic packaging is higher in Swedish municipalities with weight-based charges. The same result was found in Denmark when waste statistics from 1999 was analysed in 2012 (Hogg, 2012).

12.1.4 Possibilities for increased Nordic cooperation

Nordic cooperation within the field of plastics collection and recycling exists, but could be further developed. Stakeholders have along the project work expressed a positive attitude towards increased Nordic collaboration. Increased Nordic cooperation within the field could possibly take its form into one or several of the following areas:

- Common public procurement within treatment and logistics of plastic packaging waste.
- Predictability – possibility to map demand for plastic waste for the coming years for both product developers using secondary raw materials, and demand for recycling.
- Initiation of a structured dialogue between product manufacturers, recyclers and waste management companies.
- Nordic investments in sorting capacity.
- Creation of guidelines on how to calculate national recycling rates in the Nordics by going further than stated in the Packaging directive. This could lead to facilitated comparisons and finding of best practice in the Nordics.

13. Conclusions from part 1 of the project

The idea with part 1 of the project *Improvements in existing collection and recycling systems for plastic waste from households and other MSW sources* was to provide facts and information about how plastic waste from MSW sources are collected and recycled in the Nordic region today. The information creates a platform for part 2 of the project, allowing for deeper analysis and focus on certain parts within the broad area of plastics collection and recycling. The main findings from part 1 of the project are:

- Two strategies of separate collection of plastic packaging waste can be distinguished in the Nordic region. One is to collect and recycle plastic packaging waste from MSW sources (Denmark, Norway, Sweden and Iceland). The other strategy is to separately collect the plastic packaging waste for energy recovery as a fuel of high calorific value (Finland and Åland). Flexible and rigid plastic packaging waste is collected together in the Nordic countries apart from in Åland where rigid plastic packaging waste is handled as a separate fraction.
- Bring systems are the most common way to separately collect plastic packaging waste from MSW sources in Denmark, Iceland, Sweden and Åland, as opposed to Norway where kerbside collection is dominating. Kerbside collection includes a broad range of solutions such as multi-compartment bins, source-sorting in differently coloured bags prior to optical sorting and sorting in plastic bags.
- Kerbside collection of plastic packaging waste seems to generate the highest collection rates compared to other collection systems. This conclusion will however be more profoundly analysed as comparisons are difficult to make. The link between collection rates and collection system are not easily analysed as the collection rate is influenced by other factors such as type of housing, communication, source-sorting of other waste fractions and for how long source-sorting has been in place.

- PET bottles are collected and recycled through separate deposit return systems in the Nordic region excluding Greenland. Åland and Finland have a joint deposit return system whereas there is one deposit system for each region in the rest of the Nordics. Deposit return systems in general gives high rates of recycling.
- Goals targeted on plastic packaging are of two origins, the minimum requirement stated in the Packaging directive and national recycling targets. Norway (EPR agreement) and Sweden have higher recycling targets than the minimum requirement of the directive. No Nordic country has specific targets for collection and recycling of plastic waste other than for plastic packaging and PET bottles.
- Comparing recycling rates for different Nordic countries is challenging as the calculation methods vary. The countries reporting data to Eurostat are free to use methods of their choice as long as the Eurostat instructions are followed. The way of calculating the nationally set targets have proven to vary significantly as well. In Finland, Denmark and Åland, PET bottles are included in the separately collected amounts whereas they are not in the Swedish and Norwegian figures. For Finland and Åland this makes an important difference as hardly any plastic packaging from households apart from PET bottles is subject to recycling. To consider or not consider moisture and contaminants in the plastic packaging waste flows also contributes to difficulties in comparing statistics.
- An attempt to compare recycling rates reveals that Norway presents the highest recycling rates for plastic packaging waste, followed by Sweden. The same pattern applies for PET bottles.
- Plastic bulky waste and non-packaging small plastic waste items are not subject to any dedicated collection and recycling systems in the Nordics. An increased trend of collecting plastic bulky waste at municipal recycling centrals is thus observed, especially in Sweden and Denmark. The collection is based on initiatives between municipalities and waste management companies.
- Small plastic waste other than packaging is taken care of in a similar manner in the Nordic region. The fraction is collected together with other types of waste and commonly sent to energy recovery. The only difference is the case of Finland where separately collected plastic waste, both packaging and non-packaging small plastic waste, is collected together based on material rather than on product type.

- Identified challenges hampering the collection and recycling of plastic waste are lack of communication and trust for collection and recycling of plastic waste in general, lack of treating and sorting capacity in the Nordic region, costly treatment and logistics, difficulty with obtaining high-quality secondary raw material to enable competition with virgin material, lack of product design to facilitate recycling (e.g. black plastics are not sorted out with NIR technology), weak market demand for recycled plastics and absence of incentives and goals for boosting recycling of plastics.
- The defined success criteria for obtaining increased collection and recycling of plastic waste in the Nordics are to take into account the entire value chain when optimising the collection and recycling systems, to create a higher market demand for recycled plastics and increase the sorting and treating capacity in the Nordics, to introduce practical solutions that motivate the public to sort out plastic waste, to better communicate benefits of plastics recycling and to favour an improved dialogue between actors in the value chain to favour design for recycling and high-quality secondary plastic raw material.
- Possible alternative solutions for increased recycling of plastics in the Nordic region could be or include collection of plastic packaging in a mixed packaging fraction, central sorting of mixed waste, practical solutions for collecting the most plastic packaging waste with sufficient purity, increased collection and recycling of plastic bulky waste at manned recycling centrals, collection in material streams and possibilities for increased Nordic cooperation.

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Sammanfattning

I denna rapport presenteras resultat från del 1 av projektet *Improvements in existing collection and recycling systems for plastic waste from households and other MSW sources* som initierats av Nordiska avfallsgruppen (NAG). Rapport för Del 2 kommer att publiceras när projektet är klart i december 2014. Projektgruppen består av fem organisationer: IVL Svenska Miljöinstitutet (projektledare), Østfoldforskning, VTT Technical Research Center of Finland, Aalborg Universitet och Environice.

I rapport 1 beskrivs befintliga system för insamling och materialåtervinning av plastavfall genererat från hushåll och andra kommunala avfallskällor för varje nordiskt land, inklusive Färöarna, Åland och Grönland som i sammanhanget räknas som individuella länder. Rapporten innehåller detaljerad information om insamling och materialåtervinning av plastförpackningar, plast i form av grovavfall och smått plastavfall som inte utgörs av förpackningar från hushåll och andra kommunala avfallskällor. Med förpackning menas "produkter som framställs av material av något slag och som används för att innehålla, skydda, hantera, leverera och presentera varor, från råmaterial till slutlig produkt och från producent till användare och konsument," enligt definitionen i förpackningsdirektivet.²¹ Med plast i form av grovavfall menas stort plastavfall som inte ryms i kärl- och säckavfallet och därför behöver tas omhand separat.

Smått plastavfall som utgörs av annat än förpackningar avser mindre plastavfall som praktiskt ryms inom samma insamlingssystem som plastförpackningar.

Informationen i rapporten bygger på intervjuer med nyckelaktörer i respektive nordiskt land samt kunskap från tidigare studier och projekt. De viktigaste resultaten från projektets första del kommer utgöra ett viktigt underlag för del 2 av projektet och sammanfattas nedan. I del 2 kommer analysen att fördjupas ytterligare.

Rapporten ingår i de nordiska statsministrarnas initiativ för grön tillväxt, Norden – ledande i grön tillväxt. Läs mer i webbtidningen

²¹ Europaparlamentets och rådets direktiv 94/62/EG av den 20 december 1994 om förpackningar och förpackningsavfall (ändrat genom direktiv 2004/12/EG och direktiv 2005/20/EG).

Green Growth the Nordic Way på adressen www.nordicway.org eller www.norden.org/sv/tema/green-growth

Insamlings- och återvinningssystem

I Norden har kommunerna ansvar för insamling av plastförpackningar från hushåll och andra kommunala avfallskällor (inklusive regioner där uttjänta plastförpackningar inte samlas in separat), förutom i Sverige. I Sverige är det producenterna av plastförpackningar som ansvarar för insamlingen av plastförpackningar som avyttras i de insamlings- och återvinningssystem som producenterna tillhandahåller. Fem av de nordiska länderna har infört producentansvar för förpackningar och förpackningsavfall, däribland plastförpackningar. Sverige, Finland, Åland och Island har ett lagstadgat producentansvar medan Norge har infört ett frivilligt producentansvar. I Danmark har förpackningsdirektivet implementerats utan att införa producentansvar. Ansvaret för återvinning av uttjänta plastförpackningar vilar på producenterna i länderna med producentansvar (i Finland endast från verksamheter).

De nordiska kommunerna ansvarar för plastavfall som del av grovavfall samt för smått plastavfall som inte utgörs av förpackningar.

Två huvudstrategier för separat insamling av uttjänta plastförpackningar finns i Norden. En strategi är att samla in och materialåtervinna uttjänta plastförpackningar från hushåll och andra kommunala avfallskällor och den andra är att separat samla in uttjänta plastförpackningar för energiutvinning, som bränsle i industrin. Bringsystem är det vanligaste sättet att separat samla in uttjänta plastförpackningar från kommunala avfallskällor i Danmark, Island, Sverige och Åland, till skillnad från Norge, där fastighetsnära insamling dominerar. Fastighetsnära insamling omfattar en rad praktiska lösningar såsom flerfackskärl och källsortering i olikfärgade påsar för optisk sortering.

Mjuka och hårda plastförpackningar samlas in tillsammans i Norden, utom i Finland och på Åland. I Finland samlas förpackningar och annat plastavfall in tillsammans och på Åland endast hårda plastförpackningar från hushåll. PET-flaskor samlas in och materialåtervinns genom pantsystem i Norden förutom på Grönland. Åland och Finland har ett gemensamt pantsystem medan övriga nordiska länder har separata pantsystem.

Plastavfall som del av grovavfallet och annat smått plastavfall som inte utgörs av förpackningar ingår inte i några separata, nationella insamlings- och återvinningssystem i Norden. Småskaliga initiativ mellan kommuner och avfallsentreprenörer finns dock och trenden att ha separata containrar för plastavfall på återvinningscentraler ökar.

Annat smått plastavfall tas om hand på ett liknande sätt i Norden (samlas in i blandade avfallsfraktioner och går till energiutvinning eller deponering). En del smått plastavfall följer dock med plastförpackningsflödet eftersom hushåll inte alltid skiljer på vad som utgör en förpackning och inte. Om plastavfallet är av samma polymertyper som förpackningsflödet sorteras fraktionen ut till materialåtervinning i sorteringsprocessen för förpackningar.

Källsorterade uttjänta plastförpackningar i Norge och Sverige går samma sorteringsväg till mötes. FTI och Grønt Punkt Norge har fyra kontrakterade sorteringsanläggningar för de insamlade plastförpackningarna, en i Sverige och tre i Tyskland. Polymertyperna som sorteras ut för materialåtervinning är för närvarande LDPE (polyeten med låg densitet), HDPE (polyeten med hög densitet), PP (polypropen) och PET (polyetentereftalat). PS (polystyren) sorteras ut vid de tyska anläggningarna. Övriga polymertyper som kan finnas i plastförpackningsflödet går inte till materialåtervinning. Sorteringsprocessen bygger grovt förklarat på NIR(Near Infrared)-teknik. Det sekundära råmaterialet från den hårda plastförpackningsfraktionen materialåtervinns framförallt till plastprodukter, såsom blomkrukor, rör och bänkar, och inte tillbaka till plastförpackningar. Utsorterade mjuka plastförpackningar materialåtervinns däremot ofta tillbaka till förpackningar i form av plastpåsar. PET-flaskor materialåtervinns vanligtvis tillbaka till flaskor.

Kartlagda plastavfallsströmmar och återvinningsgrad

Omkring 600 000 ton plastförpackningar och 56 000 ton PET-flaskor sätts årligen på den nordiska marknaden. Runt 284 000 ton uttjänta plastförpackningar (exklusive PET-flaskor) källsorteras och samlas in separat, varav ca 161 000 ton går till materialåtervinning.

Det finns två typer av materialåtervinningsmål riktade mot plastförpackningar, minimikravet enligt förpackningsdirektivet och eventuella nationella materialåtervinningsmål. Färöarna och Grönland har inga mål som fokuserar på plastförpackningar eller plast generellt. Island, Finland och Åland har valt att inte gå längre än minimikraven i direktivet (22,5 procent). Sverige har ett högre nationellt mål än kravet i direktivet, liksom målet för det norska, frivilliga producentansvaret. Danmark har ett mål för samtliga återvinningsbara fraktioner, inkluderat plast.

Återvinningsmålet för PET-flaskor varierar mellan 80 procent (Finland och Åland) och 90 procent (Sverige). Inget nordiskt land har specifika mål för insamling och materialåtervinning av andra plastavfallsfraktioner än för plastförpackningar.

Det är vanskligt att jämföra återvinningsgrader eftersom beräkningsmetoderna varierar kraftigt. Enligt uppgifter från Eurostat (rapportering enligt förpackningsdirektivet) har Norge den högsta materialåtervinningsgraden för plastförpackningar i Norden. Sverige och Finland uppfyller målet specificerat i direktivet medan Danmark rapporterade en materialåtervinningsgrad strax under vad direktivet kräver för 2011.

De nationella målen för materialåtervinning av plastförpackningar uppfylls i Norge och Finland, men inte i Sverige, Island och på Åland. Även metoderna för att beräkna de nationella materialåtervinningsgraderna skiljer sig åt mellan de nordiska länderna. I Finland, Danmark och på Åland är PET-flaskor inräknade i materialåtervinningsgraden för plastförpackningar medan så inte är fallet för de svenska och norska återvinningsgraderna. För Finland och Åland gör det väsentlig skillnad eftersom mycket små mängder uttjänta plastförpackningar materialåtervinns från hushåll förutom PET-flaskor. Att korrigera eller inte korrigera för fukt och föroreningar i insamlade mängder uttjänta plastförpackningar för att beräkna materialåtervinningsgraden bidrar också till svårigheter med att jämföra statistik.

Fastighetsnära insamling av uttjänta plastförpackningar tycks generera högst insamlingsgrad jämfört med andra insamlingssystem. Denna slutsats kommer dock att djupare analyseras i del 2 av projektet eftersom jämförelser är svåra att göra. Kopplingen mellan insamlingsnivåer och insamlingssystem är komplicerad eftersom insamlingsnivån påverkas av många faktorer.

Potentialer för ökad materialåtervinning

Potentialen för ökad materialåtervinning av plast från hushåll och andra kommunala avfallskällor berör både insamling av plastavfall, det vill säga att få tillgång till materialet för att möjliggöra materialåtervinning, och av tekniska förbättringsmöjligheter knutet till sorterings- och återvinningsprocesser. Till identifierade möjligheterna av mer generell karaktär hör de faktum att plastavfall fortfarande deponeras i Norden (t.ex. på Island, Grönland och i Finland), att källsorterade plastförpackningar på Åland och i Finland inte går till materialåtervinning och att annat mindre plastavfall som inte utgörs av förpackningar samt plast som del av grovavfallet inte omfattas av rikstäckande, organiserade insamlings- och återvinningssystem. En tänkbar förbättringspotential vad gäller sortering av plastavfall är att kunna sortera ut ett högre antal polymertyper.

Den teoretiska potentialen för ökad materialåtervinning i form av plastavfall i blandat kärl- och säckavfall och restavfall uppskattas till

omkring 690 000 ton, det bör noteras att siffran är osäker. Den realistiska potentialen, det vill säga hur mycket som är realistiskt att sortera ut från kärll- och säckavfallet, är sannolikt betydligt lägre.

Identifierade utmaningar som hämmar en ökad insamling och materialåtervinning av plastavfall är brist på kommunikation och förtroende för insamling- och återvinningssystemen i allmänhet, brist på sorteringskapacitet i Norden, kostsam behandling och logistik, svårigheter att producera sekundär plastråvara av tillräckligt hög kvalitet för att konkurrera med jungfruligt material, avsaknad av produktdesign för att underlätta materialåtervinning (t.ex. svart plast sorteras inte ut med NIR-teknik eller förekomst av farliga ämnen i produkterna), svag efterfrågan på återvunnen plast och brist på incitament och mål för att öka materialåtervinning av plast.

Möjliga alternativa lösningar för att öka materialåtervinningen av plast i Norden skulle kunna vara att samla in plastförpackningar tillsammans med annat avfall och sortera ut plastförpackningarna från en blandad avfallsfraktion eller från en blandad förpackningsfraktion, insamling i materialflöden, användning av viktbaserad avfallstaxa samt att öka det nordiska samarbetet inom området insamling och materialåtervinning av plastavfall.

Rapporten ingår i de nordiska statsministrarnas initiativ för grön tillväxt, Norden – ledande i grön tillväxt.



Collection & recycling of plastic waste

The first report from the project “Improvements in existing collection and recycling systems for plastic waste from households and other municipal waste sources” is focused on describing the existing situation when it comes to collection and recycling of plastic waste in the Nordic countries. The streams covered are (all from both households and other MSW sources):

- Plastic packaging waste.
- Non-packaging small plastic waste.
- Plastic bulky waste.

Similarities and differences among the Nordic countries are presented in the report. The findings provide input into the development of suggestions for improvements.

The report is part of the Nordic Prime Ministers’ green growth initiative: “The Nordic Region – leading in green growth.” Read more in the web magazine “Green Growth the Nordic Way” at www.nordicway.org or at www.norden.org/greengrowth

The report for Part 2 will be published in December 2014.

