

Guidelines to increased collection of plastic packaging waste from households



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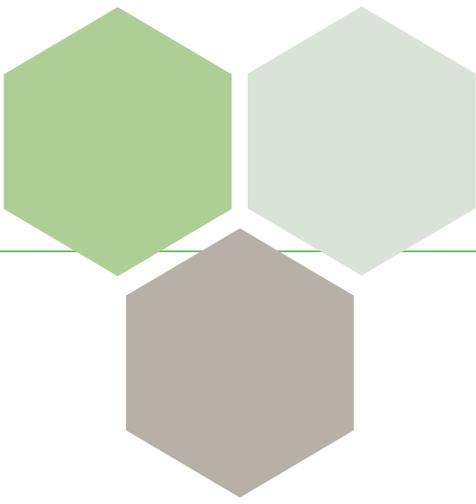
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Introduction

Unsorted plastic packaging waste in residual waste fractions represent one of the largest potentials for increased collection and recycling of plastic packaging in the Nordic countries. To exploit this potential there must be a well-functioning infrastructure targeted on collecting plastic packaging waste.

The guidelines were compiled as part of the Nordic Prime Ministers' green growth initiative, The Nordic Region – leading in green growth. The initiative identifies eight priorities aimed at greening the Nordic economies, one of which is to develop innovative technologies and methods for waste treatment.

The aim of these guidelines is to inspire and give recommendations on how plastic packaging waste can be collected, and how different aspects concerning collection of plastic packaging can be taken into account. The guidelines are based on Nordic experience in order to encourage knowledge transfer and give examples of how plastic packaging waste is collected in the Nordic region.

The intended target groups for the guidelines are primarily the actors responsible for the collection of plastic packaging waste in the Nordic region.

Instead of trying to identify a “one-size fits all” collection system, the guidelines provide information to facilitate the decision on how plastic packaging waste is best collected at a local level. Local circumstances, such as the organisation of the waste management, local targets on waste management and how long the solutions for waste management have been in place, require/demand different solutions.

The guidelines cover both single-family homes and apartment buildings, both in densely and sparsely populated areas. Deposit return systems for PET bottles are not covered in the guidelines.

The guidelines have taken the existing collection systems for plastic packaging waste for recycling in the Nordic region as a starting point, and thus start with a brief description of each of them. After that, the collection systems are evaluated according to a number of aspects that are found valuable for a collection system to fulfill.

These guidelines have been developed within the project Improvements in existing collection and recycling systems for plastic from households and other MSW on behalf of the Nordic Council of Ministers. The guidelines are written by IVL Swedish Environmental Research Institute, Ostfold Research, VTT Technical Research Centre of Finland, Aalborg University and Environice. Background information to the guidelines, as well as complete references are found in the report *Background information to the guidelines – Improvements in the existing collection and recycling systems for plastic waste from households and other MSW sources*.

The guidelines are part of the Nordic Prime Ministers' overall 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 authors would like to thank all of those who have contributed with information to the guidelines.

Collection of plastic packaging waste

Collection of plastic packaging waste for recycling in the Nordic region is based on three main principles:

1. Kerbside collection of source-sorted plastic packaging waste:

- in multi-compartment bins
- in separate containers or transparent plastic bags
- in coloured bags prior to optical colour sorting

2. Bring systems of source-sorted plastic packaging waste

3. Kerbside collection of mixed waste subject to central sorting

The meaning of kerbside collection is not explicit, but in the guidelines the definition of kerbside collection is a collection system where households are able to discard their plastic packaging waste within the boundaries of the estate. Kerbside collection systems are opposite to bring systems not for public use.

There are different levels of source-sorting, which all have in common that the households make an effort to sort their waste in a certain manner. Plastic packaging waste can either be source-sorted into a single stream, e.g. into a fraction for plastic packaging waste only, or into a fraction containing other recyclable materials or plastic waste other than packaging.

Kerbside collection of source-sorted plastic packaging waste

Kerbside collection systems are widely used in the Nordic region. The waste can be either sourcesorted or part of mixed waste fractions. Different practical solutions are used for collecting plastic packaging waste at the kerb.

Multi-compartment bins

Collection of source-sorted plastic packaging waste in multi-compartment bins is becoming a more widespread solution in Swedish and Danish municipalities, and also in Åland. In Finland there

are on-going trials, and a region in eastern Finland is already using the system.

The principle of multi-compartment bins is that different waste fractions have its own compartment in the same bin. The bin is divided into compartments instead of having separate bins for different waste fractions as multiple bins would increase the space required.

Source-sorting of plastic packaging waste in multi-compartment bins usually takes place in a bin containing four fractions. Each household normally has two bins (370 L each), and source-sort their waste into eight fractions in total. A common collection frequency is every second week for the bin containing food waste and residual waste and once every month for the other bin. The collection system is primarily designed for single-family homes. Example of multi-compartment bins, and the organisation of compartments:



Figure 1. Example of compartment organisation for multi-compartment bins (eight fractions). Source: Trelleborg municipality.

The use of multi-compartment bins in Denmark is different to the solution with eight compartments.

A predominant type in Denmark is to use a two-compartment, 180 liter bin, where the household sorts waste into two fractions:

- Paper, cardboard, and plastic foils
- Plastic, glass, and metal packaging

The two fractions are sorted into material fractions after collection. In general, the two-compartment

bin is a supplement to a bin for food waste, and a bin for residual waste. Bins with four-compartments are also used in Denmark, where two large compartments are used for paper and plastic waste, and two smaller for metal and glass waste. In Åland only rigid plastic packaging waste is source-sorted in the multi-compartment bins, not flexible plastic packaging waste.

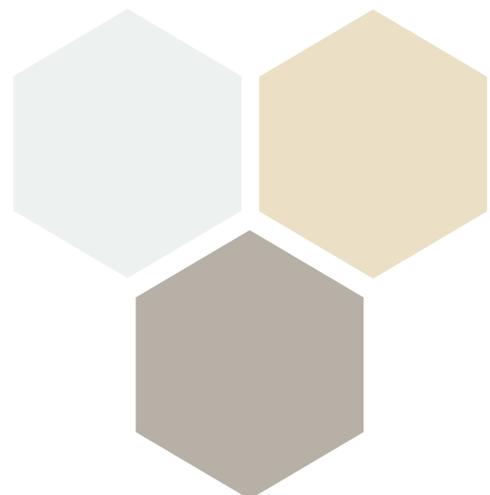
Multi-compartment bins are collected with special, rear-loaded vehicles containing four compartments. It is, depending on the compartment organisation, in some cases possible to empty traditional waste bins in the multi-compartment vehicles. This is useful when multi-compartment bins are not used by all households.

Use of multi-compartment bins in the Nordic region

Denmark	No figures available
Finland	Used to a small extent, no figures available
Iceland	Not used
Norway	Used to a small extent, no figures available
Sweden	Available in 27 ¹ municipalities
Åland	2000 households in 16 municipalities ²

¹ Avfall Sverige (2014). Införande av system för fastighetsnära insamling av förpackningar och returpapper. Guide nr 6. Trelleborg and Härnösand municipality introduced the system in 2014.

² Ålands Renhållning (2014). Personal communication with Robert Nylund.



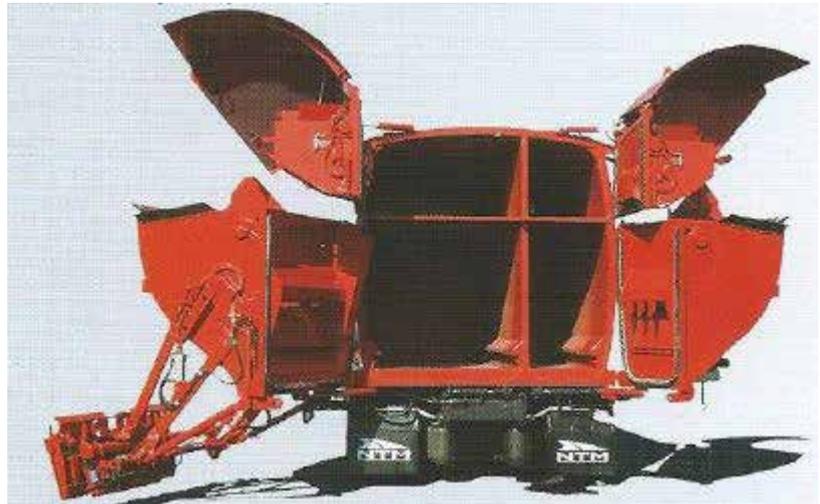


Figure 2. A multi-compartment vehicle.
Source: NTM (2014).

Remember

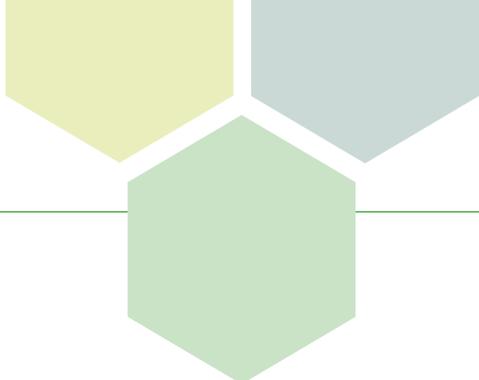
The compartments in a multi-compartment bin can be organised differently. The organisation should be made with foresight as a change of organisation can be time-consuming and challenging in terms of communication. The composition of the household waste, collection frequency and waste management goals in the municipality should be taken into account when deciding on a final organisation of compartments.

It is recommended to use one of the larger compartments for plastic packaging waste. The reason is that the volume of the flexible plastic packaging waste can cause problems when emptying the bin if a small compartment is used. There are many examples of municipalities where a too small compartment is used for plastic packaging waste. As a result the households are informed by the municipality to throw flexible plastic packaging in the residual waste. There are practical solutions on the market to compress the flexible plastic packaging waste at home. Information to households on how to compress the flexible plastic packaging waste might also be a solution, even if a larger compartment is used.

Härnösand – the first Swedish municipality north of Stockholm introducing multi-compartment bins

Härnösand has around 24 500 inhabitants and has offered every single-family home a multi-compartment bin since May 2014. The choice fell on multi-compartment bins due to the high service level the collection system offers and the positive results in collected amounts and quality of the source-sorted waste fractions. The single-family homes can choose between multi-compartment bins or a separate bin for food waste and another for residual waste.

About 63 percent of the single-family homes have until now chosen multi-compartment bins. The extra collection costs for having multi-compartment bins are spread out on the total amount of households. The extra cost for the multi-compartment bins is around 20 euros per year. They estimate that they can empty 250 – 275 bins per day and plan to empty the vehicle twice a day.



Separate containers or transparent plastic bags

In densely populated areas with a high number of apartment buildings and multi-family housing it might be unpractical to have private waste bins for each household. Therefore joint solutions are common in such areas. These solutions are usually designed for individual apartment buildings, but can also be found in areas with single-family homes. The system can be shared among the households in either one, or several apartment buildings.

The practical solutions have different appearances, but all of them can accommodate relatively high amounts of plastic packaging waste. Separate bins for plastic packaging waste (140 to 660 liters) are the most common solution for apartment buildings in Sweden, whereas the major solution in Norway is the use of transparent plastic bags, which are left next to the ordinary waste bins. The containers and plastic bags are placed indoors or outdoors, usually close to where residual waste is normally discarded. An alternative

to separate bins are underground containers, which are frequently used in larger cities. Underground containers can also be part of an automated collection system based on vacuum technology.

The collection frequency varies depending on the size of bins and the number of households. Transparent plastic bags are usually collected every fourth week. It is common to use single- or double-compartment collection vehicles.



Figure 3. Typical plastic bags (140 liters) in Norway. Source: Grønt Punkt Norge.



The green bin on Iceland

In several municipalities in Iceland the households are equipped with a separate bin for kerbside collection of plastic packaging waste (most often referred to as the “green bin”) or alternatively with a few bins or a small container in the case of multi-family dwellings. The “green bin”,

with the appearance of a traditional waste bin, is a kerbside collection system designed for collection of plastic packaging waste, paper packaging waste and metal waste. The plastic packaging waste is to be left in the bin in transparent plastic bags and the same applies to metal waste.

The green bins are emptied by a collection vehicle used solely for this purpose and brought to a central sorting facility where the material is roughly sorted into plastic, metals and in one or more category of paper/cartridges.

Use of separate bins or transparent plastic bags in the Nordic region

Denmark	Used, but no overall figures available
Finland	Not used
Iceland	11% of the population lives in one of 13 municipalities offering the collection system ³
Norway	67% of the population lives in a municipality offering the collection system ³
Sweden	Used, but no overall figures available
Åland	Used, but no overall figures available

³ Fråne, Stenmarck, Gíslason, Lyng, Løkke, zu Castell-Rüdenhausen Wahlström (2014). Improvements in existing collection and recycling systems for plastic waste from households and other MSW sources. Nordic Council of Ministers. TemaNord 2014:543.

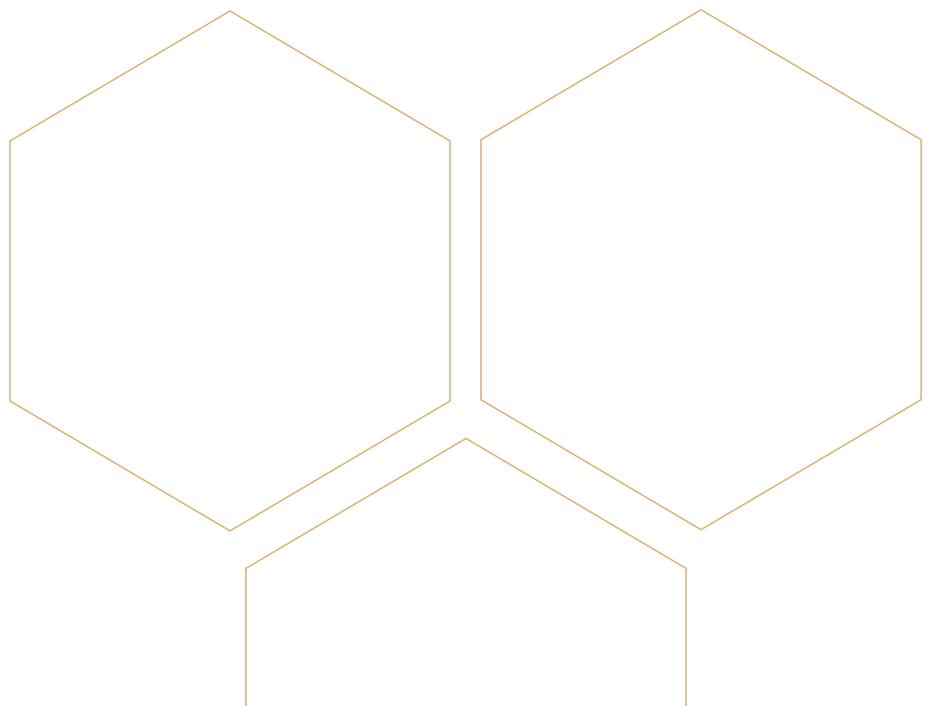




Figure 4. Examples of underground containers in Sweden (Source: Sansac AB).

Coloured bags prior to optical colour sorting

This collection system is based on source-sorting in specifically coloured plastic bags where one colour is used for plastic packaging waste. The coloured plastics bags are thrown in the same container and transported by a single-compartment vehicle to a sorting facility where the bags are optically colour sorted into the different fractions. Plastic packaging waste can be one of three to six fractions. It is however, rare that municipalities

use six fractions (one municipality in Sweden and at least one in Norway). The fractions are commonly plastic packaging waste, metal packaging waste, paper packaging waste, newsprint, residual waste and food waste or varieties of these. Transparent and colored glass are discarded at recycling stations to avoid the breaking of glass and contamination of other waste fractions.

In the sorting facility the coloured bags are transported to optical

readers that identify the color of each bag. The bags are pushed into separate containers and opened. Depending on the material the fractions are either sent to further sorting (e.g plastic packaging waste), to recycling, to biogas production or to incineration. This kerbside collection system is used in several municipalities in Norway and in one municipality in Sweden. A higher number of municipalities uses optical colour sorting, but not for collection and separation of plastic packaging waste.

Use of coloured bags prior to optical sorting in the Nordic region

Denmark	Not used
Finland	Not used
Iceland	Not used
Norway	18% of the population lives in one of 26 municipalities offering the collection system ⁴
Sweden	Around 20 000 households in one municipality, 0.5% of the total population ⁵
Åland	Not used

⁴Fråne, Stenmarck, Gíslason, Lyng, Løkke, zu Castell-Rüdenhausen Wahlström (2014). Improvements in existing collection and recycling systems for plastic waste from households and other MSW sources. Nordic Council of Ministers. TemaNord 2014:543.

⁵Eskilstuna Energi & Miljö (2014). Sopsortering-villa. <http://www.eem.se/privat/atervingning/villa/>.

1 household ≈2.22 inhabitants.

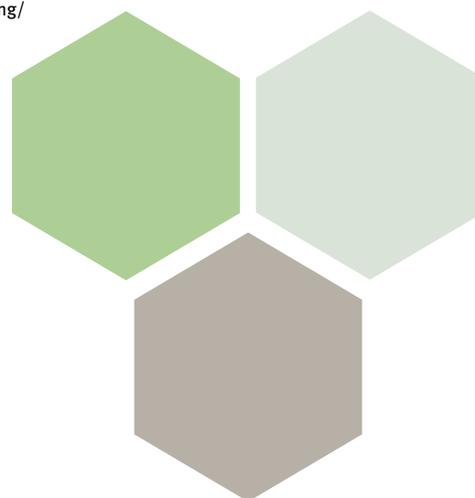




Figure 5. Source: Eskilstuna Energi & Miljö (2014)
Right: Source: Avfallsservice (2014).



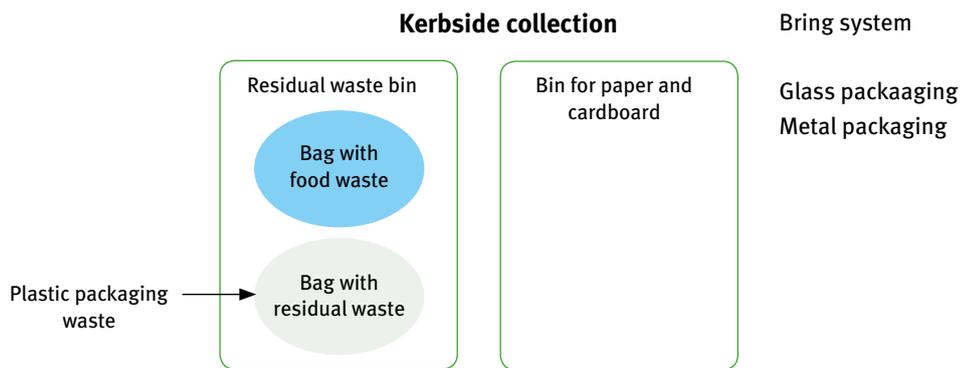
Kerbside collection of mixed waste subject to central sorting

Central sorting of mixed waste is developing in Europe. In the Nordic region, central sorting where plastic waste is sorted out from mixed waste only currently exists in Norway, where the first central sorting plant opened in 2013. It is owned by the eight municipalities Enebakk, Fet, Gjerdrum, Lørenskog, Nittedal,

Rælingen, Skedsmo and Sørum within the intermunicipal collaboration ROAF.

Norwegians with access to the system discard plastic packaging and non-packaging small plastic items waste in the relatively dry mixed waste fraction as food waste is placed in a separate bag (green). The mixed waste bag, containing plastic

packaging waste is placed in the same bin as bags with food waste. Paper and cardboard is source-sorted and thrown in a second bin. Glass and metal packaging waste is collected by bring systems. Households in single-family homes as well as in apartment buildings have access to the system.



Mixed waste sorting

Plastic bags with food waste and bags with mixed waste are separated at the central sorting facility by optical readers, based on the colours of the bags. Using NIR technology, the plastic packaging waste is sorted out from the rest of the mixed waste into five different polymers such as low density polyethylene (LDPE), high-density polyethylene (HDPE), polyethylene terephthalate (PET), and polypropylene (PP) and polystyrene sulfonate (PSS). The sorted plastic polymers are sent to recycling plants. Source-sorted plastic packaging waste undergoes similar sorting by polymer.

Plans for the South West region in Norway

Five intermunicipal companies, covering 23 municipalities and about 300 000 inhabitants in the south west of Norway, have decided to invest in a central sorting plant based on the same technology as in the ROAF municipalities. One major difference, however, compared to the ROAF plant, is that this plant will implement one further step of the recycling value chain by including the extrusion of the sorted LDPE, HDPE and PP plastics into granulates. Thus, this recycled plastics granulate can be sold directly to plastic manufacturers. The PET and PS plastics will be sent to external recycling plants due to different melting points. The plant is scheduled to start operating in 2016.

Bring systems

Use of bring systems in the Nordic countries is widespread. These public drop-off points include other packaging waste fractions, where people bring their source-sorted plastic packaging waste. At these points people can deliver their source-sorted plastic packaging waste regardless of whether they

live in apartment buildings or single-family homes.

There are two major varieties of drop-off points:

1. Recycling stations where packaging waste fractions are discarded. The recycling stations are equipped with large containers (above or underground) for different

packaging waste fractions. This collection system is used both for single-family homes and apartment buildings.

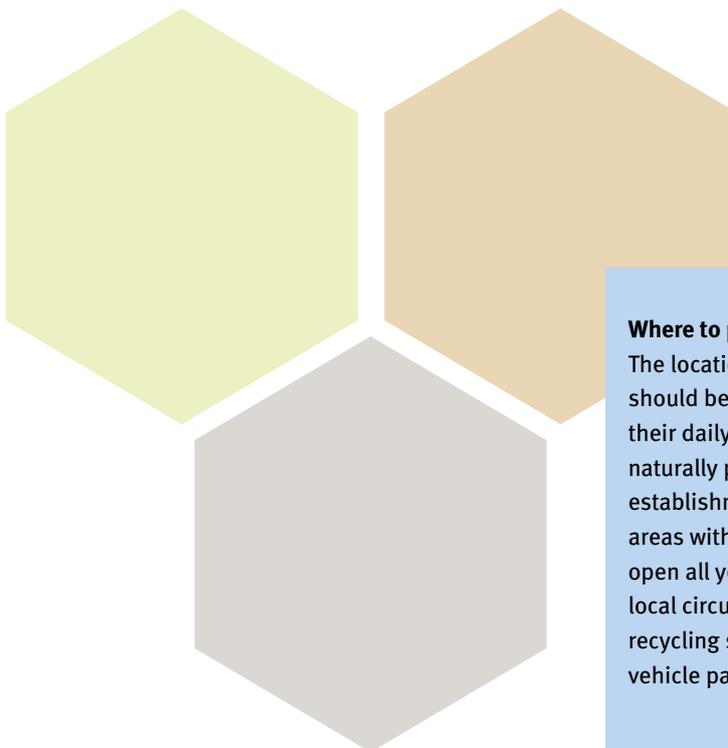
2. Manned recycling centrals where packaging waste and other waste fractions can be discarded.



Figure 6. Examples of unmanned recycling stations in Sweden (top, source: FTI AB) and Finland (source: VTT Technical Research Centre of Finland).

Use of bring systems in the Nordic region

Denmark	Available in all 98 municipalities
Finland	Available in some municipalities
Iceland	Available in almost all municipalities (74 in total)
Norway	Available in all municipalities (428 in total)
Sweden	Available in almost all 290 municipalities
Åland	Available in all 16 municipalities



Where to place public drop-off points

The location of drop-off points is important. They should be strategically placed where people do their daily business and at places where people naturally pass. FTI in Sweden previously motivated establishment of unmanned recycling stations in areas with at least 500 inhabitants and a supermarket open all year. The decision is now rather based on local circumstances. The establishment of a new recycling station can e.g. be motivated if the collection vehicle passes the area on its normal route.



Aspects to consider when evaluating a collection system

Deciding on the best collection system for plastic packaging waste for a municipality or a region can seem overwhelming, which is why it is important to know where to start. One first step could be to look at existing collection systems, gather information about each one of them, and sort the information under relevant aspects. In these guidelines we have limited the scope and looked more deeply at the following aspects:

- Collected amounts
- Quality of the collected material
- Economic aspects
- Environmental impact
- Service level and communication
- Flexibility

Collected amounts

It is easy to concentrate on the collected amount of plastic packaging waste as it is a measurable parameter. However, it does not tell the whole truth about the performance of a collection system, which is important to bear in mind. It is also crucial to look at the total amount of generated plastic packaging waste and try to find out the fraction that is captured by the collection system.

Practical aspects about collected amounts:

- Both the amount of collected plastic packaging waste, and the amount of unsorted plastic packaging waste in residual waste fractions should be taken into account to find out a rate of

source-sorting as a percentage of all available plastic packaging waste.

- Do not only look at the collected amounts but also try to evaluate the quality of the collected material. Highly contaminated plastic packaging waste fractions might give the impression that a high amount is collected, but the weight may in fact include a lot of moisture, dirt and other contaminants.
- Food waste highly influences the percentage of plastic packaging waste in residual waste fractions, so the amount of plastic packaging waste in kilos should preferably be looked at as well.



- Pay attention to the fact that statistics on collected amounts of plastic packaging waste from bring systems in touristic municipalities might be misleading as the generation of plastic packaging waste is diverted from one municipality to another. The unit “kg per citizen” is less robust in sparsely populated municipalities than in more densely populated ones as a single or a couple of incorrect measurements are enough to create a significant change in the measure.

- Collection of plastic packaging waste is not a stand-alone activity, but part of the entire waste management system.

Parameters influencing the collected amounts

Kerbside collection tends to favour the amounts of collected plastic packaging waste compared to bring systems, according to studies from Sweden and Norway. However, the results are based on the current situation, which means that the impact of a potential increase in the

number of drop-off stations has not been taken into account.

In general, a higher amount of plastic packaging waste is collected by kerbside collection, but there are examples of municipalities with bring systems collecting more than that. Communication to households about recycling is crucial no matter the type of collection system.

Examples of measured collected amounts of plastic packaging waste from different kinds of collection systems:

Way of collecting plastic packaging waste	Collected amount per person and year (kg/person) (year 2013)*				
	Denmark	Finland	Iceland	Norway	Sweden
1. Kerbside collection of source-sorted plastic packaging waste					
1.1 In multi-compartment bins	No figures available	No figures available	Not used	No figures available	7 and 11 ⁷
1.2 In separate containers or transparent plastic bags	No figures available	Not used	No figures available	0.9 – 14.7 ⁹ (average 7.1)	5, 14 and 12 ⁸
1.3 In coloured bags prior to optical colour sorting	Not used	Not used	Not used	2.9 – 7.1 ⁹ (average 4)	11 ¹⁰
2. Bring systems	0.08-20 ¹¹	No figures available	Not used	0.7 – 6.3 ⁹ (average 4)	3.5 ¹²
3. Kerbside collection of mixed waste subject to central sorting	Not used	Not used	Not used	13.5 ¹³	Not used

⁷ Based on figures from Västblekinge Miljö AB (year 2013), NSR AB (year 2014).

⁸ Avfall Sverige (2014). Införande av system för fastighetsnära insamling av förpackningar och returpapper. Guide nr 6. Figures from Familjebostäder Göteborg (year 2011), Renhållningen Kristianstad (year 2013) and Mimer, Västerås (year 2011 and 2012).

⁹ Grønt Punkt Norge (2014). Statistics plastic packaging households.

¹⁰ Avfall Sverige (2014). Införande av system för fastighetsnära insamling av förpackningar och returpapper. Guide nr 6.

¹¹ Approximate values for plastic waste collected at recycling centres based on the DEPA waste database. The figures do include plastic waste from small business.

¹² FTI AB (2014). Personal communication with Annica Dahlberg. Average value collected from bring systems. The figure is not statistically proven.

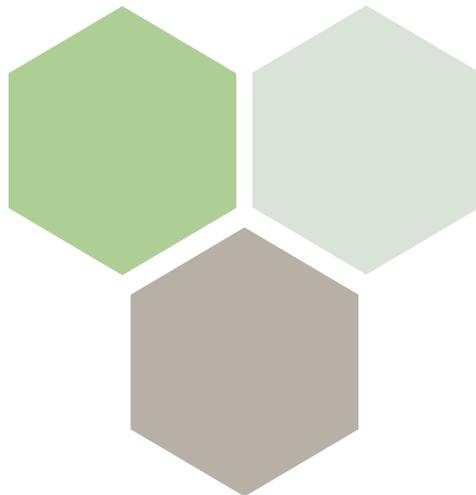
¹³ ROAF (2014). Personal communication with Telco Øyvind Brevik, Managing Director at ROAF. When assuming the average share of contaminants in kerbside systems in Norway (9.2%), this collected amount corresponds to a “kerbside collection” of 14.7 kg/person, year, which equals the best registered figures from kerbside systems in Norway.

* The figures refer to the collected amounts of the fraction plastic packaging waste. Contaminants are not considered.

Unsorted plastic packaging waste left in mixed waste fractions

Swedish experience shows that multi-compartment bins seem to generate the lowest share of unsorted packaging waste residing in the mixed waste fraction (source-sorting of food waste applied) when

looking at median values from a high number of waste analyses. Median values should be regarded as “average” values whereas minimum and maximum values show the distribution in the results. Data from other Nordic countries are examples of results from single analyses.



Way of collecting	Amount and share of unsorted plastic packaging waste in residual waste fractions ¹⁵									
	Denmark		Finland		Iceland		Norway		Sweden	
	%	kg (per person and year)	%	kg (per person and year)	%	kg (per person and year)	%	kg (per person and year)	%	kg (per person and year)
1. Kerbside collection of source-sorted plastic packaging waste										
1.1 In multi-compartment bins	No figures available		No figures available		Not used		No figures available		12.1 ¹⁶	7.7 ¹⁶
1.2 In separate containers or transparent plastic bags	No figures available		No figures available		No figures available		12.2 ¹⁸ and 16.5 ¹⁸	11.4 ¹⁸ and 20.2 ¹⁸	No figures available	
1.3 In coloured bags prior to optical colour sorting	No figures available		Not used		Not used		10.8 ²⁰	13.7 ²⁰	15.5 ¹⁶	No figures available
2. Bring systems	5.4 ¹⁷	10.2 ¹⁹	No figures available		No figures available		12.2 ¹⁸ and 16.5 ¹⁸	11.4 ¹⁸ and 20.2 ¹⁸	13.8 ¹⁶	14.1 ¹⁶
3. Kerbside collection of mixed waste subject to central sorting	Not used		Not used		Not used		Not relevant in this context as plastic packaging waste is part of the residual waste fraction		Not used	

¹⁵ Data includes moisture and dirt.

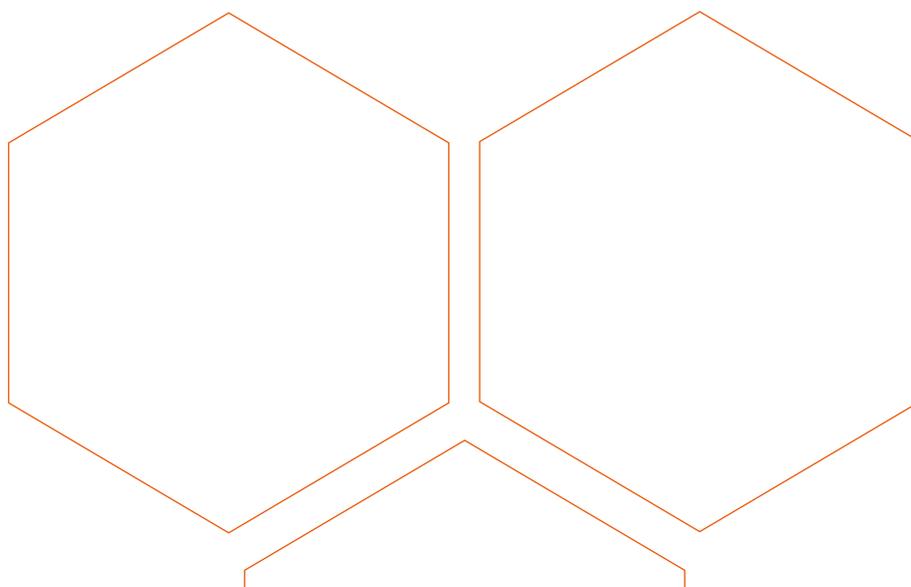
¹⁶ Avfall Sverige(2011). Nationell kartläggning av pluckanalyser av hushållens kärl- och säckavfall. Report U2011:04. Median value based on waste analyses. Separate collection of food waste.

¹⁷ Miljøstyrelsen (2012). Kortlægning af dagrenovation i enfamilieboliger. Miljøprojekt nr. 1414, Miljøstyrelsen. 5.4% corresponds to 190 g/person/week.

¹⁸ IVAR IKS (2011). Plukkanalyser husholdningsavfall 2011, Asplan Viak, 1/2011-06-29.

¹⁹ Miljøstyrelsen (2012). Kortlægning af dagrenovation i enfamilieboliger. Miljøprojekt nr. 1414, Miljøstyrelsen.

²⁰ Plukkanalyse 2012 En analyse av husholdningsavfall fra henteordninger i Grenland, <http://rig.no/nyttig-aa-vite/statistikk-oganalyser/plukkanalyser/plukkanalyse-2012>



Quality of the collected material

A collection system where as much plastic packaging waste as possible is collected is desirable, but not at the expense of the quality of the material. First of all, the term “quality of the material” has to be defined. The key question is how much of the collected plastic packaging waste is actually sent to recycling. The quality has also to do with the purity of the material, i.e. how much contaminants the collected material contains.

It is more or less impossible to collect completely pure and clean plastic packaging waste. A certain amount of contaminants will always follow. The amounts collected will therefore not correspond to the

amount of plastic packaging waste actually recycled. The reasons for this are multifold and are explained by the fact that the collected amounts:

- contain contaminants attached to the plastic packaging waste such as food waste, moisture, paper labels etc.
- contain non-plastic material that is incorrectly sorted at source.
- contain plastic types that cannot be separated for recycling by the technique used at the sorting facilities.

Additionally, losses of plastic do occur in the sorting processes.

How much of the source-sorted collected amounts of plastic packaging waste is actually plastic packaging waste?

It is not possible to answer the question for the entire Nordic region, but in Sweden the average content of plastic packaging waste is 72 percent of the collected plastic packaging waste fraction. Around 16 percent is non-packaging plastic waste and the remaining 12 percent non-plastic waste as seen in (Figure 7)²⁰.

In addition to this, the 72 percent share of plastic packaging waste contains moisture and dirt such as food. According to the study, about 8 percent of the weight of the plastic packaging waste consisted



Figure 7. Composition of collected amounts of the fraction named plastic packaging waste (left), and the composition of the actual plastic packaging waste fraction (right).

²⁰ Dahlén L, Vukicevic S, Tapper M. (2013). Återvinning av plast från hushållsavfall. Insamlingsresultat och kvalitet av källsorterad plast. Average of both kerbside collection and bring systems, source-sorted amounts.

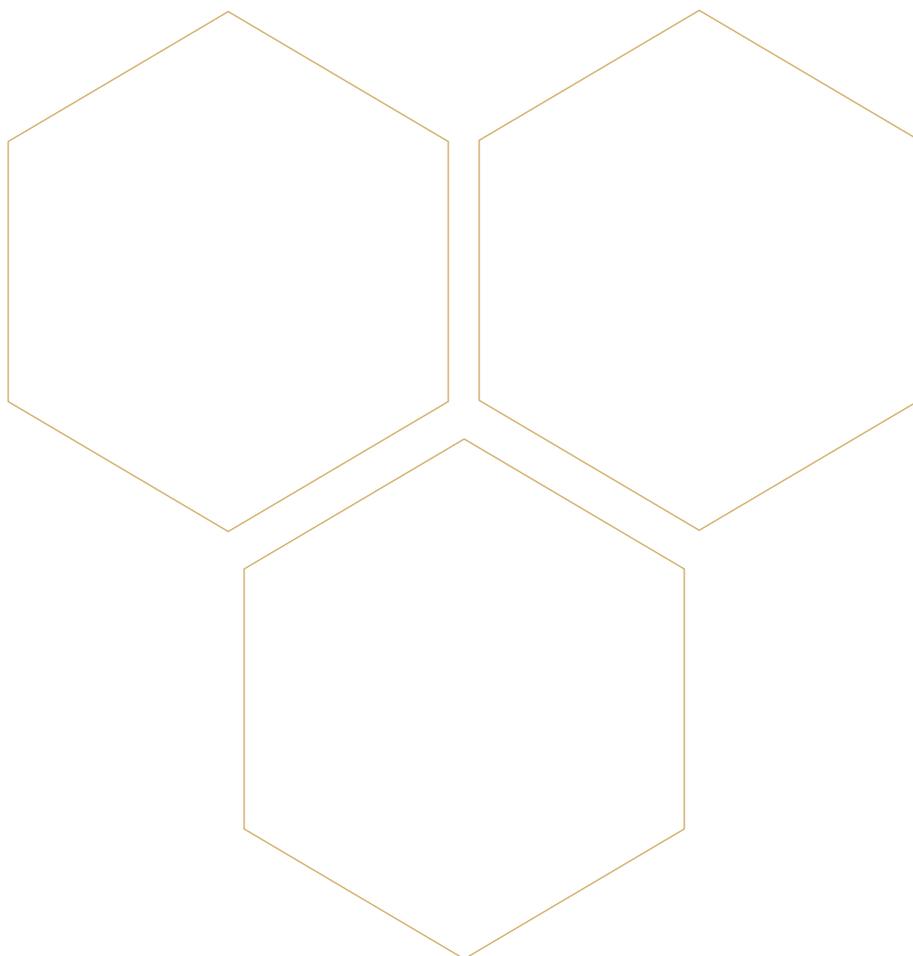
of these kinds of contaminants. Thus, pure plastic packaging accounted for only 66 percent (92% of the 76%) of the plastic packaging waste. Some of the non-packaging waste can be subject to recycling (same polymers as the packaging waste). Assuming that the entire amount of non-packaging plastic waste is subject to recycling, the figure increases to around 80 percent (taking moisture and dirt into account). When comparing collection systems, collecting rates and recycling rates, it is very important to be aware of what kind of data is actually being compared.

Does the collection system influence the quality of the collected plastic packaging waste?

The answer to the question is yes; the collection system does influence the quality of the collected material. The problem is to find out how and to what extent the quality differs.

The area is not extensively studied, but in a Swedish study kerbside collection in single-family homes was shown to generate plastic packaging waste with less contamination compared to plastic packaging waste sorted out through the bring system. The quality of plastic packaging waste sorted out by kerbside collection from apartment buildings was varying.

Norwegian experience shows that the purity of plastic packaging waste collected through both kerbside and bring systems varies. Grønt Punkt Norge collects data about the amount of contaminants in the source-sorted plastic packaging waste. Updated average data for 2013 for the amount of contaminants in the different collection systems are: 12%, for kerbside collection with transparent plastic bags, 10%, for kerbside collection with coloured bags prior to optical colour sorting and 20% for bring systems.



Economic aspects

Implementing a collection system for plastic packaging waste has economic consequences no matter how the waste is being collected. Any change in the existing waste management system naturally results in changes in the economic calculation, both in terms of costs and in terms of income. It is generally difficult to separately look at a single waste stream as the economic aspects for waste management is dependent on the entire system. It is also hard to allocate, or even know the costs and incomes related to one waste fraction, as for example a municipality planning to introduce kerbside collection in multi-compartment bins is inevitably also introducing a new waste collection system for many other waste fractions at the same time.

Economical evaluation of a collection system

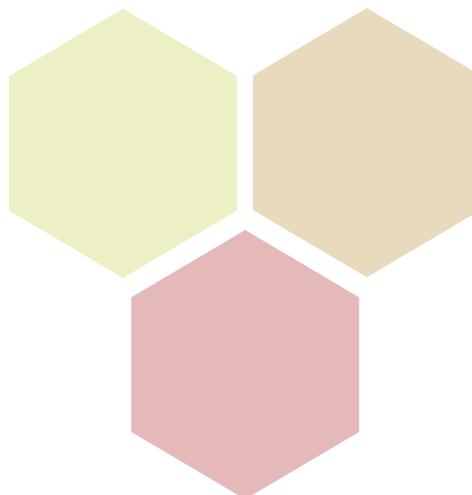
It would be desirable if recommendations could be given whether a certain collection system is more economically feasible than another. However the reality is

unfortunately not that simple as local conditions in the specific municipality needs to be taken into account. Instead of recommending one system over another, we have chosen to give some general recommendations on aspects that are important to consider and include in a calculation to economically evaluate a collection system:

- One of the aims of introducing kerbside collection of plastic packaging waste is to increase the source-sorting of plastic packaging waste and thus avoid plastic packaging waste in the mixed, unsorted waste fractions. Achieving this would mean that the amount of mixed waste decreases and so also the treatment costs for the mixed waste.
- Kerbside collection of plastic packaging waste might generate income for the collected material, either from the EPR organisations or by own sales (depending on local circumstances in the Nordic region).

- Every major change in the waste management system might require extra staff at the introduction stage for communicating the change to the households as well as staff for more practical duties such as distributing bins etc.
- A change in the waste management system often requires changes to the actual collection method or system. It is likely that changes in the system will lead to changes in collection costs, including cost of transportation.

Collection of plastic packaging waste will most likely include investment costs, operational costs such as collection of the waste, maintenance costs as well as costs for information and administration. These costs can again typically not be allocated to plastic packaging waste only. The unique overall costs for each collection system are listed below. The figures should be seen as indicative.



	Investment costs	Operational costs	Comments
Kerbside collection of source-sorted plastic packaging waste:			
in multi-compartment bins	Investments in: multi-compartment bins four-compartment vehicles solution for compressing the flexible plastic packaging waste (not compulsory).	Maintenance of bins (increased number of bins) Changed costs associated with collecting/transportation	A multi-compartment bin (370 L, three wheels, two insets, four compartments) costs around 165 euros in comparison to a 370 L ordinary waste bin to the cost of around 110 euro ²¹ . A vehicle for emptying multi-compartment bins costs in general between 280 000 – 290 000 euro ²¹ . Some municipalities with multi-compartment bins distribute so-called minimizers to the households to be used for compressing the flexible plastic packaging waste at home. The minimizers cost around 8 euros each ²¹ .
in separate containers or transparent plastic bags	Investments in: containers collection vehicles	Purchase of: transparent plastic bags Changed costs associated with collecting/transportation	The price of the optical sorting facility of Eskilstuna with a capacity to sort 20 000 – 30 000 tonnes per year was 5.2 million Euro. The municipality built the facility on their own land and reused old buildings and process equipment to keep the costs down. A similar facility for a municipality with around 500 000 inhabitants would cost around 11 million euro ²² . Plastic bags (0.03 euro per bag ²³). Eskilstuna municipality estimates that every household uses 240 plastic bags per year.
Bring systems	Investments in containers Preparation of the piece of land e.g. asphalt covering	Waste collection Maintenance costs (cleaning and snow clearance)	The collection costs for bring systems is in general lower than for kerbside collection of plastic packaging waste. This is explained by the fact that the time for emptying a multi-compartment bin is longer than for emptying a traditional bin, and that there are a higher number of collection points. Asphalt covering costs around 3200 euro per recycling station, and the maintenance costs 150 – 200 euro per year (excluding snow clearance). ²⁴
Kerbside collection of mixed waste subject to central sorting	Investments in a central sorting plant		

²¹ NTM (2014). Personal communication with Gert Olsson.

²² Göteborgs stad (2012). Fastighetsnära insamling. Litteraturstudie 2012.

²³ Göteborgs stad (2012). Fastighetsnära insamling. Litteraturstudie 2012.

²⁴ Kojo (2010). Uuden jätelainsäädännön mukaisten keräysverkostovaati- musten kustannusvaikutukset pakkausten jätehuollossa.

On the income-side there will be revenues from selling the collected packaging waste fractions, including plastic packaging waste if possible. The prices for secondary plastic raw material are commonly the same no matter if the polymers are sorted out from source-sorted sources or from centrally sorted mixed waste, given that the quality is the same (which it commonly is). Indicative prices for sorted household plastic waste are²⁷:

- Low-Density polyethylene (LDPE) film: 40 – 60 €/tonne (mixed color), 200 – 250 €/tonne (transparent/white).

- PET: bottles clear 350 – 400 €/t, bottles mixed color (>90 % bottles) 200 – 250 €/tonne, PET mixed bottles/trays (50%/50%) 20-50 €/tonne
- High-Density Polyethylene (HDPE): 260 – 300 €/tonne
- Polypropylene (PP): 180 – 220 €/tonne
- Polystyrene (PS): 100 – 150€/tonne

Treatment costs for mixed household waste will also be reduced if the total mass is reduced. The average cost to send a tonne of mixed household

waste to incineration was in Norway in 2012 1100 NOK per tonne²⁸ (134 EUR). The average cost in Sweden was 500 SEK per tonne in 2013 (55 EUR)²⁹. In Finland the cost seems to be around 80 and 90 EUR per tonne. The relationship between the costs and revenues depends on the amount collected, the quality of the collected amounts, the local treatment cost for mixed waste, the market prices for recycled plastics, and how the rest of the waste management is organised.

Cost savings in transport when collecting high quality material

High quality of the source-sorted collected plastic packaging waste is important from an economic point of view. Low purity of the collected plastic packaging waste results in transportation of material that belongs to other waste fractions. An estimate of the cost savings can be obtained by calculating the costs for the unnecessary treatment when the share of contaminants decreases. Another significant factor influencing the transport costs is the density of the material, that the transport of air is avoided as much as possible.

²⁷ Tomra (2014). Personal communication with Oliver Lambertz.

²⁸ Avfall Norge (2014). Status for energitnyttelse av avfall i Norge. Report 3/2014.

²⁹ Avfall Sverige (2014). Svensk avfallshantering 2013.



Environmental impact

Recycling of plastic packaging waste is generally more environmentally beneficial than incineration according to Nordic LCA studies. The environmental impact should be evaluated at a system level, taking into account the way of collection, the recycling processes and the replacement of virgin raw materials. The most important parameters for reducing the environmental impact for a collection and recycling system at a system level are:

- to create a system that maximizes the percentage of plastic packaging waste being collected
- to collect material of high quality to limit the amount of rejects in the following sorting and processes
- that the recycled plastics replace virgin raw materials to the highest degree possible

Transportation has generally a minor environmental impact compared to the above mentioned aspects. How plastic packaging waste is collected does not therefore determine the overall environmental impact of the system. Increased transport distance can be motivated if the amounts and quality of plastic packaging waste increase. The impact is thus obviously greater for higher transport distances why the system design should try to avoid this, e.g. to avoid that people drive to drop-off points only to recycle and not on their way to something else.

Service level and communication

Different ways of collecting plastic packaging waste correspond to a certain level of service for the households. The current legislation on plastic packaging waste in the Nordic countries does not distinguish between sparsely and densely populated areas when it

comes to service level.

In the guidelines we have defined the service level according to two aspects that are known to be valuable for households:

1. Physical availability – the distance to discard plastic packaging waste for households
2. User friendliness – is the system easily understandable and logical?

The described collection systems are evaluated in terms of current service level according to a number of questions under each of the two aspects.

Case Finnish Lapland

A case study conducted by the Finnish Environment Institute SYKE assessed the life cycle impacts of packaging waste collection in northern Finland, Finland's most sparsely populated area. One of the main questions of the study was to find out if separate collection of packaging waste is reasonable in remote and sparsely populated areas.

The study compared separate collection and sorting of plastic packaging waste to recycling to collection of mixed waste subject to incineration and substituting peat as the main fuel. The results from the study indicate that source-sorting of plastic packaging waste is beneficial from an environmental point of view compared to collection of mixed waste to incineration, even in remote, sparsely populated areas.

	Kerbside collection of source-sorted plastic packaging waste			Bring systems	Kerbside collection of mixed waste subject to central sorting
	In multi-compartment bins	In separate containers or transparent plastic bags	In coloured plastic bags prior to optical colour sorting		
Physical availability:					
Possibility to discard plastic packaging waste within the boundaries of the estate?	Yes	Yes	Yes	No	Yes
Is there need for extra bins at the property?	Yes	Yes (separate containers) NO (transparent plastic bags)	No	No	No
Possibility to discard packaging waste, mixed waste and food waste at the same place?	Yes	Yes	Yes	No (but would be possible in theory)	Yes
Need for space for source-sorted fractions at home	Medium	Medium	High	Medium	Low
User friendliness:					
Can rigid and flexible plastic packaging waste be part of the same fraction?	Yes	Yes	Yes	Yes	Yes
Need to separate plastic packaging waste from the mixed waste?	Yes	Yes	Yes	Yes	No
Accessible for both single- family homes and apartment buildings?	Yes (but is currently not common for apartment buildings)	Yes (but is currently not common for single-family homes)	Yes (but is currently not common for apartment buildings)	Yes	Yes

Communication to households

The results of a collection system based on source-sorting of plastic packaging waste depend on the consumers' attitude and willingness towards source-sorting. Getting the consumer engaged might be one of the top challenges with collection systems based on source-sorting. Only a fraction of the information households receive is actually paid attention to. The likeliness that the information leads to a change in behaviour or intensifies the existing behaviour is rather low. These are challenges that the generator of information needs to be aware of, and the reason why information should be carefully developed.

Well-known aspects that influence the tendency to source-sort more plastic packaging waste are:

- Information about the environmental benefit of source-sorting – your effort makes a difference.
- That the collection system is easily understandable and user-friendly.
- To be able to place rigid and flexible plastic packaging together in the same fraction
- Short distances to discard source-sorted plastic packaging.
- Higher costs for unsorted mixed waste favours source-sorting.

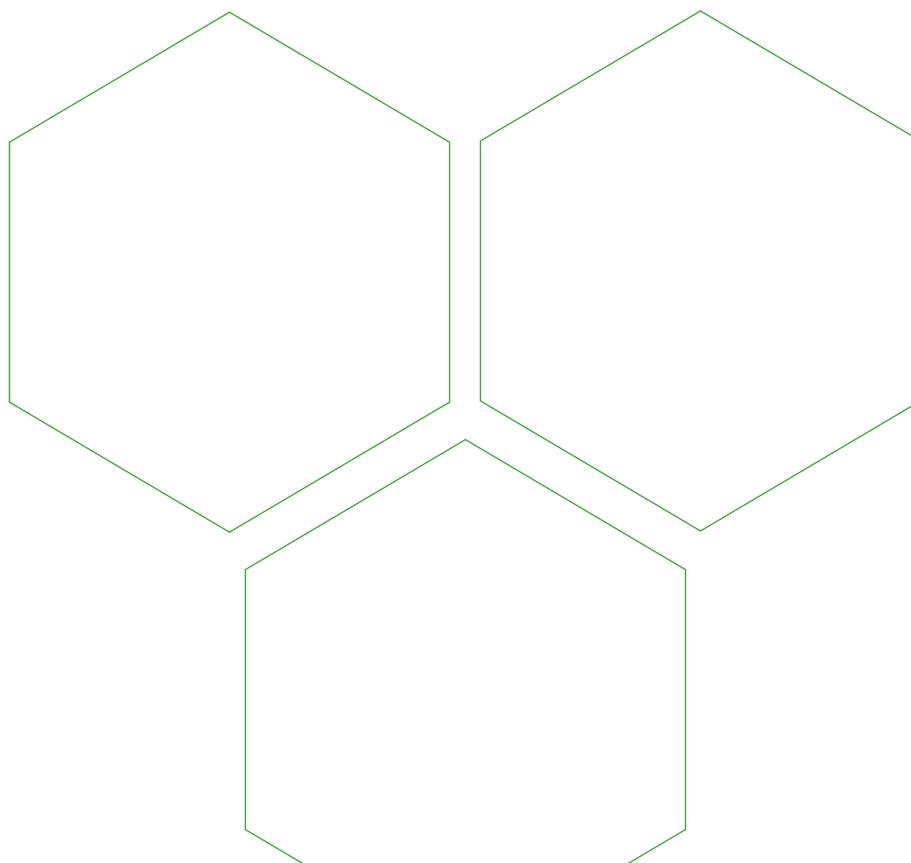
Recommendations on how to successfully communicate to households:

1. Consider the source of information. First of all, the receiver

has to perceive the source as trustworthy, reliable and relevant. The power to motivate a change in behaviour is also dependent on the perceived expertise of the source of information, the recognition and identification.

2. Use two combined/supportive types of information. Inform about the effects and consequences of the behavior, e.g. the benefits of source-sorting plastic packaging waste, and describe how to do it in practical terms.

3. Communicate what happens with the plastic packaging waste. What households often lack is information about how the source-sorted material is taken care of after collection, to be assured that their efforts are appreciated, independent of the collection





system. It has been shown that knowledge about the fate of the plastic packaging waste is lower than for other packaging waste fractions.

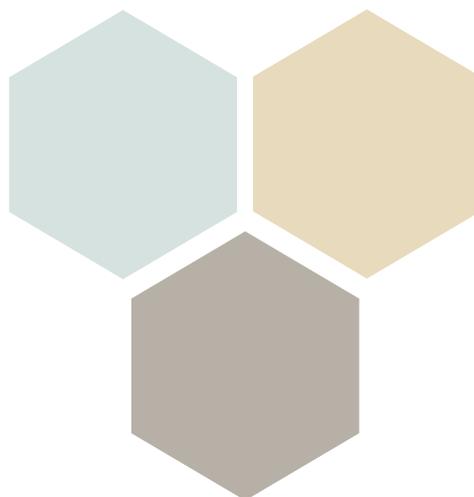
4. Focus the communication on target groups. This can be done by analysing the source of the waste and the motivation needs of the target group. Information targeted on households in apartment buildings might for example not be relevant for households in single-family homes. Communication towards target groups is also about making sure that the information that is specific and easily recognizable, such as rules applicable in an actual residential area.

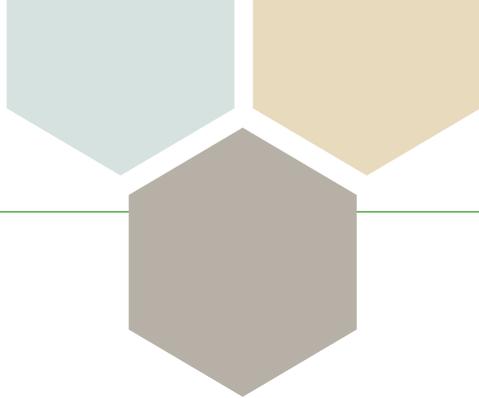
5. Different demographic groups seek information from different sources, so it is important to keep in

mind that one solution does not fit everybody. It is important to consider how to communicate information to the younger generation, older generations, people from foreign origin (especially people who perhaps do not speak the language), etc.

6. Pay special attention when the collection system is relatively anonymous. Devoted communication is especially important when the collection systems are public or accessible to a high number of people, such as bring systems and separate containers or transparent bags for apartment buildings. Kerbside collection systems where each household has their own bin or disposal solution provide by its existence information about the possibility to source-sort the waste.

7. Use short, relevant and distinct information. The layout and structure of the information is important as it is hard to get the households to pay attention to certain information. Visual information could have advantages above information containing dense texts. There might not be an interest to search for information about the collection system, which means that information about plastic packaging, on TV, radio, on public transport etc. is a good complement to internetbased information. Face-to-face communication has actually proven to be the most effective method to spread the word.





Flexibility

The flexibility is about how easy it is to change the collection system when the surrounding circumstances change. This applies e.g. to changes in other parts of the waste management chain or to changes in national or international legislation. Questions that should be asked before implementing a certain collection system for plastic packaging waste are:

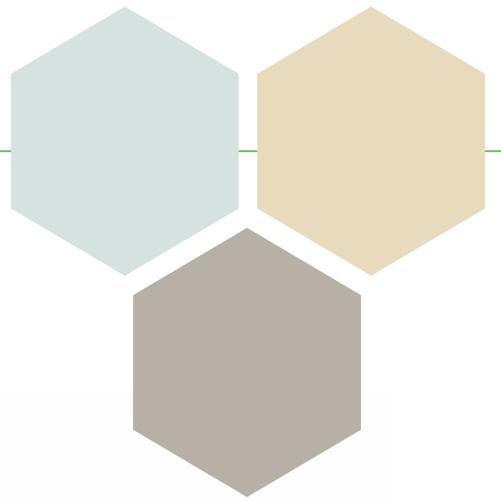
- How flexible is the technical setup (practical solutions, sorting equipment, collection vehicles etc.) if the collection system is no longer required?
- Will the system be capable of handling increased collected amounts of plastic packaging waste?
- Is it possible to collect both non-packaging plastic waste and plastic packaging waste together? How does a higher number of plastic waste fractions influence the collection system?

We have compared the collection systems by putting a value on the level of flexibility according to the questions above. The evaluation is by no means complete, but there to highlight the importance to consider the flexibility of a certain collection system.

1. Kerbside collection of source-sorted plastic packaging waste:		
	Level of flexibility	Explanation
1.1 In multi-compartment bins		
Technical setup	Medium	<p>Bins: The inset in the bin can be removed, and the bin converted to a “traditional” waste bin. The alternative use of multi-compartment vehicles is limited.</p> <p>Vehicles: It is possible to use the same vehicle for emptying ordinary waste bins if the compartments are organised in a certain manner.</p>
Adaptation to increased collected amounts	High	Increased collection of plastic packaging waste requires a higher collection frequency or a higher number of bins.
Adaptation to increased number of source-sorted plastic packaging waste fractions	Low	The number of fractions is currently limited to four per bin. It is thus common to have two bins with a total of eight fractions. More fractions would require another bin or another structure of the waste fractions.
Collection of both plastic packaging and non-packaging waste in the same fraction	High	Change in collected amounts needs to be paid attention to as well as the risk of introducing hazardous substances in the recycling system.

	Level of flexibility	Explanation
1.2 In separate containers or transparent plastic bags		
Technical setup	High	Bins: Ordinary waste bins can be used. Vehicles: Standard single-or two-compartment vehicles are used enabling emptying of bins with different sizes.
Adaptation to increased collected amounts	High	Increased collection of plastic packaging waste requires a higher collection frequency or a higher number of bins.
Adaptation to increased number of source-sorted plastic packaging waste fractions	High	Another bin or plastic bag can be added.
Collection of plastic packaging and non-packaging waste in the same fraction	High	Change in collected amounts needs to be paid attention to as well as the risk of introducing hazardous substances in the recycling system.
1.3 In coloured bags prior to optical colour sorting		
Technical setup	Medium	Bins: Ordinary waste bins can be used. Vehicles: Ordinary collection vehicles can be used. Sorting facility: Optical sorting requires investments in sorting plants making the systems less flexible towards external changes as it is costly to change to another collection system where optical colour sorting is not used. It is however possible to adapt the sorting lines to a higher or lower number of fractions.
Adaptation to increased collected amounts	High	Increased collection of plastic packaging waste requires a higher collection frequency or a higher number of bins.
Adaptation to increased number of source-sorted plastic packaging waste fractions	High	Another coloured bag dedicated to a new waste fraction can be added and sorted out at the optical sorting facility.
Collection of plastic packaging and non-packaging waste in the same fraction	High	Change in collected amounts needs to be paid attention to as well as the risk of introducing hazardous substances in the recycling system

2. Bring systems		
	Level of flexibility	Explanation
Technical setup	High	The collection vehicles and containers are of standard type and could find other uses.
Adaptation to increased collected amounts	High	Change to larger containers is possible. If a higher number of drop-off stations is needed it can be challenging to find areas for establishment in densely populated urban areas. A higher collection frequency is also a part of the solution.
Adaptation to increased number of source-sorted plastic packaging waste fractions	High	Another container can be added.
Collection of both plastic packaging and non-packaging waste in the same fraction	High	Change in collected amounts needs to be paid attention to as well as the risk of introducing hazardous substances in the recycling system
3. Kerbside collection of mixed waste subject to central sorting		
Technical setup	Low	<p>Bins: Ordinary waste bins can be used.</p> <p>Vehicles: Ordinary collection vehicles can be used.</p> <p>Sorting facility: The central sorting facility requires investments making the systems less flexible towards external changes as it is costly to change to a source-sorting collection system.</p>
Adaptation to increased collected amounts	High	Increased collection of plastic packaging waste requires a higher collection frequency or a higher number of bins. The same waste flows are still collected together.
Adaptation to increased number of source-sorted plastic packaging waste fractions	Not relevant	Plastic packaging waste is not source-sorted within the system.
Collection of both plastic packaging and non-packaging waste in the same fraction	High	Change in collected amounts needs to be paid attention to as well as the risk of introducing hazardous substances in the recycling system.





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