THE RECYCLING OF HEINZ PET PACKAGING IN EUROPE

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BACHELOR THESIS

THE RECYCLING OF HEINZ PET PACKAGING IN EUROPE

Heinz would like to know how their post-consumer PET plastic packaging is recycled in Europe. This report describes the organization, legislation and techniques concerning PET recycling in the Netherlands, Germany and the United Kingdom. Two types of Heinz bottles are evaluated on their compatibility with legislation and recycling techniques and recommendations are made on how to improve the packaging for recycling.

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1. INDEX

2. SUMMARY

This research project on the legislation and practice of recycling of PET packaging in Europe is conducted on behalf of the H.J. Heinz Innovation Centre continental Europe. The objectives of the research project are:

- To determine what legislation and guidelines the European Union and individual European countries currently have for the recycling of Heinz' plastic packaging, and if there are any changes to be foreseen in the next 5 years.
- To describe what recycling methods European countries currently use for the recycling of Heinz' plastic packaging, and if there are any changes to be foreseen in the next 5 years.
- To determine the 'recyclability' of Heinz' plastic packaging by researching the compatibility of the packaging with current recycling methods.
- To make recommendations for the Heinz' packaging development team, using the information gained, about design guidelines for recycling. This is to inform Heinz about optimally and effectively responding to current and future legislation and recycling methods.

The research project was conducted in four months time. Due to the limited time available the research was restricted to the exploration of three countries: The Netherlands, Germany and the United Kingdom. And two types of Heinz packaging: the Top Down 570ml bottle and the Icon 875ml bottle.

The focus of the research project is on mechanical recycling, where used plastic packaging is converted to new raw material, that can be used for the production of new products.

The bottles are made up of the elements shown in Figure 1. The container is multilayer of PET, and an oxygen-barrier. The labels are made of paper, the cap is PP. A silicone valve is included in the cap of the Top Down bottle.

European legislation stimulates mechanical recycling of plastic packaging by setting recycling targets for it's member states, the current recycling target for plastic packaging is 22.5%. The legislation contains essential requirements for packaging, these focus on material reduction and making the packaging suitable for reuse, incineration, recycling or composting.

Figure 1 The bottles researched: Top Down (left) and Icon bottle (right)

The Netherlands, Germany and the UK transposed the European legislation into national law, and stated that companies that put plastic packaging on the market are responsible for the recovery and recycling of that packaging. In practice there are organizations that are financed by membership fees or taxes of these companies and that take over this responsibility from the paying companies by organizing separate collection and recycling of plastic packaging. Most European countries use a system where the consumer submits plastic packaging waste separately from other household waste.

Once used plastic packaging is collected from the consumer it needs to be sorted to polymer type. This happens at sorting stations who remove contamination like non-packaging items and metal and that use automated sorting to sort to polymer type. PET that is sorted out is sold to a PET recycler. The recycler washes and shreds the PET objects into flakes and separates the PET flakes from other plastics like PP and PE that come from caps and labels. The PET is now 'rPET', recycled PET, and is sold to manufacturers in the form of flakes or granulate. Typical end-uses of rPET are fiber, sheet, bottles and strapping.

The sorting of the Heinz bottles was tested, and turned out to be problematic. The automated sorting machines work with Near Infra Red (NIR) technology, they project NIR light at a plastic object and register the reflected light, every polymer type reflects the light differently thus different polymer types can be distinguished. Ketchup residue inside the post-consumer Heinz bottles changes the reflected NIR light so that it cannot be detected as being PET, thus the bottles are not sorted into the PET output and instead go for incineration.

Evaluation of the Heinz bottles at PET recyclers showed that the barrier in the PET container shows yellow/brown discoloration when heated. This discoloration shows in the final product and is especially disturbing for sheet and bottle end-uses. The silicone valve enclosed in the cap of the Top Down bottles results in droplets in the products made from the rPET, deceasing the quality of the products. Concluding the bottlenecks observed at the recyclers, the paper labels contaminate the washing water of the PET recycler because they pulp.

The research on legislation and recycling practices and the observation of bottlenecks with the Heinz bottles leads to the following recommendations to the Heinz packaging development team.

Features of the perfect Heinz ketchup bottle, facilitating bottle to bottle recycling:

Figure 2 The perfect bottle

Summary of the most important recommendations for follow-up research:

Recommendations on follow-up research:

- Research other types of packaging and other countries
- Research sorting problems
- Research compliance with the essential requirements
- Research the effect of using recycling logo's on packaging on the consumer
- Research the use of a diffrent type of barrier
- Research a dispensing mechanism that does not need silicone

Figure 3 Recommendations for follow-up research

3. SUMMARY IN DUTCH

Dit onderzoek naar de wetgeving en praktijk rondom de recycling van PET verpakkingen in Europa is uitgevoerd namens het H.J. Heinz Innovation Centre continental Europe. De doelstellingen van het onderzoek zijn als volgt:

- Het beschrijven van de huidige wetgeving in de Europese Unie en individuele Europese landen betreffende de recycling van de plastic verpakkingen van Heinz, en de eventuele te voorziene veranderingen in deze wetgeving in de komende 5 jaar.
- Het beschrijven van huidige recycling methoden voor de plastic verpakkingen van Heinz in verschillende Europese landen, en de eventuele te voorziene ontwikkelingen in de komende 5 jaar.
- Het bepalen van de mate van ‘recyclebaarheid’ van de plastic verpakkingen van Heinz door te onderzoeken hoe de verpakkingen de huidige recycle processen doorlopen.
- Het doen van aanbevelingen voor het verpakking ontwikkelingsteam van Heinz betreffende ontwerprichtlijnen voor recycling, naar aanleiding van de onderzoeksresultaten. Dit om Heinz optimaal en effectief te laten inspelen op huidige en toekomstige wetgeving en recycling methoden.

Het onderzoek is uitgevoerd in een tijdspan van vier maanden. Door deze beperkte tijdspan is het onderzoek beperkt tot het onderzoeken van drie landen: Nederland, Duitsland en het Verenigd Koninkrijk. En mede tot twee typen verpakkingen van Heinz: de Top Down 570ml fles en de Icon 875ml fles.

De focus van het project ligt op mechanische recycling, waarbij gebruikte kunststof verpakkingen omgezet worden naar nieuwe grondstoffen die gebruikt kunnen worden voor de productie van nieuwe producten.

De flessen bestaan uit de elementen te zien in Figuur 1. De container is meerlaags en bestaat uit PET en een zuurstofbarrière. De labels zijn gemaakt van papier en de doppen van PP. Een siliconen spuitmond is opgenomen in de dop van de Top Down fles.

De Europese wet stimuleert de mechanische recycling van plastic verpakkingen door het stellen van recycle doelstellingen voor haar lidstaten, de huidige doelstelling voor de recycling van kunststof verpakkingen is 22,5%. De wet bevat essentiële eisen voor verpakkingen, die richten zich op materiaal reductie en het geschikt maken van de verpakking voor hergebruik, verbranding, recycling of composteren.

Figuur 1 De onderzochte flessen: Top Down (links) en Icon fles (rechts)

Nederland, Duitsland en het Verenigd Koninkrijk hebben de Europese wet omgezet in nationale wetgeving, en stellen dat de bedrijven die kunststof verpakkingen op de markt brengen verantwoordelijk zijn voor het terugwinnen en recyclen van die verpakkingen. In de praktijk bestaan er organisaties die gefinancierd zijn door lidmaatschapsgelden en belastingen van deze bedrijven en die deze verantwoordelijkheid van deze bedrijven overnemen door het organiseren van gescheiden inzameling en recycling van plastic verpakkingen. De meeste Europese landen gebruiken een systeem waarbij de consument de kunststof verpakkingen gescheiden van ander huishoudelijk afval aanlevert.
Wanneer de gebruikte kunststof verpakkingen ingezameld zijn dienen zij gesorteerd te worden naar kunststofsoort. Dit gebeurt in sorteringinstallaties die vervuiling zoals niet-verpakkingen en metaal verwijderen en die geautomatiseerde sorteermachines gebruiken voor het scheiden naar kunststofsoort. Uitgesorteerd PET wordt verkocht aan een PET recycler. De recycler wast en vermaalt de PET objecten tot snippers en scheidt de PET snippers van andere kunststoffen zoals PP and PE die afkomstig zijn van doppen en labels. Het PET wordt nu ‘rPET’ genoemd, recycled PET, en is verkocht naar fabrikanten in de vorm van vlokken of granulaat. Typische eindtoepassingen van rPET zijn vezels, sheet, flessen en strapping.

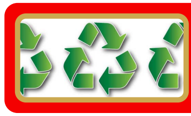
Het sorteren van de Heinz flessen is getest, en bleek problematisch te zijn. De geautomatiseerde sorteermachines werken met Near Infra Red (NIR) technologie, ze projecteren NIR licht op een kunststof voorwerp en registreren het weerkaatste licht, elk soort kunststof reflecteert het licht anders en zo kunnen verschillende kunststofsoorten onderscheiden worden van elkaar. De ketchup die achterblijft in gebruikte Heinz flessen verandert de reflectie van het NIR licht zodat het niet gedetecteerd kan worden door de sorteermachines als zijnde PET, zo worden de flessen niet gesorteerd naar de PET uitvoer maar worden ze verbrand.

De evaluatie van de Heinz flessen bij PET recyclers liet zien dat de barrière in de PET containers bij verhitting geel/bruin verkleurt. Deze verkleuring verschijnt in de producten gemaakt van het rPET en verstoort met name de productie van sheet en flessen. De siliconen spuitmond die in de dop van de Top Down fles zit resulteert in druppels in producten gemaakt van rPET of rPP, wat de kwaliteit van de producten vermindert. Het laatste knelpunt dat geobserveerd werd tijdens de evaluatie waren de papieren labels die het waswater van de recycler vervuilen omdat ze pulp vormen in water.

Het onderzoek naar de wetgeving en recycling technieken en de observatie van knelpunten met de Heinz flessen heeft geleid tot de volgende aanbevelingen voor het verpakking ontwikkelingsteam van Heinz.
Eigenschappen van de perfecte Heinz fles, die bottle to bottle recycling mogelijk maakt:

De perfecte fles
voor B2B recycling

De container heeft een zuurstof-barriere die niet verkleurt tijdens verhitting, en die een redelijke shelf-life garandeert



De container bestaat uit een percentage rPET, dit voltooit de kringloop: fles naar rPET naar fles

De dop bevat geen siliconen

De labels op de fles zijn van kunststof

Figuur 2 De perfecte fles

Samenvatting van de belangrijkste aanbevelingen betreffende vervolgonderzoek:

Aanbevelingen voor vervolgonderzoek:

- Onderzoek andere typen verpakkingen en andere landen
- Onderzoek de sorteerproblemen
- Onderzoek de naleving van de essentiële eisen
- Onderzoek het effect van recycling logo's op verpakkingen op de consument
- Onderzoek het gebruik van een ander type barriere
- Onderzoek een dispenseer mechanisme dat geen siliconen nodig heeft

Figuur 3 Aanbevelingen voor vervolgonderzoek

4. INTRODUCTION

4.1. INTRODUCTION TO THE RESEARCH PROJECT

This research project is executed on behalf of the H.J. Heinz Innovation Centre continental Europe.

The H.J. Heinz Company is a global U.S.-based food company. It owns iconic brands on six continents, and in more than 50 countries it enjoys a number one or number two market position. Heinz is famous for it's ketchup, but Heinz also markets an ever-expanding selection of other foods. The core products include ketchup, sauces, meals, snacks, an infant/nutrition. (1)

In 1958 Heinz was first established in the Netherlands, in Elst, and started with production and sales of sandwichspread and later on, tomato ketchup. The present Heinz in the Netherlands was established in 2001, with the acquisition of Honig and the Ruijter. This acquisition makes Heinz the second greatest player in Foods in the Netherlands. (2)

> **"AS THE TRUSTED LEADER IN NUTRITION AND WELLNESS, HEINZ – THE ORIGINAL PURE FOOD COMPANY – IS DEDICATED TO THE SUSTAINABLE HEALTH OF PEOPLE, THE PLANET AND OUR COMPANY"**

H.J. Heinz company mission statement (3)

As stated in Heinz' mission statement, Heinz is dedicated to the sustainable health of people, the planet and it's company. Sustaining the health of the planet has been a hot topic worldwide for the last decades, and focusing on sustainability is becoming more important for companies, including Heinz.

The most popular definition of sustainability can be traced to a 1987 UN conference and can be expanded with definitions of Rosenbaum and Viera:

"Sustainable developments are those which fulfill present and future needs (WECD, 1987) while [only] using and not harming renewable resources and unique human-environmental systems of a site: [air], water, land, energy, and human ecology and/or those of other [off-site] sustainable systems (Rosenbaum 1993 and Viera 1993)" (4)

Three pillars of sustainability can be deduced from this definition: economic, environmental and social. These pillars are also incorporated by the United Nations' Division of Sustainable Development: "The achievement of sustainable development requires the integration of its economic, environmental and social components at all levels". (5)

The mission statement of Heinz fits together perfectly with the three pillars of sustainability: Heinz is dedicated to the sustainable health of people (social), the planet (environment) and our company (economic).

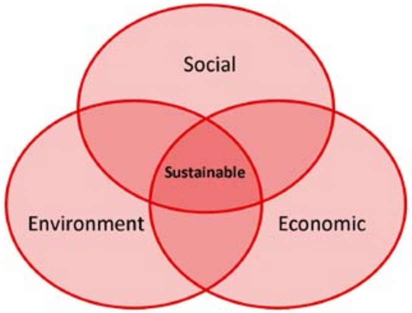


Figure 4 Three pillars of sustainability

Heinz is a food-based company, and all foods of Heinz need packaging. Materials used for Heinz' packaging include plastic, glass, metal and paper. Packaging is necessary for transport , food safety and shelf life, but also poses an impact on the environment. The production of packaging requires the use of scarce natural resources and comes with the emission of greenhouse gasses.

One way of reducing the impact of packaging on the environment is recycling. Regulations and methods concerning recycling are continuously evolving. To help pursue it's mission statement, Heinz wants to know how it can reduce impact on the environment, while still sustaining the health of people (food safety, quality, A-brand image) and the company (costs/savings). Heinz possesses enough knowledge about the recycling of glass and paper, but would like to know more about recycling of plastic because plastics compose the largest part of Heinz' packaging and the habit of recycling plastic packaging is increasing greatly in Europe. With this study in particular, Heinz would like to obtain more information about regulations and methods of recycling plastic packaging within Europe.

The objectives of this research project are:

- To determine what legislation and guidelines the European Union and individual European countries currently have for the recycling of Heinz' plastic packaging, and if there are any changes to be foreseen in the next 5 years.

- To describe what recycling methods European countries currently use for the recycling of Heinz' plastic packaging, and if there are any changes to be foreseen in the next 5 years.

- To determine the 'recyclability' of Heinz' plastic packaging by researching the compatibility of the packaging with current recycling methods.

- To make recommendations for the Heinz' packaging development team, using the information gained, about design guidelines for recycling. This to inform Heinz about optimally and effectively responding to current and future legislation and recycling methods (in order to decrease environmental impact from Heinz' packaging, and sustain or improve Heinz' corporate economic health).

The research project was conducted in four months time. Due to the limited time available the research was restricted to the exploration of three countries and two types of Heinz packaging.

4.2. Introduction to plastic packaging

Even though packaging is widely used all over the world, it's role is often underestimated. Packaging is indispensable for storage, distribution and use of a broad variety of products. During it's lifetime, a piece of packaging moves through different phases, during which the function the packaging fulfills will often change. (6)

History's first forms of packaging are found in nature: like the shell of a nut and the peel of an orange. Humans started packaging things with leaves, woven baskets, animal skin and animal intestines like bladder and bowels. In the centuries BC, glass and stoneware were popular methods of packaging. Not until the industrial revolution other types of packaging were developed. The emergence of mass production resulted in cardboard and tin can packaging in the 18th and 19th century. In the beginning 19th century the first plastic packaging were made from PVC, PE, PS and Bakelite.

In the seventies the first beverage bottles were made from plastics, mainly PVD and PAN. The use of PET for beverage bottles started in the late seventies and flourished in the eighties. Ever since, PET is one of the two dominant plastics used for plastic bottles. Figure 5 shows the growing demand in Western Europe for PET since the late eighties.

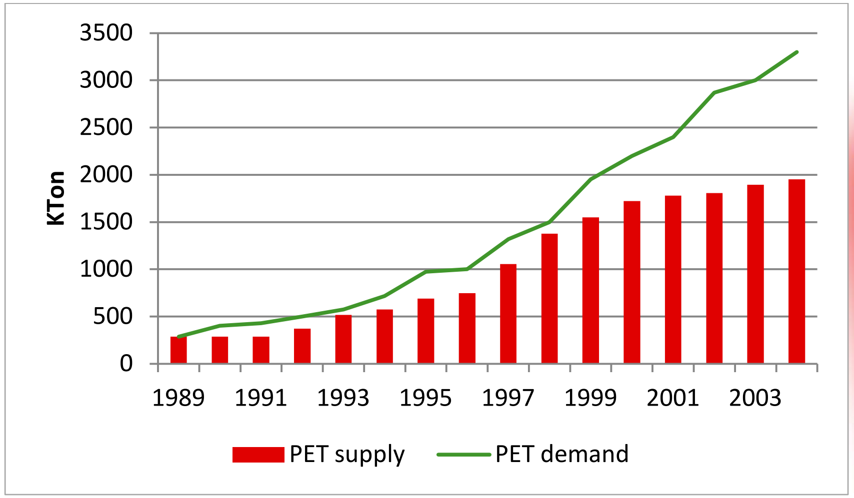


Figure 5 Supply/demand balance PET for Western Europe (7)

Ten Klooster (6) describes a total of five packaging functions:

1. To contain: the content, the packaged product
2. To facilitate transport, storage and handling
3. To protect (the content) from environmental influences
4. To inform
5. To facilitate end-use and disposal

These functions need to be optimally fulfilled, but often have to be weighed against each other. For example, glass bottles have excellent barrier properties for environmental influences, but are difficult to transport. This research project will focus mainly on function 5: the facilitation of end-use and disposal. But the other four functions will be taken into consideration when making recommendations to improve recyclability.

H.J. Heinz is a food company, so when considering packaging for Heinz products, packaging function one: containing the product, is very important. Food is packaged to prevent food waste. A Dutch concept on food waste is the 'Ladder of Moerman'. The Ladder of Moerman describes ways to use food waste in order of preference, starting with the greatest preference: prevention, and ending with landfill as least preferential.

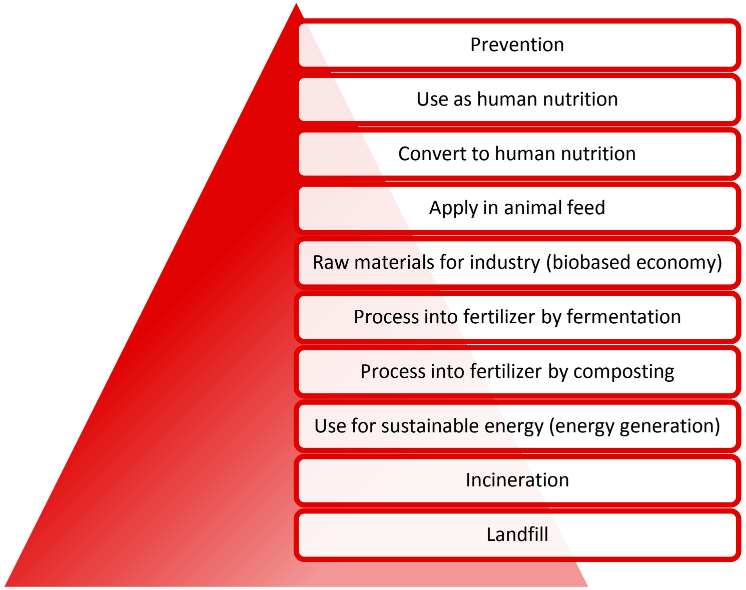


Figure 6 'Ladder of Moerman'

Packaging plays an important role in the prevention of food waste. For some people, plastics have a bad reputation: they unnecessarily use materials and energy. But because packaging prevents food waste, packaging food can actually be more sustainable than not packaging food, as shown in Figure 7.

Packaging prevents food waste, the top priority in the Ladder of Moerman. But packaging also creates waste, thus the prevention of food waste should be weighed against the creation of packaging waste. The next chapter will look into ways of reducing the impact of PET packaging on the environment.

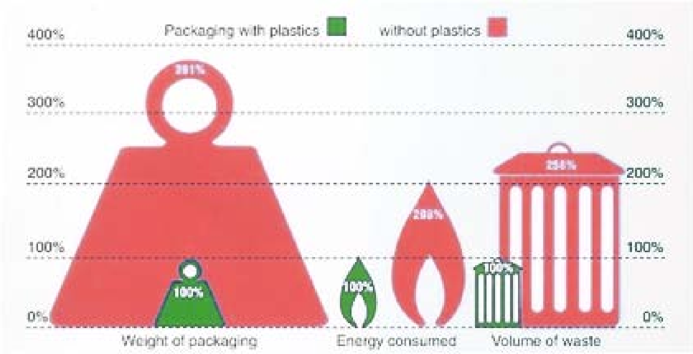


Figure 7 Plastic packaging versus non-plastic packaging (8)

4.3. Introduction to plastic recycling

With the rising amount of plastic packaging used in Europe and the rising concerns for the environment, the European Parliament imposed the Packaging Waste Directive (94/62/EG) in 1994. The directive is concerned with minimizing the creation of packaging waste material, and promotes recovery of plastic packaging (post-consumer and production waste).
There are several options to recover plastic waste, Figure 8 gives an overview of these options.

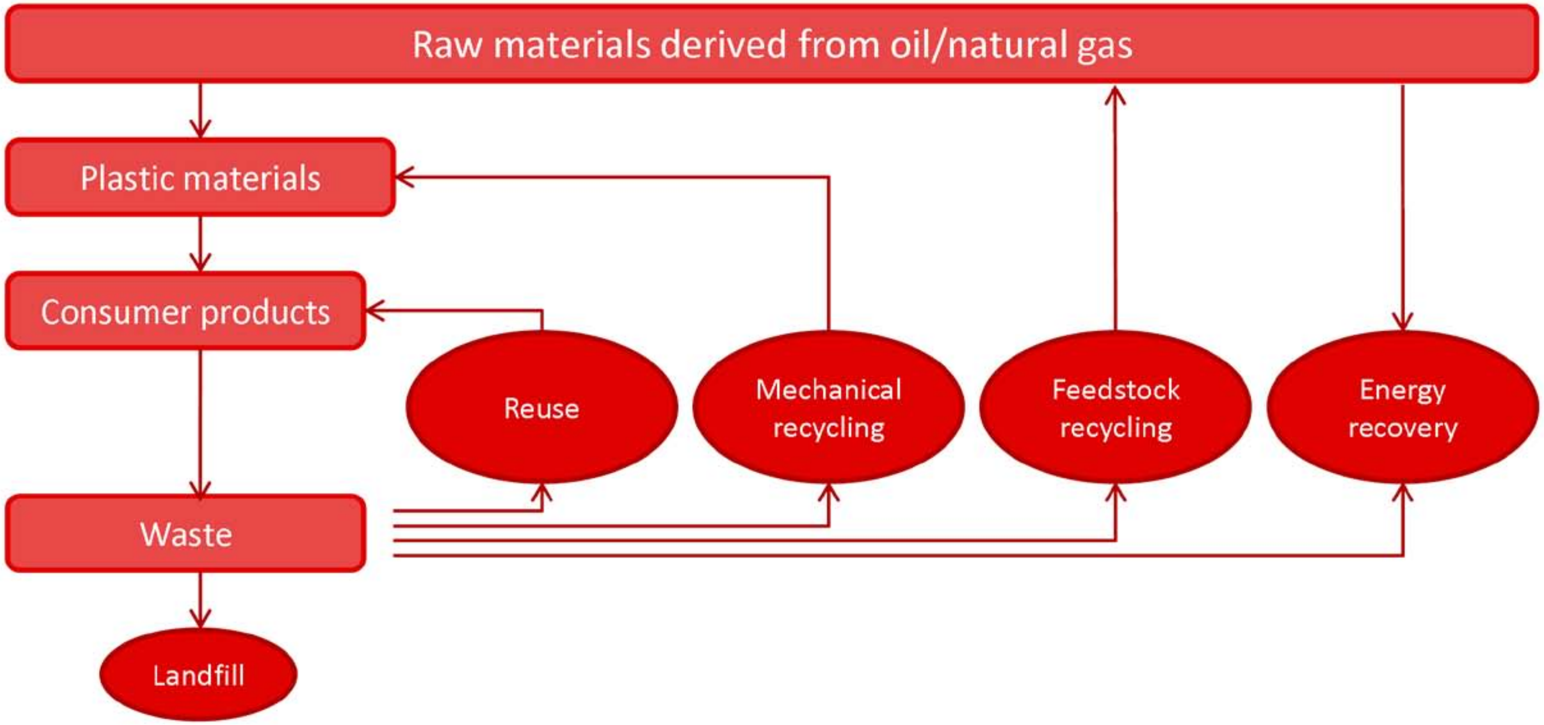


Figure 8 Recovery options of plastic waste (9)

The cycle starts with the production of plastic materials from raw materials (oil/natural gas). The plastic materials are converted into consumer products, and after use by the consumer, the plastic turns into waste. Once the plastic becomes waste there are several recovery options:

Reuse: If a packaging is reused the original shape and/or function remain recognizable. A distinction can be made between two types of reuse. Primary reuse: the reused packaging keeps the same function as before (e.g. the refilling of bottles). Secondary reuse: the reused packaging is used for a new function and is possibly adjusted in shape (e.g. using a shopping bag to cover furniture while painting the house). (10) The consumer can initiate the reuse on his own: for example reusing a carrier bag from the supermarket. But some reuse is initiated by the government or companies, the most common example of this are beverage bottle deposit systems.

Mechanical recycling: The packaging is converted into a new raw material that can be used for the production of new products. The original shape and function of the packaging are no longer recognizable after mechanical recycling. If the waste material is applied to manufacture the same type of product that it used to be, it is called primary mechanical recycling (e.g. 'Bottle to Bottle recycling': post-consumer PET beverage bottles are used to manufacture new PET beverage bottles). In secondary mechanical recycling the waste material is applied in the manufacturing of a completely different product (e.g. PET bottles being recycled into polyester fabric). Mechanical recycling is also differentiated into internal and external recycling. Internal

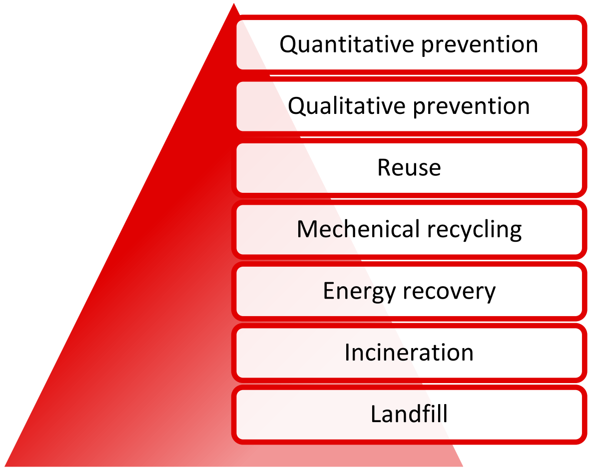


Figure 9 'Ladder of Lansink'

recycling is when the recycled material is used by the same company (e.g. production waste), and external recycling is when a different company uses the recycled material. (10)

Chemical recycling: is also called feedstock recycling. Chemical recycling is a group of recycling technologies that convert mixtures of plastics into petroleum feedstock or raw materials that can be used in refineries and petrochemical facilities. These secondary raw materials can be used to make new products. (11)

Energy recovery: The process of recovering the thermal energy produced through incineration. Through energy recover, plastics can substitute fossil fuels as an energy source.

Landfill: Landfilling is not a recovery method, but a disposal method. Landfilling, or 'dumping', is disposing of waste by burial. The European Union is aiming to reduce landfilling as a waste disposal option.

Like the 'Ladder of Moerman' on food waste, there is the 'Ladder of Lansink' (named after the Dutch politician Lansink, who introduced this ladder in 1979) on waste management. The 'Ladder of Lansink' describes ways to deal with waste, in order or preference: prevention, reuse/recycling, incineration and landfill. In 2002 the ladder was expanded to 7 steps, as shown in Figure 9. Quantitative prevention means preventing development of waste, and qualitative prevention means using materials that have as little impact on the environment as possible.

The Ladder of Moerman and the Ladder of Lansink need to be weighed against each other when designing packaging. For example, fully focusing on packaging material reduction can endanger food waste prevention. Thus Moerman and Lansink should meet in the middle.

This research project focuses mainly on optimizing packaging for mechanical recycling of plastic packaging and on guidelines about quantitative and qualitative prevention. Reuse, chemical recycling, incineration and landfill will not be looked into. This because there are currently no reuse schemes in place in Europe suitable for Heinz packaging (only beverage bottle deposit systems) and chemical recycling is barely practiced in Europe (as can be seen in Figure 10) and incineration and landfill are the least preferential waste treatment options in the 'Ladder of Lansink'.

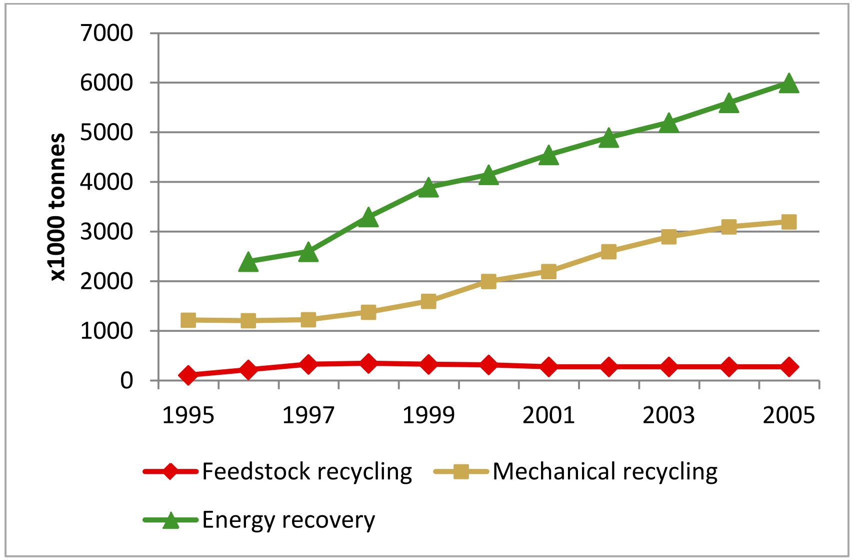


Figure 10 The development of plastic waste treatment options in Europe (12)

5. SELECTION OF RESEARCH SUBJECT

5.1. PACKAGING

This research project will be restricted to the packaging of Heinz' largest stock keeping unit and to the European countries where most of the largest stock keeping unit is distributed to. This chapter arguments the choice of the packaging and countries that are researched.

Plastic Heinz ketchup bottles are the largest stock keeping units of H.J. Heinz Company in Europe. The ketchup bottle range contains top down bottles and icon bottles in different sizes.

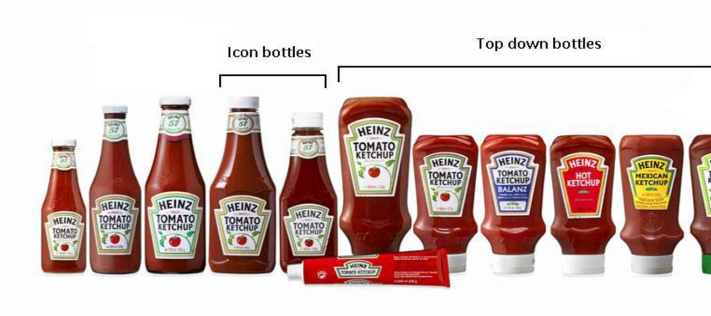


Figure 11 Heinz ketchup bottles (The Netherlands)

Figure 12 shows that the top down bottle 570ml is produced in the greatest volume. The top down bottle cap and icon bottle cap are also produced in large numbers. These caps fit on different sized bottles, this explains why they outnumber the amount of individual bottles.

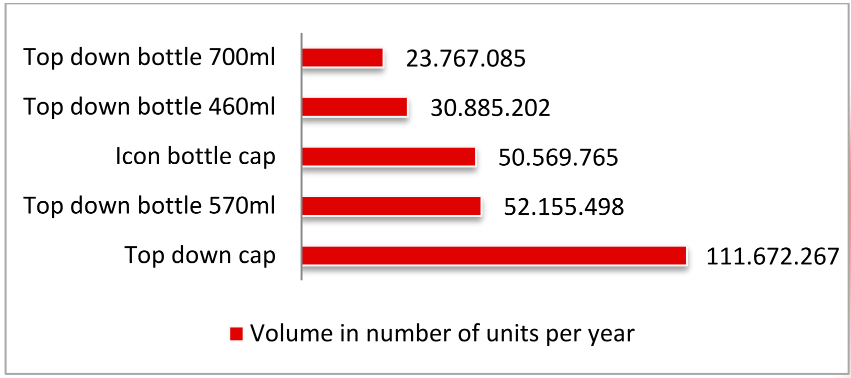


Figure 12 Heinz Europe top 5 types of packaging per year (May 2010 to April 2011) (13)

A great volume in numbers does not automatically mean a greater weight in waste, because some bottles or caps weigh more than others. To determine what packaging results in the greatest weight in waste, we multiply the volume in numbers with the weight of one unit. The result is shown in Figure 13. Despite the large numbers of caps produced, the bottles produce more waste because of their larger weight, the Top Down 570ml bottle results in the greatest weight in waste.

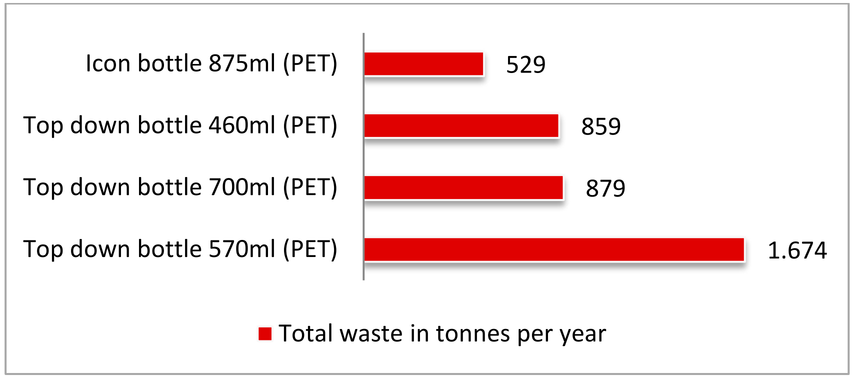


Figure 13 Heinz Europe top 4 types of packaging resulting in the greatest volume of waste in kg (may 2010 to april 2011) (13)

Heinz would like to include the Icon 875ml bottle in this study because this bottle is spread all over Europe (unlike the top down bottles), and therefore is very universal.

Figure 14 Icon 875ml bottle (left) and Top Down 570ml bottle (right)

The above argues why this research project focuses on the top down 570ml bottle; because it results in the greatest volume of waste in Europe. And also includes the Icon 875 ml bottle; because Heinz prefers this, and the bottle is almost the same (material wise) as the top down bottle.

5.2. Countries

Heinz tomato ketchup is a popular product in Europe. As can be seen in Figure 15, the United Kingdom is the biggest consumer of Heinz ketchup in Europe. But Heinz Europe also serves some countries outside of Europe, Figure 15 shows that Russia is actually the second largest consumer of Heinz ketchup of all countries Heinz Europe serves.

Figure 13 showed that the Top Down 570ml bottles result in 1,674 tons of packaging waste in Europe, and the Icon 875ml bottles result in 529 tons of packaging waste. This packaging waste is not distributed equally among the European countries because some countries use more ketchup, and packaging, than others. And not all types of bottles are distributed in all European countries, in the UK, for example, there is no Icon 875ml bottle. The figures on page 13 show the distribution of packaging waste in Europe of the Top Down 570ml and the Icon 875ml bottle.
See Appendix B for a list of country abbreviations.

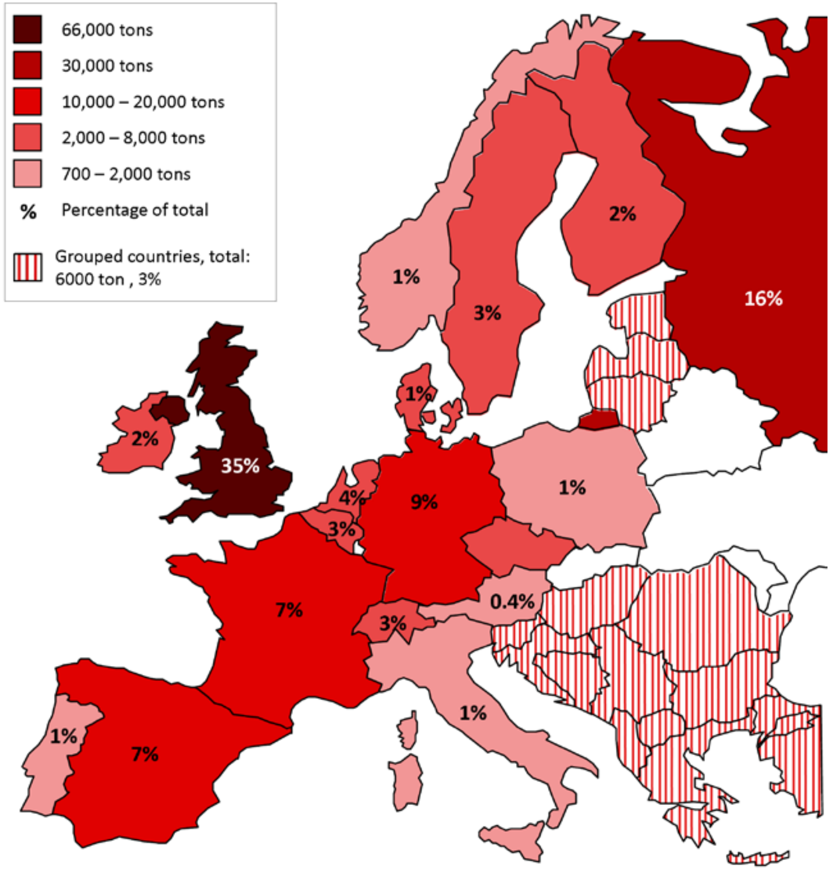


Figure 15 Distribution of Heinz tomato ketchup in tons (May 2011 to April 2012) (14)

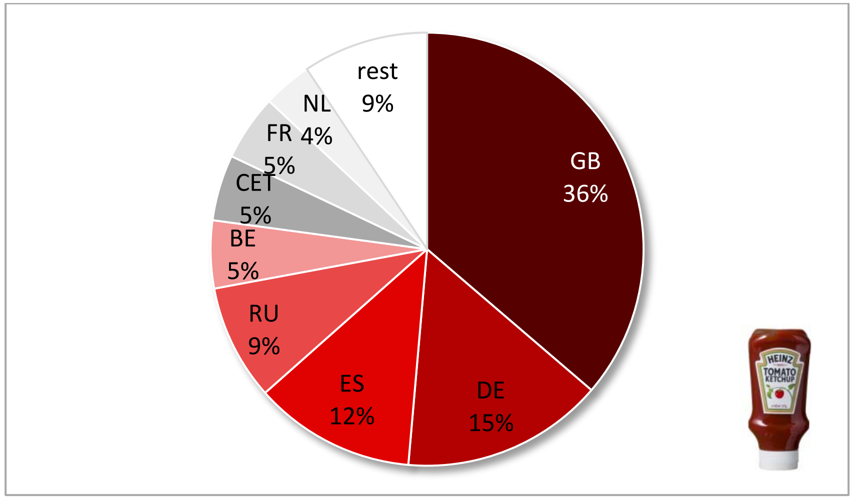


Figure 16 Distribution of packaging waste in Europe of the Top Down 570ml bottle (May 2011 to April 2012) (14)[1]

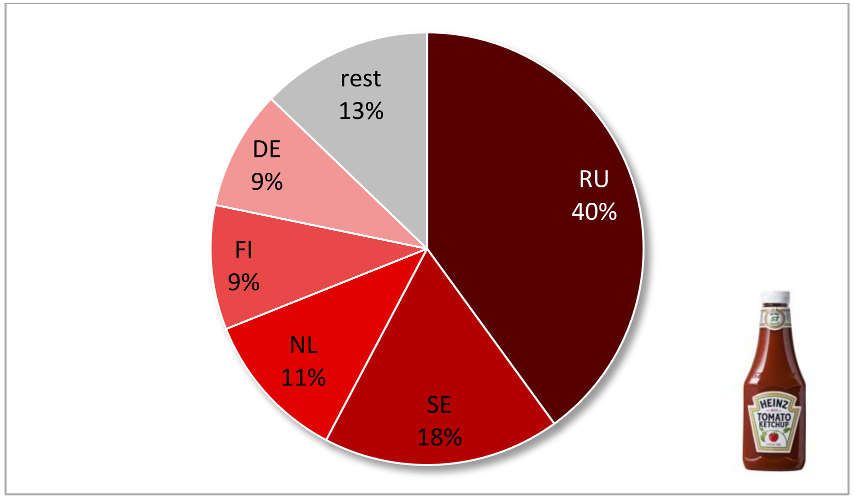


Figure 17 Distribution of packaging waste in Europe of the Icon 875ml bottle (May 2011 to April 2012) (14)

Figure 16 and Figure 17 show that the greatest weight in packaging waste are distributed to the United Kingdom, Germany and Spain (Top Down 570ml bottle) and to Russia, Sweden and The Netherlands (Icon 875ml bottle).

The United Kingdom, Germany, Spain, Sweden and The Netherlands all have systems in place for mechanical recycling of plastic packaging waste (Figure 18), and all collect post-consumer plastic packaging waste separately from other household waste (Figure 19).

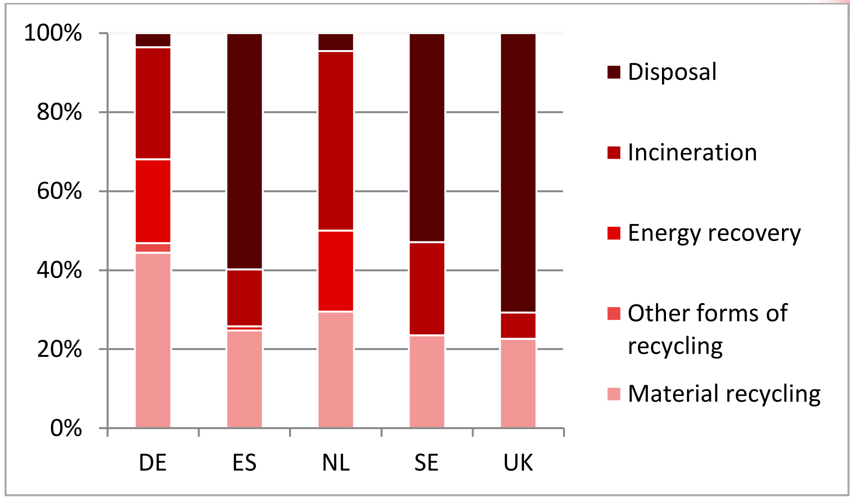
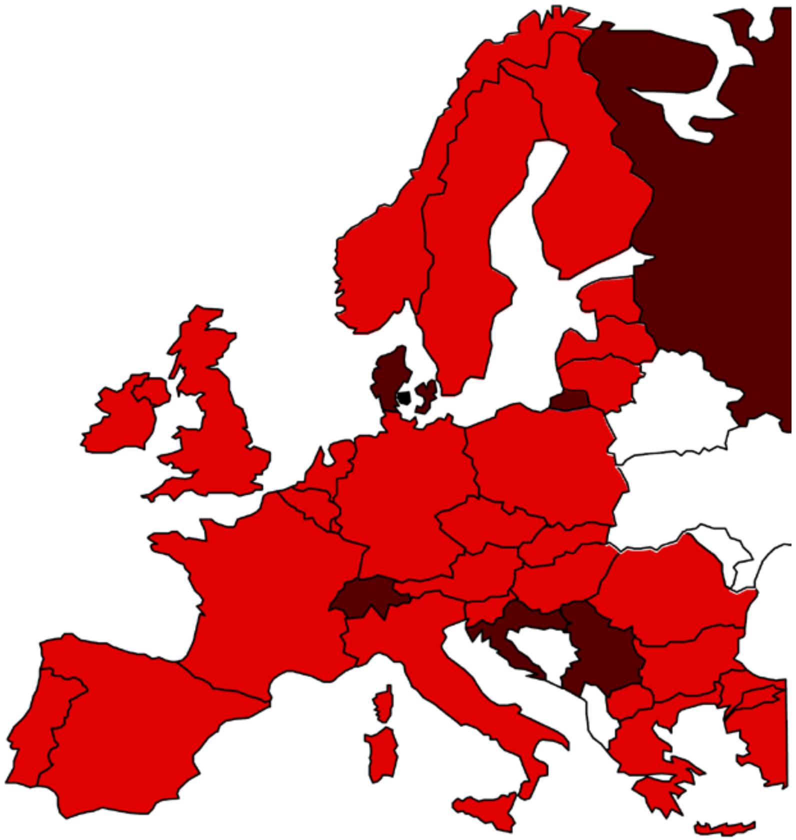


Figure 18 Share of recycling and recovery operations for plastics packaging 2008 (15)

In Russia, plastics from big companies and shopping malls are collected and recycled sometimes, but household plastic packaging is not being collected or recycled. This will not change any time soon, because of cultural, infrastructural and regulatory difficulties. (16) Instead of recycling, a lot of incineration and landfilling takes place in Russia. A short time was spent to research the option of using a biodegradable plastic (PLA, Polylactic acid) for Heinz bottles in Russia, so that it would degrade in Russian landfills. But PLA only degrades under specific circumstances, requiring a temperature of about 70°C, humidity and oxygen. (17) Because these requirements are not met in landfill circumstances, using a PLA bottle in Russia would not improve impact on the environment. Changing the Heinz ketchup bottle in any way will not

[1] CET is a group of some smaller countries

improve plastic recycling in Russia; therefore the situation in Russia was not explored in this research project.



Seperate collection of plastic packaging waste

No seperate collection of plastic packaging waste, but CH and DK do collect PET beverage bottles

Figure 19 Separate collection of post-consumer plastic waste in Europe (for sources see Appendix C)

The countries that are investigated in this research project are: The Netherlands, The United Kingdom and Germany. This is because The United Kingdom and Germany are the biggest outlets of Heinz bottle's plastic waste. The Netherlands is a smaller outlet market of plastic waste for Heinz, but does provide an straightforward source of information because the Heinz Innovation Centre continental Europe is based in the Netherlands.

6. THE PACKAGING

The Top Down 570ml and the Icon 875ml bottle are very similar to each other, the greatest difference is the use of a valve in the cap of the Top Down bottle. Figure 20 shows that both bottles are made up of four main elements: the container, the cap, the labelling and the seal.

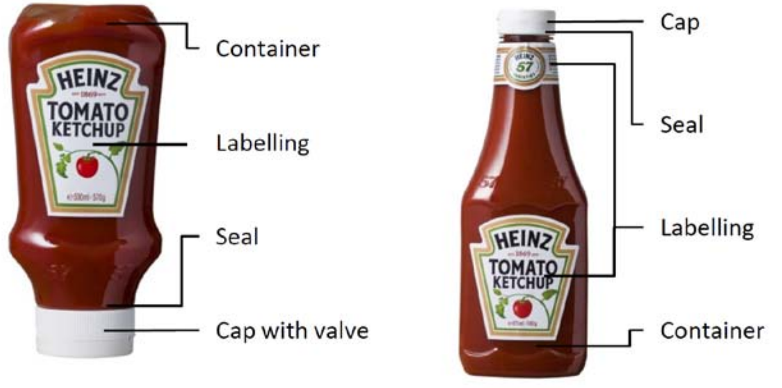


Figure 20 Main elements of the Top Down and Icon bottles

The weight distribution among the different elements is shown in Table 1. The Icon bottle weighs about 6% more than the Top Down bottle.

Top Down bottle

Weight %	Item
67.3%	Container (PET) - 0.1 to 5% barrier
31.2%	Cap (PP) - 0.8% valve (silicone)
1.1%	-Labels (paper+varnish) - Ink - Glue
0.4%	Seal (multilayer)

Icon bottle

Weight %	Item
87.0%	Container (PET) - 0.1 to 5% barrier
10.8%	Cap (PP)
1.6%	- Labels (paper+varnish) - Ink - Glue
0.6%	Seal (multilayer)

Table 1 Weight of the different elements making up the Top Down (left) and Icon bottles (right)

The containers of both the bottles are multilayer, produced with a co-injection moulding technique. The outer layers contain pure PET, and the middle layer (0.1-5% of the container) contains a barrier. This barrier is made up of 50-70% PET and 50-30% other materials. Hence the total quantity of non-PET materials in the container is approximately 1%. The barrier in the container is needed to prevent oxygen-migration into the bottle, spoiling the ketchup. Pure PET is too permeable for oxygen to obtain a desired shelf-life for ketchup.

The cap of the Top Down bottle contains a little silicone valve, this helps the consumer to keep the cap clean. The silicone valve is attached to the cap with a valve ring of PP. The silicone used for the valve has a density >1 gram/cm^3, and therefore sinks in water. The cap of the Icon bottle does not contain a valve.

Figure 21 From left to right: Icon bottle cap, Top Down bottle cap, valve ring, valve

Both bottles have paper labels glued to the container. The glue used is water and alkali soluble. The ink is non water soluble, and non alkaline resistant.

The opening of the container of both bottles is sealed off with a 'Lift 'n' Peel™' seal, that needs to be removed by the consumer before use. The seal is multilayer, containing polyolefin (52%), polyester (25%), adhesive (17%) and aluminium (6%).

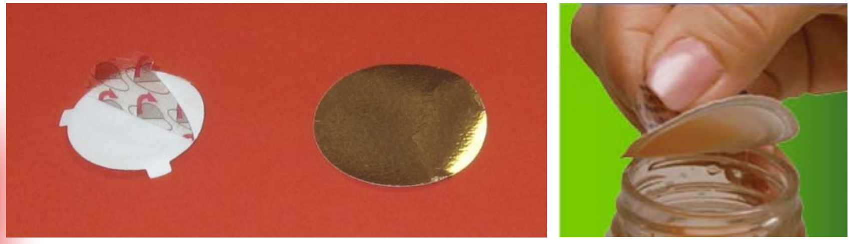


Figure 22 Left: Seal of the Top Down bottle (left) and upside down seal of the Icon bottle (right). Right: removing of the seal.

The containers take up the largest part (in weight) of the packaging, so this study will focus mainly on the recycling of these PET containers. But the recycling of the cap and labelling are also taken into consideration. The seal is removed from the packaging before use, and will probably end up in residual household waste and not in separate plastic collection bags. However, there are still some consumers that do not peel the entire seal off, but use a knife to remove only party of the seal. The recyclers that were interviewed during this research project stated that they were not bothered by incidental residue of an incompletely removed seal on the bottle. So no further research was conducted on this subject.

7. LEGISLATION

7.1. EUROPEAN LEGISLATION

The EU has various means to its disposal to govern it's member states (18):

European Directive: A binding text that obligates each member state to reach a result within a certain time frame. Directives contain 'essential requirements'. A directive must be transposed into national law, whilst leaving national authorities the choice of form and means.

European Regulation: A binding text that is directly applicable in all member states.

European Decision: A binding text for those to whom it is addressed, eg. a State, an EU citizen, or a certain group of EU citizens.

Harmonized standards: A standard describes, by means of technical data, how something needs to be executed. Compliance with regular standards in itself is not legally enforceable. But referring to standards in a directive, regulation or decision (harmonizing the standard) gives a standard a more enforceable nature.

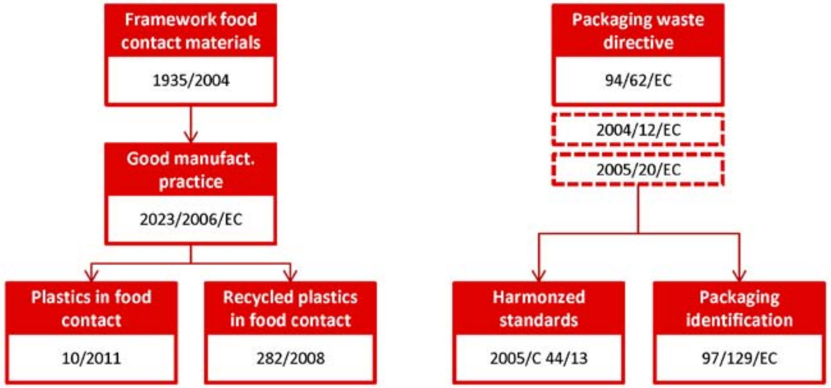


Figure 23 Overview of relevant EU legislation on food packaging and recycling as of January 1st 2013

There are several directives, decisions and regulations in place on the topic of plastic recycling; Figure 23 shows an overview of the legislation relevant for this research project.

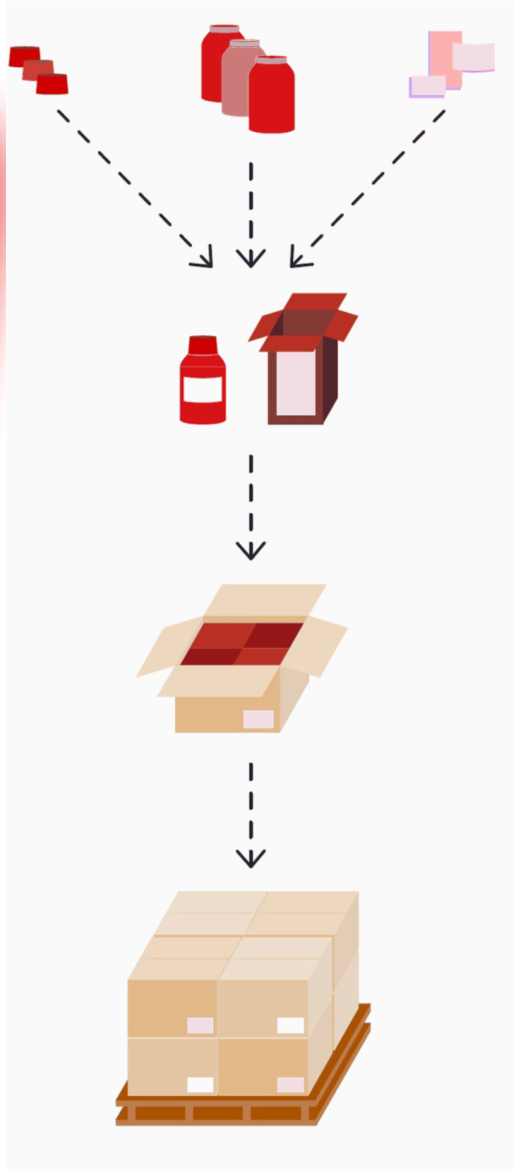
The two main laws concerning recycling and food are the packaging waste directive (94/62/EC, amended by 2004/12/EC and 2005/20EC) and the framework food contact materials (regulation, 1935/2004).

The packaging waste directive aims to harmonize national measures. It has twin objectives: To prevent and reduce effects of packaging and packaging waste on the environment, while safeguarding the operation of the internal market by removing obstacles to trade and distortions of competition. The directive states that the first priority is prevention, and that reuse and recycling are preferential. But the European Union recognizes that packaging has a vital social and economical function, so the regulations should not detract from other quality requirements on the packaging or packaged products.

To try and achieve these objectives the directive includes the following matters:

- Recovery and recycling targets for different materials
- National governments must ensure that systems are set up for the return or collection of used packaging, so that it is effectively reused or recovered. Member states must inform users of packaging on available return or collection systems, contribution users can make and the meaning of markings on packaging.
- Member states are to set up national databases to provide information on the magnitude, characteristics and evolution of packaging and packaging waste flows at a national level. For monitoring purposes.
- Essential Requirements concerning the composition, the reuse and recovery, including recycling, of packaging.

Types of packaging governed by the directive include: primary packaging, secondary packaging and tertiary packaging. Figure 24 illustrates these terms.



Sales packaging (or primary packaging) constitutes the sales unit. It's the package the consumer picks up at the point of sale.

Grouped packaging (or secondary packaging) groups a given number of sales units together into a convenient unit at the point of sale. Grouped packaging typically has one of two roles: it can be a convenient means to replenish the shelves; or it can group sales units into a package for purchase. It can be removed without affecting the product's properties, and generally defines the unit used by the retailer.

Transport packaging (or tertiary packaging) is designed to ensure damage-free handling and transport of a number of sales or grouped packages. This does not include road, rail, ship or air containers. Transport packaging is normally a shipping unit such as an outer case, a pallet or a crate.

Figure 24 Types of packaging covered by the EU packaging waste directive (19)

The target recovery and recycling rates are calculated by weight; by dividing the amount of packaging waste recycled by the total amount of packaging waste generated. Plastic packaging recycling rates were set in two stages. The first stage was set in directive 94/62/EG and demands a plastic recycling rate of 15%. The second stage was set in directive 2004/12/EG and demands a plastic recycling rate of 22.5%.. In directive 2005/20/EG exceptions for the 2nd stage deadline were made for new EU members. Table 2 shows an overview of the target rates imposed by the European Parliament. For a list of country abbreviations see Appendix B.

	1st stage 94/62/EG	**2nd stage 2004/12/EG**	**2nd stage 2005/20/EG**
Deadline for all EU members	to 30.06.2001	to 31.12.2008	
For PT, EL, IE	to 30.06.2005	to 31.12.2011	
For new members	2005 - 2009		
For CZ, EE, CY, LT, HU, SI, SK			31.12.2012
For MT			31.12.2013
For PL			31.12.2014
For LV			31.12.2015
Recovery	Min.: 50 % Max.: 65 %	Min.: 60 % Max.: -	
Recycling	Min.: 25 % Max.: 45 %	Min.: 55 % Max.: 80 %	
Recycling specific materials			
Glass	Min.: 15 %	Min.: 60 %	
Paper	Min.: 15 %	Min.: 60 %	
Metal	Min.: 15 %	Min.: 50 %	
Plastic	Min.: 15 %	Min.: 22.5 %	
Wood	Min.: -	Min.: 15 %	

Table 2 Overview of the packaging directives imposed by the European Parliament (20) (21)

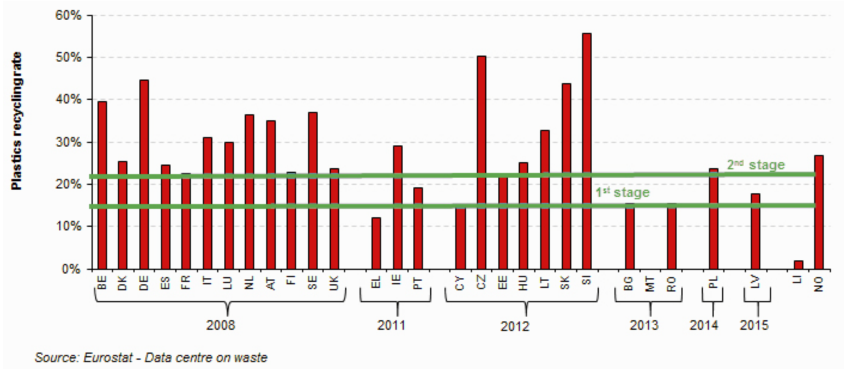


Figure 25 Material recycling rates for plastics packaging, 2008 (15)

The recycling rates shown in the figure above indicate that Greece (12 %) and Cyprus (14.8 %) have not achieved the first stage targets. Bulgaria (15.6 %) and Romania (15.5 %) both have achieved their target before the corresponding deadline. Malta did not supply data in-time. All Member States which were due to fulfill the second stage targets of 22.5 % by the end of 2008 have exceeded this target. Some countries with a later deadline have already achieved the targets: Ireland (29 %), the Czech Republic (50%), Hungary (25 %), Lithuania (33 %), the Slovak Republic (44 %), Slovenia (56 %) and Poland (24 %). (15)

The packaging directive contains a list of essential requirements on packaging. The essential requirements focus on material reduction and designing for end-use (recycling, energy recovery, composting, biodegrading). The Essential Requirements for packaging are summarized in Figure 26 (page 19), this scheme can be used as a quick guideline for checking a packaging for compliance with the essential requirements.

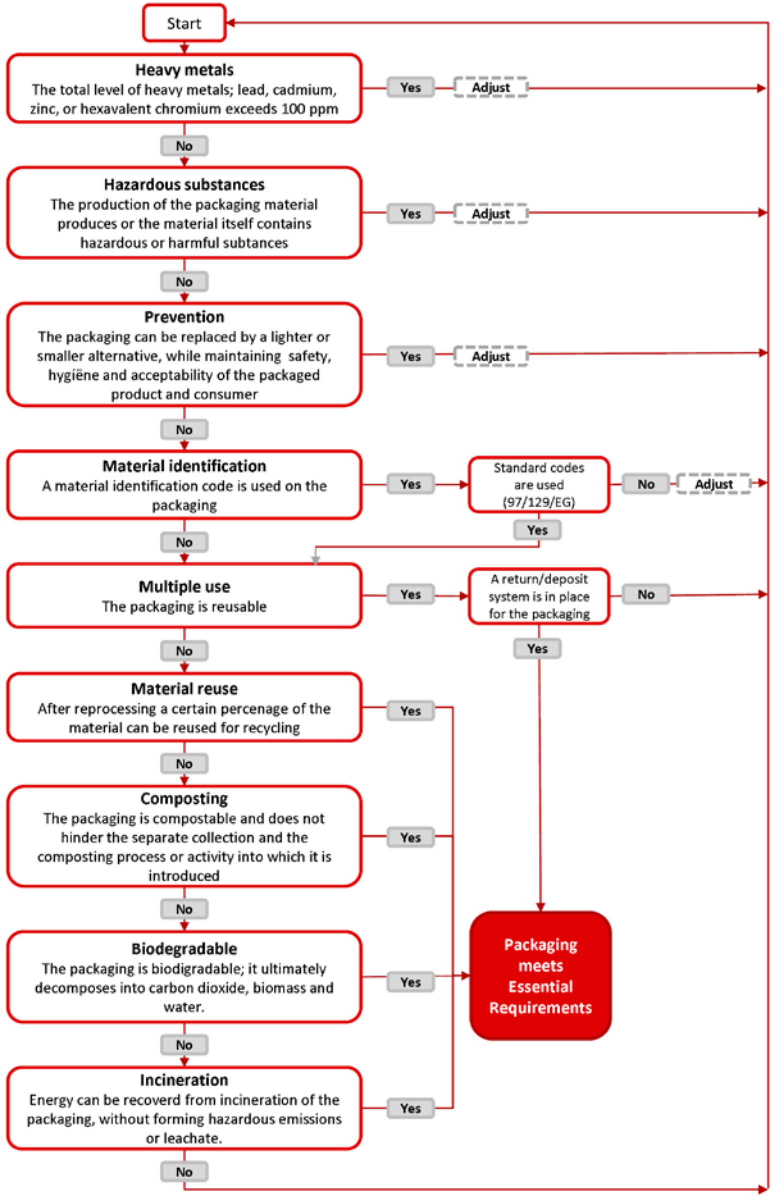


Figure 26 Checklist Essential Requirements

European decision 97/129/EC describes identification codes for different materials. Identification codes can be used on a voluntary basis. But if identification is used, the following codes for plastics must be used:

Material	*Abbreviation*	*Numbering*
Polyethylene terephthalate	PET	1
High density polyethylene	HDPE	2
Polyvinyl chloride	PVC	3
Low density polyethylene	LDPE	4
Polypropylene	PP	5
Polystyrene	PS	6

Identification codes for paper and cardboard, metals, wood, textile, glass and composites are also included in the decision.

The harmonized standards 2005/C 44/13 help implement the essential requirements from the packaging waste directive. It refers to standards EN 13427 to EN 13432, drawn up by the CEN. Table 3 shows a summary of these standards.

Standard	Summary
EN 13427	Requirements for the use of European Standards in the field of packaging and packaging waste. This is the basic standard.
EN 13428	Requirements specific to manufacturing and composition. Prevention by source reduction
EN 13429	Requirements for reuse of packaging
EN 13430	Requirements for packaging recoverable by material recycling
EN 13431	Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior caloric value
EN 13432	Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging.

Table 3 Harmonized standards on packaging (18)

The CEN has made these standards to help companies meet the essential requirements, stated in the European Packaging Waste Directive. Only the relevant standards for this research project are summarized in this chapter: the umbrella standard for packaging (EN 13427), prevention (EN 13428), material recovery (EN 13430) and energy recovery (EN 13431). The standards on reuse, organic recovery, heavy metals and dangerous substances are not covered in this report.

EN 13427 – Requirements for the use of European Standards in the field of packaging and packaging waste. EN 13427 is the 'umbrella standard', and explains the application of EN 13428 to EN 13432.

This umbrella standard states that companies involved in the production of packaging need to meet the standards EN 13428 to EN 13432. In some cases the standards can be mutually incompatible, all standards need to be taken into consideration when designing packaging.

Companies need to review if their packaging meets the standards, but it is not necessary to meet all standards as can be seen in Table 4. The results of the review need to be recorded in a review summary.

Standard		Obligation to meet?
Prevention by source reduction (EN 13428)		Yes
Heavy metals (CR 13695-1)		Yes
Dangerous substances (EN 13428 CR 13695-2)		Yes
Reuse (EN 13429)		Only if claimed
Recovery	Material recovery (EN 13430)	At least one of these standards
	Energy recovery (EN 13431)	
	Organic recovery (EN 13432)	

Table 4 Obligation to meet harmonized standards

EN 13428 – Requirements to manufacturing and composition – Prevention by source reduction. The standard specifies a procedure for assessment of packaging to ensure that the weight and/or volume of its material content is at the minimum commensurate with the maintenance of :

- functionality throughout the supply and user chain
- safety and hygiene for both product and user/consumer
- acceptability of the packed product to the user/consumer

The company that produces the packaging has to be able to demonstrate that the minimum adequate amount of weight and/or volume of the packaging has been reached. To do this, performance criteria have to be reviewed on the presence of a ‘critical area’. The critical area is the specific performance criterion which prevents further reduction of weight and/or volume of the packaging without endangering the necessary levels of safety, hygiene and user/consumer acceptability. Examples of performance criteria are: product protection, compliance with filling process, and consumer acceptance.

If a critical area is found for any of the performance criteria, the value of it needs to be determined with for example a test report. The weight and/or volume of the packaging should be as close to the greatest critical area as possible.

EN 13430 – Requirements for packaging recoverable by material recycling. The standard specifies the requirements for packaging to be classified as recoverable in the form of material recycling. This standard does not have to be met if the standards EN 13431 and/or EN 13432 are already met.

To get a packaging classified as begin recoverable in the form of material recycling two matters have to be covered:

- The company has to be able to demonstrate that a certain percentage of the packaging materials can be claimed to be recyclable, by following the procedures explained in the standard.
- The company has to provide a declaration of the percentage of materials in the packaging that are recyclable.

To prove recyclability of the packaging the following design criteria should be taken into account:

- Substances or materials that are liable to create technical problems in the recycling process
- Materials, combinations of materials or designs of packaging that are liable to create problems in collecting and sorting before material recycling
- The presence of the amount of substances or materials that are liable to have a negative influence on the quality of the recycled material

The standard provides two tables with questions to be filled in by the company, to help prove compliance with the standard. The first table helps prove compatibility with the recycling process, the second helps determine the percentage of a packaging available for recycling.

EN 13431 – Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior calorific value. The standard specifies the requirements for a packaging to be classified as recoverable in the form of energy and sets out procedures for assessment of conformity with those requirements. This standard does not have to be met if the standards EN 13430 and/or EN 13432 are already met.

To claim recoverability in the form of energy the inferior calorific value of the total packaging has to be equal or greater than 5 MJ/kg. The standard explains how to determine the calorific value of a packaging.

Besides European legislation on recycling, there is also legislation on the use of recycled plastic in food contact. Requirements for the use of recycled plastic in food contact have been described in regulation 282/2008, the use of production scrap and recycled plastic behind a functional barrier do not fall under the scope of this regulation. The regulation states that if recycled plastic used, it must originate from plastic materials and articles that have been manufactured in accordance with directive EC/10/2011 (on plastics in food contact) and regulation 1935/2004 (on food contact materials). It must originate from a closed and controlled product loop, ensuring that only materials and articles for food contact are used and any contamination can be ruled out. Or it must be demonstrated in a challenge test, or by other appropriate scientific evidence, that the recycling process is able to reduce any contamination of the recycled plastic used to a concentration that does not pose a risk to human health.

In chapter 9.3 the Heinz bottles are reviewed for compliance with EN 13430 (material recovery, recycling) and EN 13431 (energy recovery). The review of compliance with the other laws and standards mentioned in this chapter falls out of the scope of this research project.

7.2. National legislation

Since the packaging waste directive is a European directive, it must be transposed into national law, whilst leaving national authorities the choice of form and means. The Netherlands, Germany and the United Kingdom have all transposed the directive into their national law, and added some legislation to help implement the directive in their nation. This chapter describes where the national laws deviate from the European legislation described in the previous chapter.

7.2.1. Legislation in The Netherlands

Current Dutch legislation regarding the recycling of plastic packaging came into effect in January 2006, and is called the Decree management of Packaging and Paper and Board[2].

The Decree adopts producer responsibility in order to finance the recovery and recycling of plastic packaging. Manufacturers and importers that bring packaging on the market for the first time are responsible for the costs of collecting household packaging waste, and are required to pay packaging taxes. There is a threshold (50,000 kg in 2011) before companies have to pay packaging taxes. The packaging is used to fund the Dutch waste fund[3], and the Waste fund funds municipalities that collect packaging.

To make the Decree workable, the Ministry of VROM (Housing, Spatial Planning and the Environment)[4], industry and municipalities came to agreements. These agreements, valid from 2008 to 2012, are defined in the Framework agreement[5], that was signed in July 2007.

The Framework agreement applies to household waste and states that municipalities bare the responsibility of collecting that waste. The expenses the municipalities make for collecting waste are covered by the Dutch waste fund, each year 115 million Euros are deposited in the waste fund by the Ministry of VROM.

Dutch plastic recycling targets are set higher than the European target of 22.5%:

- 32% recycling in 2009
- 38% recycling in 2010
- 42% recycling in 2012

[2] In Dutch: 'Besluit beheer verpakkingen en papier en karton'
[3] In Dutch: 'Afvalfonds'
[4] In Dutch: 'Ministerie van VROM' (Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer)
[5] In Dutch: 'Raamovereenkomst'

7.2.2. Legislation in Germany

Current German legislation on the recycling of plastic packaging dates from April 1st 2009, and is the fifth amendment of the Packaging Ordinance[6].

German law has also adopted producer responsibility; manufacturers and distributors who put sales packaging filled with product and typically arising at the private final consumer into circulation for the first time, have to take part in one or several compliance schemes. A manufacturer or distributor can also collect their packaging waste themselves. Compliance schemes are companies that relieve the manufacturers and distributors of their obligation to take back their own packaging waste. German law states that a compliance scheme shall ensure adequate, regular and free of charge collection of used and emptied sales packaging from or in the vicinity of the private final consumer. This can be through a drop-off system (consumer brings waste to a bring site) and/or a kerbside system (waste gets collected from the kerb). All compliance schemes take part in the Joint Agency, that coordinates the different compliance schemes and distributes supplementary fees. Every year, companies that put more than 30,000kg of plastic packaging on the market have to submit a declaration of compliance.

German recycling targets exceed European legislation: a 36% plastic recycling target, composed of 60% recovery target and a 60% recycling target of these recovered plastics.

7.2.3. Legislation in the United Kingdom

The European Packaging Waste Directive has been transposed into UK law by the Producer Responsibility Obligations (Packaging Waste) Regulations 2007 , and has been amended in 2010.

The UK adopted a shared producer responsibility, which differs from the producer responsibility in the Netherlands and Germany. In the UK, not only the company that puts the packaging onto the market for the first time is responsible for recovery and recycling, but also other companies in the supply chain. Companies above the threshold of a £2million annual turnover and handling more than 50 tonnes of packaging a year pay for a certain proportion of the UK obligations to recycle packaging. The contribution division is as follows:

[6] In German: 'Verpackungsverordnung' or in short 'VerpackV'

- Raw material manufacturers 6%
- Converters 9%
- Packers/ fillers 37%
- Sellers 48%

Companies fulfill their obligation by buying Packaging Waste Recovery Notes (PRNs, otherwise known as certificates of recycling evidence) or Packaging Waste Export Recovery Notes (PERNs). These have a market value which can fluctuate in relation to demand for the notes in relation to the supply of recycled material; the UK recycling targets set for that year; and the amount of PRNs/PERNs companies or compliance schemes already purchased. Obligations for company activities that have taken place abroad, are completely taken over by the importer.

Companies can join a compliance scheme to deal with their obligation for them, or arrange for recovery and recycling themselves. Packaging compliance schemes are businesses which: take on the legal obligations of packaging producers who join the scheme, provide an operational plan on behalf of all the scheme members, and are responsible for providing evidence of recovery and recycling for its members. (22)

UK plastic recycling targets are set higher than the European target of 22.5% (23):

- 29% recycling in 2010
- 32% recycling in 2011 and 2012

7.2.4. Summary of national legislation

	Party responsible for financing packaging waste recycling	Threshold for financial responsibility	Party responsible for execution of packaging waste recycling	Recycling target
NL	Producer responsibility	50,000 kg plastic waste	Nedvang (funded by government)	38% (2011) 42% (2012)
DE	Producer responsibility	30,000 kg plastic waste	Dual Systems (funded by responsible party)	36%
UK	Shared responsibility: manufacturer, converter, packer, seller.	50,000 kg plastic waste £2 million turnover	Compliance schemes (funded by responsible parties)	32% (2011, 2012)

Table 5 Summary of Dutch, German and UK legislation

7.3. Changes to be foreseen in European and national legislation

During this research project there was no indication of any big changes coming up in European legislation. But it is to be expected that the essential requirements will be more enforced. At the moment there is little to no supervision on the execution of the essential requirements by companies. The Netherlands is one of the countries that has announced to start checking companies for compliance on the essential requirements, chapter 9.3 will focus on compliance of the Heinz bottles with the essential requirements.

There has been some confusion in European legislation on the terms of biodegradability and compostability, these terms will be clarified.

The Dutch Framework agreement is valid to 2012; negotiations for renewal of the agreement are conducted at the time of this research project. The topics discussed in these negotiations are confidential; statements on changes to be foreseen are purely speculative.

Legislation that regulates the Dutch system of packaging taxes will also expire. There are some possible options in the future:

- The system of packaging taxes is continued, taxes may be significantly increased (24)
- A green dot/compliance scheme, similar to other European countries, is adopted.

In both cases, not a lot will change for Heinz. Heinz still has to keep track of the amount of packaging put on the Dutch market, and pay for recovery and recycling. But Heinz might have to report to another organization.

There is currently a lobby in the Netherlands and in Germany of companies who would like to see more municipalities practice post-separation (separate plastics from household waste in a material recovery facility) instead of source-separation (consumer disposes of plastic waste separately from household waste). If this plan was to see through it would not change anything for Heinz, because the same sorting techniques will be used as described further on in this report.

Then there is the slight possibility of the termination of the beverage bottle deposit system in the Netherlands. Again, this will not affect Heinz.

In Germany arrangements are made to collect plastic and metal non-packaging objects together with packaging for recycling, this will probably not affect the recyclability of the Heinz bottles.

In 2009 the English Minister of Environment announced the ‘Packaging Strategy’, this document contains a strategy for the next 10 years. The trend that can be seen is increasing recycling targets and the requirement to use more recycled content in new products.

8. RECYCLING IN PRACTICE

To recycle used plastic packaging from consumers it has to be collected, sorted to polymer type, recycled into a new raw material, and manufactured into a new product. This chapter looks into how these recycling activities work and how they are organized and by whom.

8.1. ORGANIZATION OF PLASTICS COLLECTION AND RECYCLING

8.1.1. EUROPE

With the European Packaging Waste Directive imposed, European countries started organizing recycling schemes for plastic household waste. Most European countries hold the companies that put packaging waste on the market (financially) responsible for the recycling of that waste. The most widespread system of helping companies execute this responsibility is the Green Dot system. PRO Europe is the umbrella organization of organizations that use this Green Dot system.

Figure 27 The Green Dot symbol

Companies that are (financially) responsible for the recycling their packaging pay a fee to a Green Dot organization (per kg packaging material distributed), this releases them of their individual recycling obligation. With these fees the Green Dot organization organizes a collection and recycling scheme. Paying members of a Green Dot organization are allowed to put a Green Dot symbol on their packaging, the Green Dot is a financing symbol, stating that the company that used the dot on it's packaging has fulfilled it's financial obligations to finance recycling of the packaging.

As can be seen in Figure 28, the majority of European countries use a Green Dot system, but only a few countries obligate companies to print the Green Dot symbol on their packaging.

Figure 28 Use of the Green Dot system and symbol

8.1.2. The Netherlands

In the Dutch law producers and importers of plastic packaging waste are held responsible for the collection and recycling of their plastic packaging waste. In the Framework agreement companies agreed to unite in order to fulfill this obligation. The Nedvang foundation executes the Dutch law and Framework agreement for the obligated companies and organizes the separate collection and recycling of paper, cardboard, glass, plastic, metal and wood.

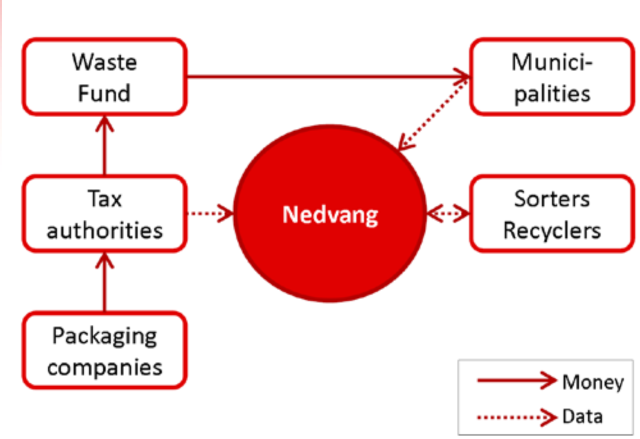


Figure 29 Nedvang business model (25)

Dutch plastic waste management is organized as can be seen in Figure 29. Producers and Importers that put plastic packaging on the market pay taxes to the tax authorities[7]. The taxes that are collected go to general means and €115 million goes to the waste fund. Nedvang is financed by the waste fund and has the following responsibilities:

- Distributing the money in the waste fund among the municipalities that collect plastic packaging waste, according to the amount of waste collected.
- Certifying sorters and recyclers to allow them to handle Dutch plastic packaging waste.
- Keeping track of the waste streams: the amount of packaging put on the market by companies, collected by municipalities and sorted/recycled by waste management companies.

Nedvang is monitored by a guidance committee, consisting of the ministry of VROM, industry and municipalities.

There is a clear overview of plastic waste streams in the Netherlands, because Nedvang closely monitors these. The overview is shown in Figure 30.

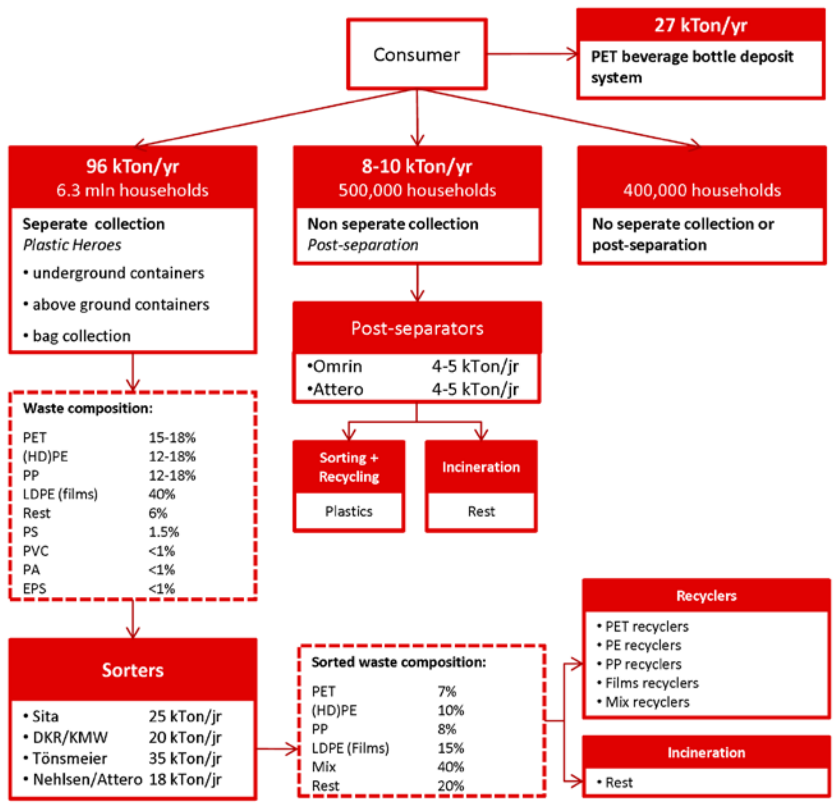


Figure 30 Plastic waste streams in the Netherlands

[7] In Dutch: 'Belastingdienst'

Plastic recycling rates are good in the Netherlands and exceed EU goals.

	2008	2009	2010	EU goals	Dutch goals
Plastic recycling rate	36%	38%	48%	22.5%	2010: 38% 2012: 42%

Table 6 Plastic recycling rates, The Netherlands (26)

8.1.3. Germany

In Germany plastic recycling is organized through a Green Dot system: German law states that all companies that put plastic packaging on the market have to join a Dual System[8] company, that organizes recycling of plastic packaging on behalf of them. The term Dual System stands for a second waste stream next to household waste. There are nine Dual Systems competing in Germany, of which Der Grüne Punkt - Duales System Deutschland GmbH is the greatest with a market share of around 50%.

It is not obligated to put the Green Dot symbol on packaging in Germany, but if a company wishes to do so they need to pay a small annual license fee to Der Grüne Punkt - DSD GmbH. If a company joined one of the other eight Dual Systems they still need to also register and pay to Der Grüne Punkt- DSD GmbH to be permitted to use the mark.

The organization of plastics recycling in Germany is illustrated in Figure 31.

Plastic recycling results are good in Germany and exceed EU goals, a 47.3% plastic recycling rate was achieved in 2008. (27)

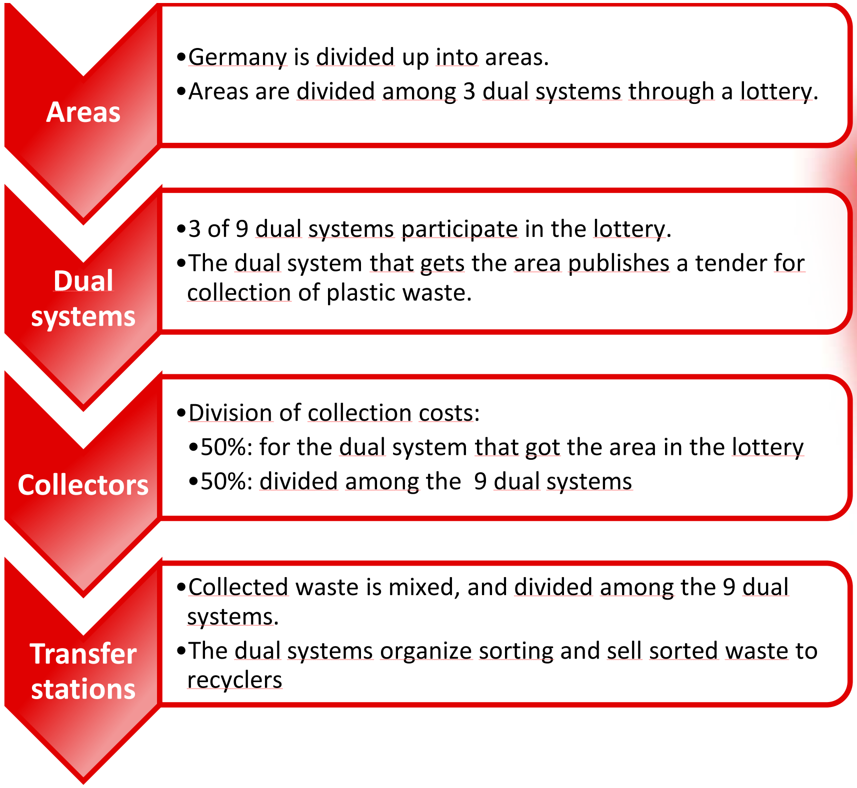


Figure 31 Organization of plastics recycling in Germany: '50+ model'

8.1.4. The United Kingdom

The United Kingdom values the free market system, this is why all kinds of collection agencies, sorters, recyclers and compliance schemes can enter the market. This does however make it more complicated to get an overview on how collection and recycling is organized.

[8] In German: 'Duales System'

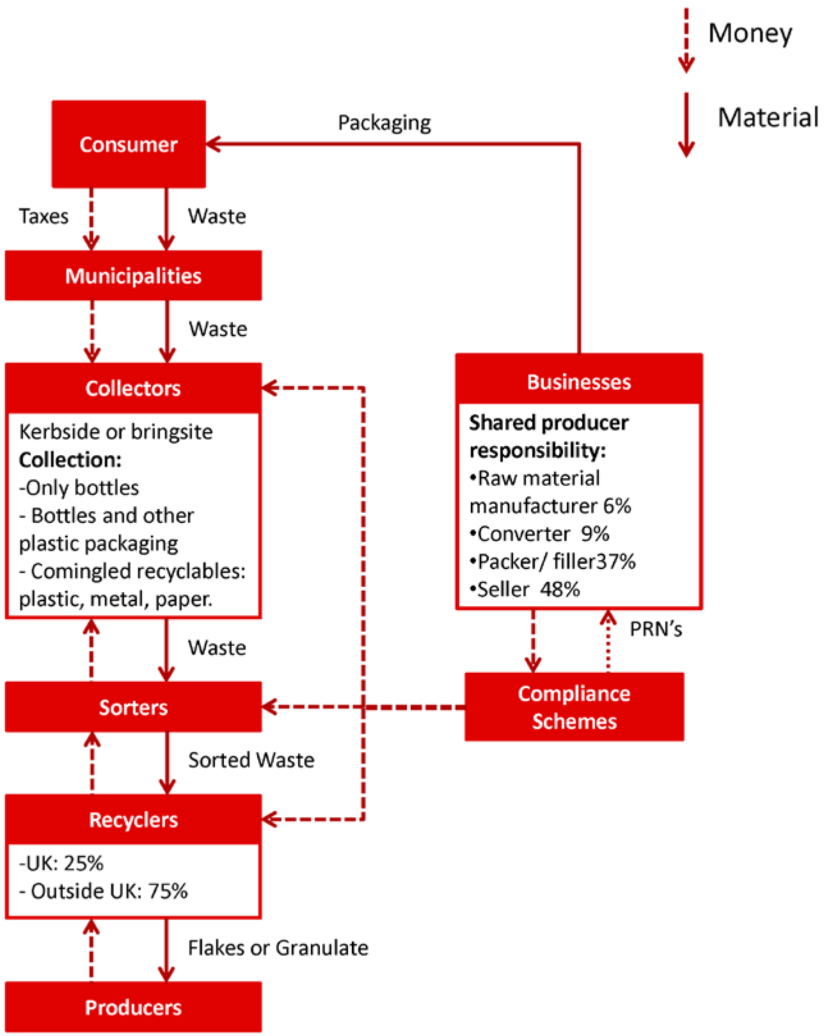


Figure 32 Organization of plastic waste collection and recycling in the United Kingdom

The UK works with a shared producer responsibility, so all obligated companies have to pay a 'compliance scheme' company to relieve them of their obligation to recover and recycle their packaging. In return, the compliance scheme provides the company with Packaging Recovery Notes (PRN's) as proof of payment. The compliance scheme is now responsible for the recovery and recycling of their client's packaging, and finances collection agencies, sorters and recyclers to execute recovery and recycling. Municipalities have a legal obligation to collect waste from their citizens, but do not have a special obligation to collect plastic packaging waste separately. If a municipality wishes to collect plastic packaging waste it can sign a contract with a collector, since the free market system is in place different collectors can bid on the task. Often, collectors and sorters are one and the same company, called MRF's: Material Recovery Facilities. After sorting, the bales of plastic are allowed to be sold in and outside of the UK, it is estimated that 75% of the UK collected bottles are exported to outside the UK. (28)
UK recycling rates are mediocre compared to Dutch and German rates, but do meet EU targets. A 23.7% recycling rate was achieved in 2008, 24.1% in 2009. (27)

8.2. Collection

8.2.1. The Netherlands

Figure 33 Plastic Hero

Plastic recycling in The Netherlands is mainly realized through separate collection by consumers. A few municipalities (500,000 households) work with a post-separation system, where plastic packaging is recovered from household waste. And some municipalities (400,000 households) have no plastic collection scheme in place. But the majority of municipalities (6.3 million households) use the 'Plastic Heroes' collection system, organized by Nedvang.

Plastic Heroes has a nationwide campaign consisting of TV commercials, billboards, and advertisements. The flagship of the Plastic Heroes campaign is the orange figure 'Plastic Hero'. Municipalities often have an extra campaign in place to increase consumer awareness about plastic recycling.

Figure 34 Plastic Heroes campaign: billboards, website

Depending on the municipality, consumers can collect their plastic waste in bags that are collected kerbside, or bring their plastic waste to containers.

Figure 35 Plastic Heroes collection bags and containers

To inform consumers on what types of packaging can be discarded through the Plastic Heroes system a list of examples is communicated through leaflets and the Plastic Heroes website, an example of this leaflet can be seen in Appendix E.

8.2.2. Germany

In most German cities, consumers can collect their plastic packaging waste, together with metal and multilayer cardboard beverage packaging, in yellow bags or bins. The choice for the distinctive color yellow stems from Der Grüne Punkt – DSD GmbH. Der Grüne Punkt was the only Dual System on the market to 2005, founded in 1990, and started up plastic packaging collection system throughout Germany. Since 2006 more Dual Systems have entered the market, but the use of the color yellow for recycling bins was not changed by these other companies.

Figure 36 Yellow bag and bins

The startup of separate plastic collection in Germany was accompanied by a large marketing campaign, organized by Der Grüne Punkt. When Der Grüne Punkt lost it's monopoly on the dual system market, no more national campaigns were launched since recycling had become common practice for German citizens. Municipalities however still publish information for their residents to inform them on the use of the yellow bags and bins.

Figure 37 Informational graphics distributed by the city of Koblenz (left) and Nürnberg Gartenstadt (right)

8.2.3. United Kingdom

Since plastic packaging waste collection in the UK is organized by a multitude of compliance schemes, every city has it's own (or no) collection system. Among the cities that have a collection system in place, kerbside collection is most popular. Most cities only collect bottles, and no other plastic packaging.

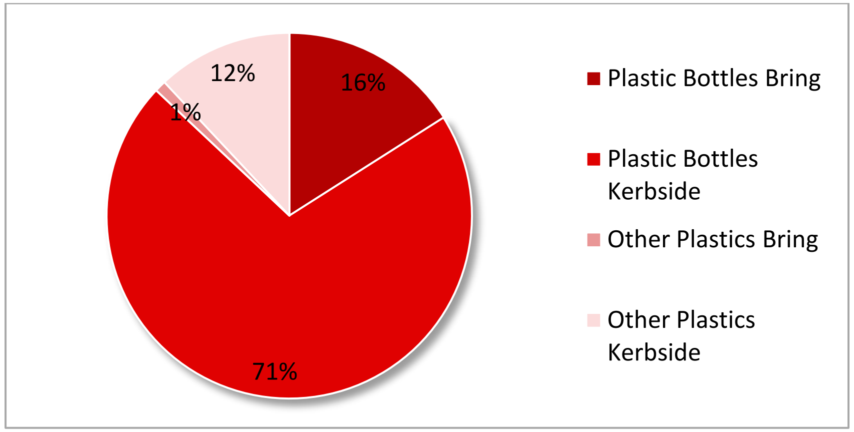


Figure 38 Collection scheme types UK (29)

Waste & Resources Action Programme (WRAP) is a not-for-profit company, backed by government funding from England, Scotland, Wales and Northern Ireland. WRAP launched the national 'RecycleNow' campaign, to inform UK citizens about recycling. RecycleNow consists of a website and a marketing campaign. On the RecycleNow website, consumers can find general information on recycling and type in their postal code to find recycling facilities in their vicinity.

Figure 39 RecycleNow website, nation wide campaign UK

8.3. Recycling symbols

There are a wide range of symbols available to print on packaging that have to do with recycling. The most common symbols are the mobius loop, and material identification symbols.

The "Mobius Loop" is a widely used international symbol indicating that the packaging is recyclable. It appears most often on paper and board packaging.

Use of the Mobius Loop is governed by an international standard, ISO 14021, which says that the Mobius Loop can only be used in relation to products or

Figure 40 Mobius loop stating recycled content

packaging which are recyclable or, when accompanied with a percent figure, which contain recycled material.

The term "recyclable" can only be used when there is evidence that collection, sorting and delivery systems, and recycling facilities are available to a reasonable proportion of users of the product and the product or packaging is being collected and recycled.

When the term "recycled content" is used, the percentage of recycled material must be stated. According to the standard, recycled content can be material which has been used and collected from households or commercial and industrial facilities, or material which has become waste during a manufacturing process (off-cuts and trimmings). (30)

The symbols on the left are used for material identification. The number and abbreviation are consistent with EU legislation. It is not obligated to identify material on packaging, but if identification is used it must be consistent with EU law.

Figure 41 On-Pack Recycling label

The British Retail Consortium (BRC) has developed a labeling scheme called 'the On-Pack Recycling Label scheme'. The On-Pack Recycling Label scheme aims to deliver a simpler, UK-wide, consistent, recycling message on both retailer private label and brand-owner packaging to help consumers recycle more material, more often. (31) The label is made up of three core messages: the packaging component, material type and recyclability status. For every component, material type and recyclability status are declared. The example in Figure 41 shows three packaging components: the sleeve, the tray and the film, that all have a different recyclability status. The recyclability status categories are based on local authority collection information and therefore provide meaningful information to consumers about whether a particular item of packaging can or cannot be recycled. The label is intended for use throughout the UK. Categories are:

- Widely recycled: At least 65% of local authorities collect
- Check local recycling: Between 15% and 65% of local authorities collect.
- Not currently recycled: Less than 15% of local authorities collect

The label is used by some UK retailers on their own-brand products and by some brands for products destined for the UK market. To use the label, an annual fee has to be paid to the On-Pack Recycling Label company (OPRL Ltd.).

8.4. Sorting

After plastic packaging waste is collected from the consumer it needs to be sorted, because the waste contains impurities and not all types of plastics are compatible with each other when recycling. Sorting techniques applied to post-consumer mixed plastic waste are similar across Europe.

During this research project two sorting facilities were studied: the Sita sorting installation in Rotterdam (NL), and the DELA sorting installation in Beckum (DE).

8.4.1. Case study: Sita sorting installation

In 2012, a quarter of all plastics collected in the Netherlands is sorted at the Sita sorting installation in Rotterdam. At this installation, Sita sorts only plastics that come from the Dutch Plastic Heroes' containers and bags, and is set up to process waste with a typical 'Dutch' composition (Dutch plastic waste contains a lot of films). The composition of the plastic waste fluctuates. These fluctuations are caused by the origin of the waste, e.g. waste from large cities is more contaminated than waste from small cities. The plastic waste is sorted into 5 plastic streams, and a residual waste stream, the average breakdown of plastic waste delivered to and sorted by Sita is shown in Figure 42.

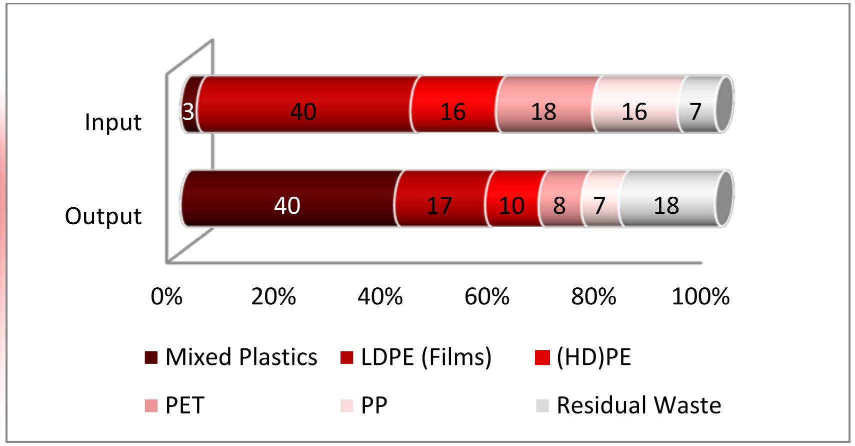


Figure 42 Sita sorting installation, sorting results

Plastic sorters have to constantly weigh yield and output quality against each other. Yield is the percentage of target polymer sorted out from the feed stream into a product stream. The output quality is influenced by the amount of contaminants in the output. While increasing yield increases the output quantity, it often decreases output quality.

In Figure 42 can be seen that the PET input at Sita is 18%, but the output is 8%, this means a yield of 44%. The PET-fraction that goes into the sorting installation consists of bottles (50%) and containers (50%). But the sorter wants to have sorted PET output with a minimum of 90% bottles, because bottles generally consist of a high quality PET and containers sometimes consist of modified PET (e.g. PETG and CPET) and contain more contaminants. This explains why a large part of the incoming PET containers are sorted out of the PET stream and end up in the residual waste. The choice for a requirement for sorted PET with a minimum of 90% bottles is made by Nedvang and DKR who market sorted plastic to recyclers. Requirements are also established for the other sorted waste streams like mixed plastics and polypropylene. An example of a requirement for a sorted waste stream, the PET 90/10 stream, is included in Appendix D (page 52).

Yield and output quality are influenced by the order and setup of the different sorting steps. Next, the sorting process at the Sita sorting installation is described.

The first part of the sita sorting process is about removing debris and plastic films from the plastic recyclables, it is shown in Figure 43.

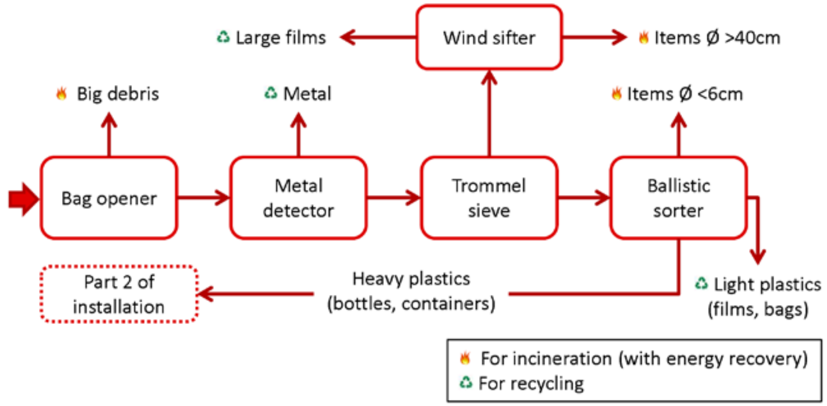


Figure 43 First part of the Sita sorting process

Plastic waste arrives at the Sita sorting installation in plastic bags or loose. It is moved onto a conveyor belt that transports the waste up to a bag opener. This bag opener consists of large pins that tear the bags open. Large debris in the plastic waste gets stuck into the pins of the bag opener, if this happens, the machine backs up and excretes the debris. Next, the waste goes through a metal detector, all metals are filtered out with a magnet and are recycled.

The most impressive piece of machinery at the Sita plant is the trommel sieve, this is where the waste goes next. In the trommel sieve 3D waste (bottles, containers) gets separated from large films. The 3D waste falls through the holes in the sieve, the largest holes have a diameter of 40cm, thus items bigger than

Figure 44 Trommel sieve at Sita

40cm don't pass through the sieve. Large films, because of their weight and size, also don't pass through the sieve. The large films and big items that did not pass through the sieve continue into a wind sifter, where the light films are separated from the more heavy 3D objects. The films go for recycling and the large 3D objects go for incineration.

Now that the big films and debris is sorted out, the smaller plastics continue on onto a ballistic sorter. On this ballistic sorter, light 2D objects are separated from more heavy 3D objects. A ballistic sorter consists of shaking 'ladders' that are placed at an angle. Because of the angle and the shaking, 2D objects get transported up, while 3D objects tumble down. Items smaller than 6cm fall through the holes of the ladders and go for incineration. The 2D objects go for recycling.

Figure 47 A ballistic sorter

Up to now the mixed plastics have only been sorted according to size, weight and shape. In the second part of the installation the plastics are sorted to polymer type using Near Infra Red (NIR) spectroscopy technology.

NIR spectroscopy automated sorting machines utilize the Near Infrared part of the electromagnetic spectrum. Electromagnetic waves are another term for light, light waves are fluctuations of electric and magnetic fields in space. The electromagnetic spectrum is the full range of frequencies, from radio waves to gamma rays, that characterizes light. (32) The NIR spectrum is a small part of the infrared spectrum and lies between the visible spectrum and the medium infrared spectrum as shown in Figure 45. The wave length range of NIR light is 0.7 to 2.0 microns (µm). (33)

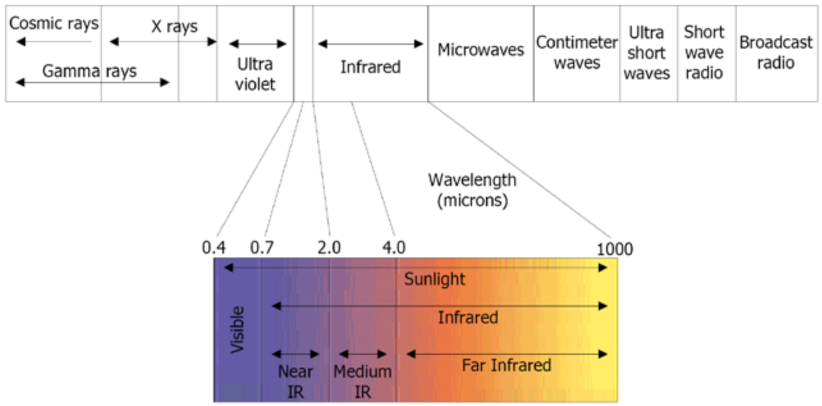


Figure 45 Electromagnetic spectrum (33)

Spectroscopy is the study of interaction between matter (e.g. molecules, atoms) and electromagnetic radiation. NIR spectroscopy automated sorting machines register electromagnetic absorption. Electromagnetic radiation can cause vibration between the atoms of a molecule, when this happens the radiation is absorbed and not reflected. The NIR sorting machine sends out a spectrum of electromagnetic radiation to a plastic object and registers what radiation is absorbed and what radiation is reflected. Individual polymer types reflect and absorb different spectra under infrared light, all polymer types have their own unique absorption/reflection spectra. (33) Figure 46 shows the spectra for PET, PP and Nylon, it can be seen that there are clear variations between the three.

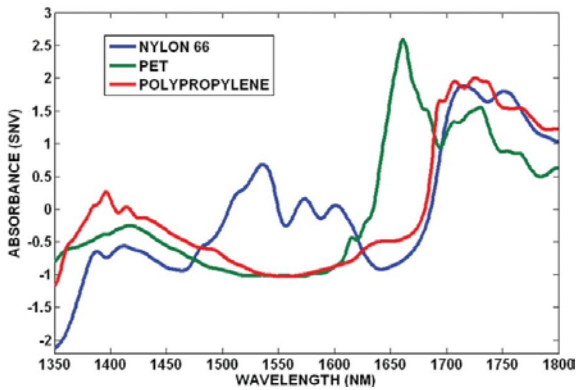


Figure 46 The NIR spectra of polypropylene (PP), polyethylene terephthalate (PET), and Nylon 66 (N66) (34)

The NIR sorter scans the objects on a conveyor belt across their full length, as shown in Figure 48, and determines types of material, size and position. The material type is recognized by comparing the spectra of the detected item with the spectra stored in the software library of each machine. If the spectrum of the item matches the sort criteria spectrum, the item will be removed by firing a jet of compressed air at the item, blowing it onto a different conveyor belt. If the spectra's do not match the item will be ignored by the NIR machine. When multiple types of material are detected within one item, the item is sorted to the material that makes up the largest part of the item.

to bottom

Figure 49 illustrates the workings of the NIR automated sorter. Unsorted material is transported onto the conveyor belt moving with a speed of approximately 3 m/s [1], and is scanned with NIR light [2], if a specific material is detected it gets blown by air jets into a separate container or conveyor belt, the rest of the materials fall down onto a different conveyor belt.

The yield of a single NIR sorter is influenced by software and hardware. The software of the sorter compares the spectra of the detected item with spectra in it's library, it can be configured very strict to obtain a high purity output, or very tolerant to increase the quantity of the output. The layout of the machine also influences yield. If the distance between the point of detection and the point of ejection by air jets is large, an item has a greater chance of changing position on the conveyor belt in between the two points. If the position of a positively detected item changes after detection, the air jets might release the compressed air at the wrong time or place. The conveyor belt speed plays a role in this: at a certain speed some round objects like bottles can start to roll on the belt instead of moving with the belt, the same thing goes for light objects like films that can start floating above the belt. This problem is illustrated in Figure 50.

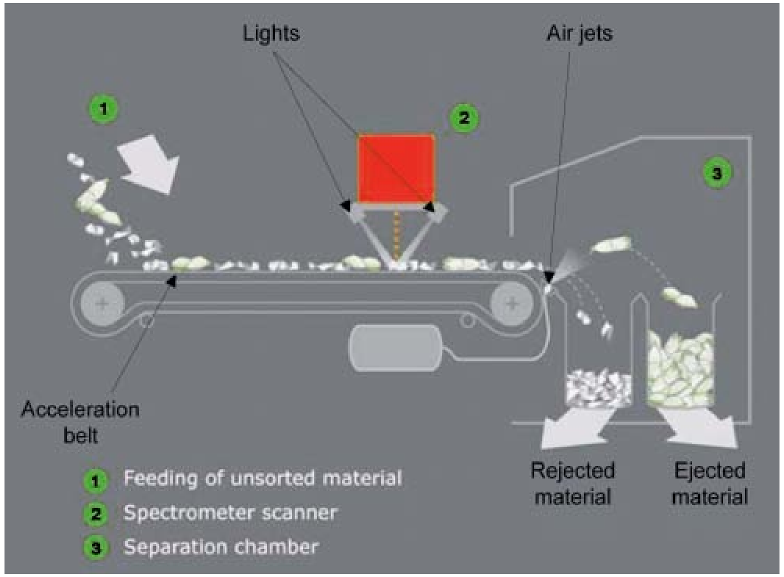


Figure 49 Schematic representation of a NIR sorter

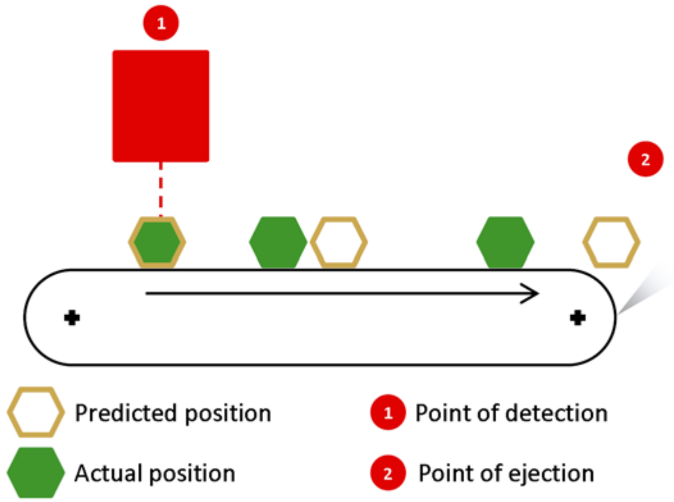


Figure 50 Hardware issues NIR sorter

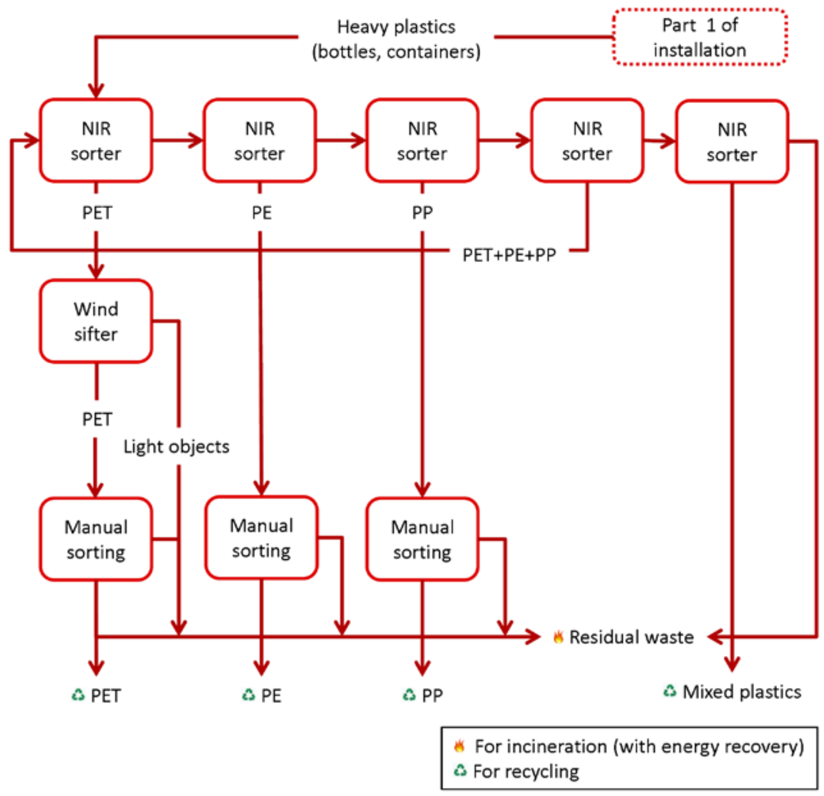


Figure 51 Second part of the Sita sorting process

At the Sita plant, the mixed plastics pass five Near Infra Red (NIR) sorters, as can be seen in Figure 51. The first NIR sorter at Sita picks out PET waste from the rest of the waste, the second sorter blows out PE, the third sorter PP. The fourth NIR sorter blows out all PET, PE and PP that has been left behind by the first three sorters, and transports it back to the first sorter. The fifth and final NIR sorter blows out all types of plastic (e.g.: PS, PVC, PP, PE, PA, etc.) to go into the mixed plastics bale.

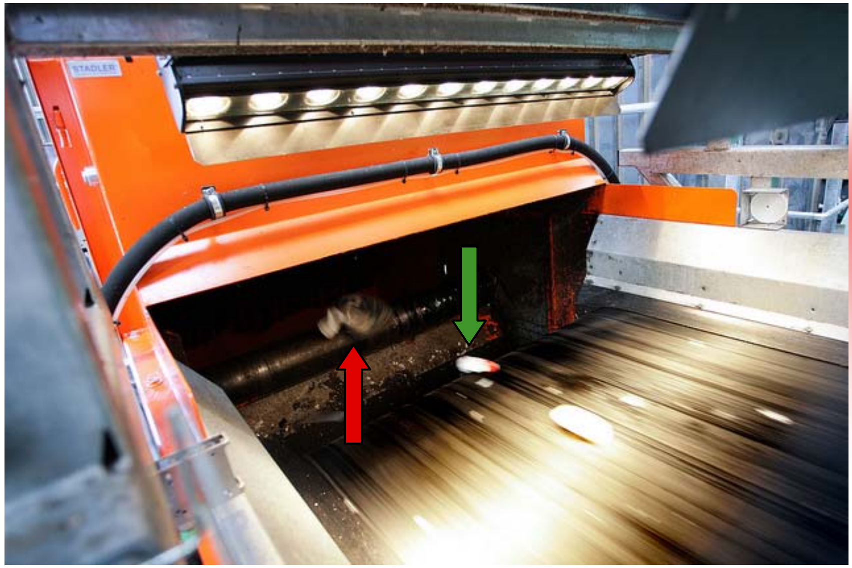


Figure 52 NIR sorter: one type of plastic gets blown out up to a separate conveyor belt (red arrow), all other items fall down (green arrow)

Figure 53 Close up of NIR sorter

The PET, PE and PP that were picked out by the NIR sorters, continue on to the manual sorting station. Only the PET has an extra sorting step in between the NIR sorter and the manual sorting: light objects (e.g. containers) are separated from heavy objects (e.g. bottles) by a wind sifter. At the manual sorting station the waste streams are cleared from incorrectly sorted objects, these objects go for incineration.

After the sorting process the different waste streams are baled.

The complete sorting process of the Sita installation is shown in Appendix F.

Figure 54 Sita output product: PET 90-10 bale: min. 90% PET bottles, max. 10% PET other containers

8.4.2. *CASE STUDY: DELA SORTING INSTALLATION*

As mentioned before, sorting techniques are generally the same across Europe. The case study of the DELA sorting installation illustrates this, it differs only slightly from the sorting installation of Sita.

The DELA sorting installation in Beckum (DE) processes a different input material than the Sita sorting installation does. The input material for the DELA plant has been pre-sorted at another facility, DELA sorts PET from mixed bottles, mixed PET and mixed plastics bales.

The DELA installation only derogates from the Sita installation on the following points:

- DELA has no trommel sieve, because the pre-sorted input material does not contain big films and debris
- DELA has 7 NIR sorters, Sita 5
- DELA sorts PET into a clear and a colored stream

The DELA sorting process is shown in Figure 55.

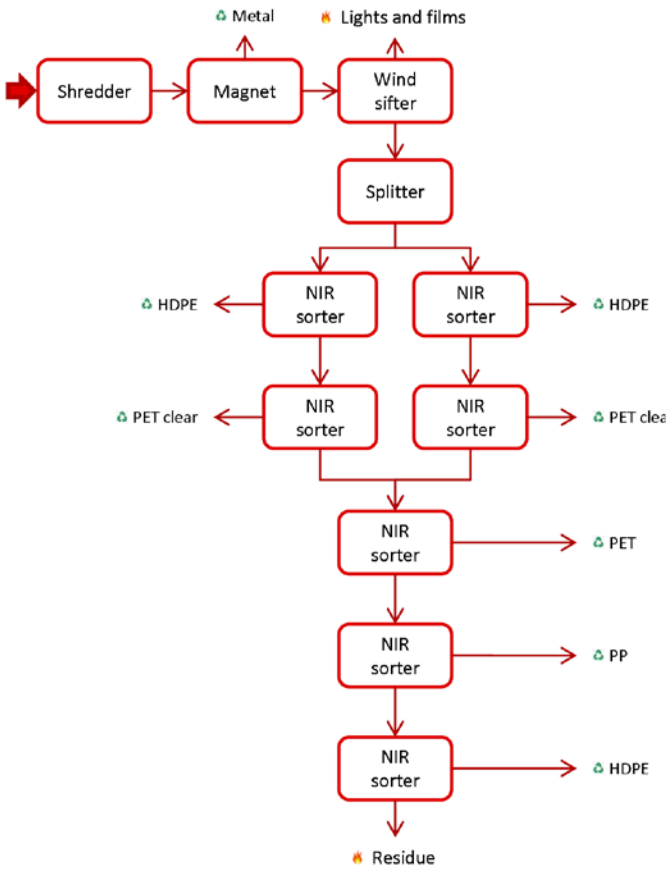


Figure 55 DELA sorting process

The sorting results of the DELA sorting installation are shown in Table 7. DELA has made the choice to prioritize the purity of the clear PET fraction over the yield, resulting in a yield of only 53% but a very high purity of 95%. A lot of PET that does not end up in the clear PET stream ends up in the colored PET stream, which has a high PET purity, but a low colored PET purity because of the large portion of clear Pet in the colored PET stream.

Figure 56 Colored and clear PET bales

Fraction	Yield	Purity
Clear PET	233	95%
Coloured PET	60%	33% with respect to colored PET 95% with respect to total PET content

Table 7 DELA PET sorting results

8.5. Recycling

After plastic waste is sorted, the different plastic waste streams are sold to recyclers. PET recyclers turn PET waste into new raw materials: flakes or granulate. This new raw material is called rPET: recycled PET, and can be used to produce new products.

Figure 59 Left: rPET flakes. Right: rPET Granulate.

The most common products made from rPET are fibers, sheet, strapping and bottles. As can be seen in Figure 60, the use of rPET for bottles and sheet have significantly increased since 2002.

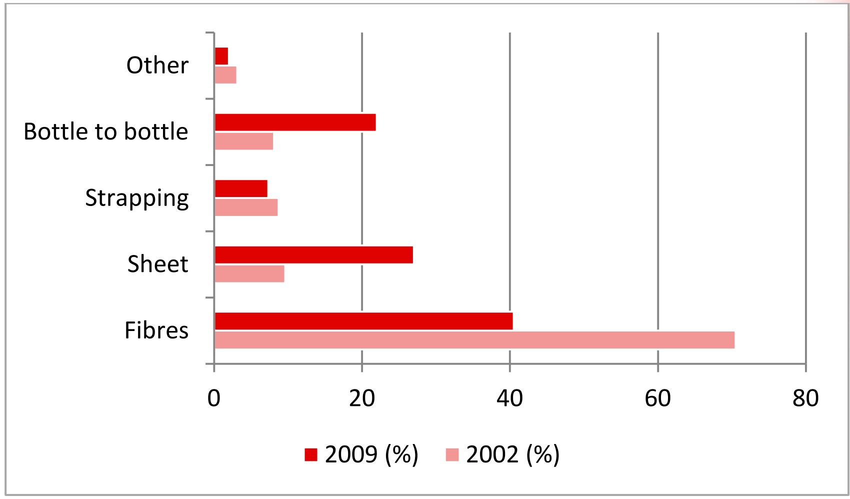


Figure 60 End-use markets for rPET 2002 and 2009 (34)

Different types of fibers can be made out of rPET depending on the spinning process and the length and thickness of the fiber. The fibers can be used as stuffing or used to spin yarn and weave fabrics, like fleece. rPET fibers are produced by extruding rPET flakes through tiny holes.

Figure 57 Polyester (PET fibre), and a fleece sweater

Figure 58 Container made from rPET sheet

Sheet can also be made from rPET flakes or granules. The flakes or granules are extruded and rolled to form sheet. The sheet can be thermoformed into all kinds of shapes, like containers. There is sheet for food and for non-food appications.

Figure 61 Strapping

Strapping is used to reinforce containers, like cartons or boxes, and can be made from rPET.

Another end-use for rPET granulate is in bottles, food and non-food grade.
These end-uses can be classified as secondary mechanical recycling: waste material is made into a product that is applied in the manufacturing of a completely different product. Bottle to bottle recycling however can also be primary recycling, recycling deposit scheme beverage bottles into new beverage bottles is the most common practice.

During this research project no universal definitions of ‘upcycling’ and ‘downcycling’ were discovered. All rPET end-uses replace virgin PET, thus investing in making the Heinz bottles ‘recyclable’ in these end-uses is contributing to saving natural resources.

Comparing the different rPET end-uses reveals that some end-uses have more critical demands on the PET source material than others. Fibers are the least critical end-use: the fibers are often colored so discoloration in rPET does not result in problems. Strapping requires rPET with a high intrinsic viscosity (IV), but since the IV of rPET is fairly simple upgraded the strapping end-use is not very critical. Sheet and bottle end-uses often require rPET with little to no discoloration because consumers are attracted to clear containers and bottles. Sheet is sometimes colored heavily (black) or mildly (a little blue mixed in with clear rPET) to conceal rPET discoloration, but this is less common in bottle end-uses.

Since bottle end-uses are the most critical application for rPET, Heinz should consider making the Heinz bottles suitable for application in rPET bottles: if the Heinz bottles don’t disturb the recycling process into bottles they probably won’t disturb the other end-uses too.

Research on the recycling of PP, the polymer used for the Heinz bottle caps, was not within the scope of this research. PP recycling however does not differ much from PET recycling, common end-uses for rPP are in items for construction, automotive and in flower pots.

The technique of recycling PET waste into rPET flakes or granules is very similar across Europe. For this research project, two recyclers were studied: 4PET Recycling in Arnhem (NL) and Wellman Recycling in Spijk (NL).

8.5.1. Case study: 4PET Recycling

4PET Recycling in Arnhem buys PET bales from The Netherlands, Germany and Belgium. The bales are converted to (color sorted) flakes or granulate. The FDA (Food and Drug Administration) certified 4PET’s rPET as suitable for the manufacture of articles in contact with food.

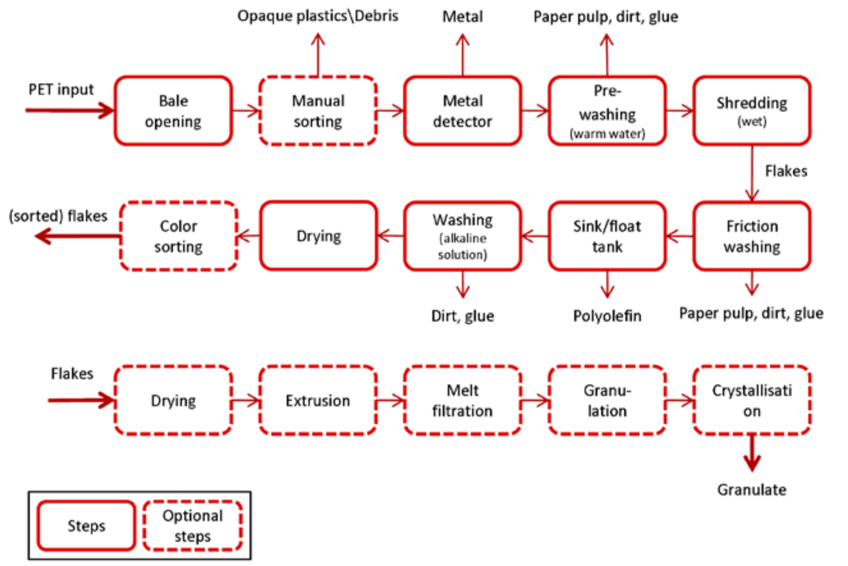


Figure 62 4PET recycling process

The recycling process of 4PET can be seen in Figure 62. The first steps in the process remove contaminants from the PET like debris and opaque plastics. Next, the PET items are washed and shredded, this removes dirt, paper labels and glue. After shredding, the flakes continue into the sink/float tank. In water, all flakes with a density >1 g/cm^3 sink, and those with a density <1 g/cm^3 float. PET sinks, and polyolefin (e.g. PE, PP) floats. The floating polyolefin (originating from bottle caps and labels) are removed from the tank, and go for recycling. The PET flakes continue to a washing tank filled with a light alkaline solution, this etches the surface of the flakes and removes the final dirt and glue residues. Optionally, the flakes can

Figure 63 Opaque PET bottle

be color sorted with a NIR-sorter, which works similar as the NIR-sorters discussed in the previous chapter.

It is also an option to transform the flakes into granulate. Flakes are not suitable for the production of some products, like bottles, so they need to be made into granulate first.

4PET recovers about 80% PET from the PET bales.

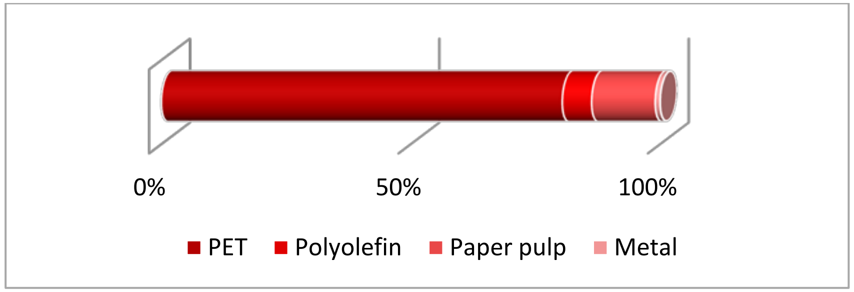


Figure 64 4PET Recycling results

The flakes and pellets produced with the process explained above can be used for non-food applications. To decontaminate the flakes or pellets for food applications 4PET uses Solid State Polycondensation (SSP). SSP can be applied on flakes (before extrusion) or on granules (after extrusion), 4PET applies the treatment on granules. SSP increases the Intrinsic Viscosity (IV) of the rPET, the rPET contains a lot of short molecules, polycondensation means ‘pasting’ these short molecules together into long ones, so increasing the IV. Besides increasing the IV, SSP decontaminates the rPET. During the process the granules reside in a vessel for 4 to 20 hours, in a vacuum or in an inert gas at a temperature of 190 to 210 °C.

SSP achieves good decontamination results, as can bee seen in the table below.

	Slightly volatile contaminants	Highly volatile contaminants
Pellet decontamination	>99%	>99%
Flake decontamination	95-99%	80-99%

Table 8 Reduction of volatile contaminants in rPET with 'super clean' treatment (35)

8.5.2. *Case study: Morssinkhof Rymoplast Recycling*

Morssinkhof recycles production waste and post-consumer waste: PET, PP, PS, HDPE and LDPE. The PET input of Morssinkhof consists of 80% PET from beverage bottle deposit systems and of 20% PET post-consumer waste (source separated).

Morssinkhof uses the same general techniques as 4PET. Morssinkhof however optionally uses a NIR sorter that can sort out PET flakes containing a barrier. This is expensive, so it is only applied to rPET for high-end end uses. It is not a technique commonly used by recyclers in Europe.

SSP is used at Morssinkhof on a very large scale. It is applied to the pet from the PET 90-10 bales, however not to make the rPET suitable for food applications, but only to upgrade the rPET’s viscosity.

8.6. Changes to foreseen in recycling practices

Sorting and recycling techniques are generally the same across Europe. These techniques might improve over the next few years, but big changes are not to be foreseen.

The NIR sorting of PET flakes containing barrier is a relatively new technique, so it might be improved over the next few years and become more effective and affordable.

9. COMPATIBILITY OF THE HEINZ BOTTLES WITH SORTING, RECYCLING AND LEGISLATION

To determine how 'recyclable' the Heinz ketchup bottles are, interviews with experts were conducted and tests were performed at sorters and recyclers. The first chapter looks into the sortability of the bottles, the next chapter is about the recyclability of the bottles after sorting. In the final chapter the compatibility of the Heinz bottles with the essential requirement is discussed.

9.1. SORTABILITY

The research on sortability is summarized in this chapter, the full description of the research can be found in Appendix G.

This chapter looks into how compatible the Heinz bottles are with current sorting techniques. As explained in chapter 8.4, the yield of sorting installations is almost never 100%, so a yield of 100% isn't to be expected from the Heinz bottles. WRAP conducted a research on six different sorting installations, 2 in the UK and 4 in Europe, PET sorting yields varied from 53% to 100% (33).

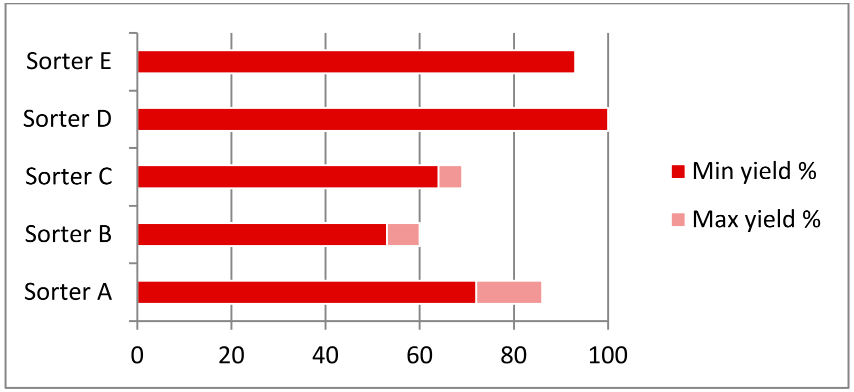


Figure 65 Sorting yield test results (33)

However, the bottles tested at the Sita and Dela sorting installation contained little to no contamination from the outside, like dirt or entanglement with other packaging, this should improve the test yield results.

A first exploratory test was performed at the Sita sorting installation in Rotterdam. To see how the Heinz' ketchup bottles would be sorted at the Sita sorting installation, a total of 16 bottles were prepared. 10 bottles (5x Top Down, 5x Icon) were emptied like a typical consumer would, 6 bottles (3x Top Down, 3x Icon) were emptied more sloppy thus contained more ketchup residue. Figure 67 shows the average amount of ketchup residue in a typically emptied bottle.

Figure 66 Left: bottle emptied sloppy. Right: bottle emptied typically.

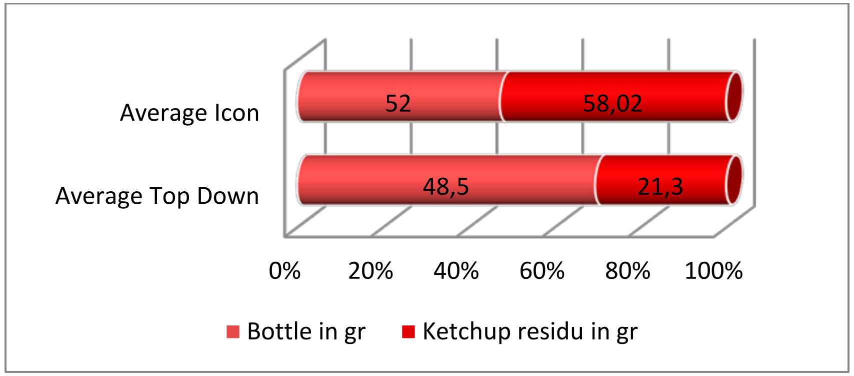


Figure 67 Average weight of the empty bottle and the ketchup residue

The 16 prepared bottles were put in the Sita sorting installation, just before the first NIR sorter. In the manual sorting room the bottles were collected at the conveyor belts for PET, Mixed plastics and residual waste.

The results, summarized in

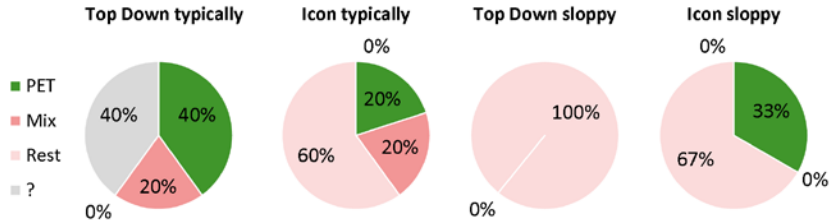


Figure 68, were a bit disappointing: half of the 16 bottles ended up in the residual waste stream, for incineration. Only four bottles made it into the PET bale and two bottles ended up in the mixed plastics bale. Two bottles got lost, they might have been sent back to the first NIR sorter by the fourth NIR sorter. This results in a yield of 25%, way below the yield to be expected from any sorting installation. There was however not a clear difference between the sorting results of the typically and the sloppily emptied bottles.

A second test at the DELA sorting plant in Beckum revealed that bottles with ketchup residue were almost never blown out into the PET stream, but bottles that were rinsed clean were sorted out without any problems.

At the Wageningen University, the bottles were scanned with a hand NIR polymer detector. The parts of the bottle without ketchup residue were correctly detected as being PET, but the parts of the bottle with ketchup residue on the wall were not able to be detected as a polymer type.

In conclusion, the Heinz bottles have a very low sortability. This is not caused by the bottle itself, but by the ketchup residue inside, which changes the absorption/reflection spectra detected by the NIR sorters. It is however unclear if the sorting problems are due to the color of the ketchup or due to the chemical composition of the ketchup.

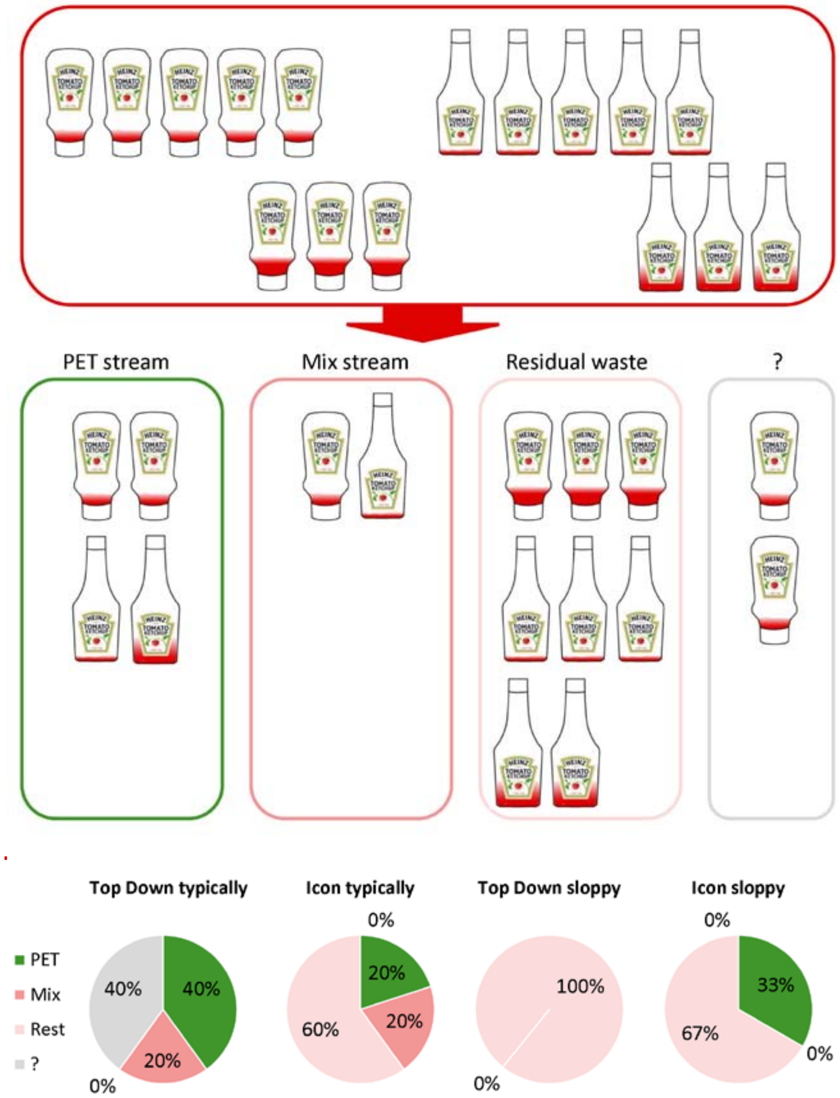


Figure 68 Results Heinz' bottle test at Sita

9.2. Recyclability

This chapter describes the compatibility of the Heinz bottles with current recycling techniques. Interviews with experts and a test at 4PET recycling were conducted to test compatibility.

Next, the recyclability of the individual main components are discussed.

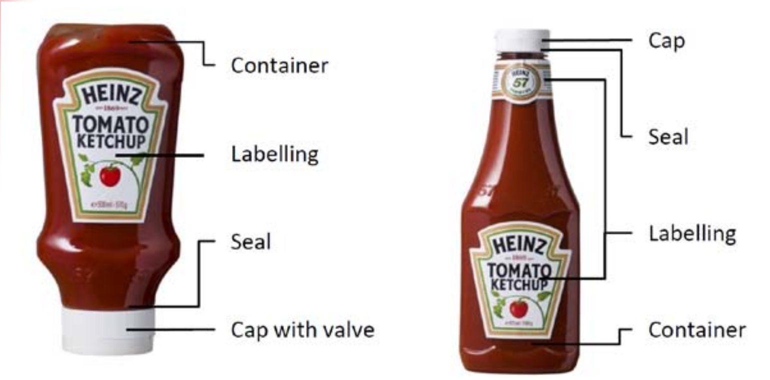


Figure 69 Main components of the Heinz bottles

Container (PET) with barrier – rPET flakes need to be heated in order to produce a new product out of them, for example by extrusion or injection molding. The Heinz bottles contain a barrier that turns yellow/brown when heated. This discoloration ends up in the rPET, this is an unwanted effect for most products made from rPET.

The flakes with barrier are not sorted from the other flakes. The discoloration does not appear until production of new products, because the flakes are not heated enough at the recycler to cause discoloration. Thus the recycler can see no difference between the PET flakes and the barrier flakes that are also clear. 4PET recycling tests batches of their rPET flakes by heating them in an oven, thus revealing barrier flakes that turn yellow/brown. Figure 70 shows the result of a heating test: the flakes on the left stayed clear (no barrier), but the flakes in the middle contained a barrier and turned brown. The flakes on the right show burnt glue residue on the edges of the flake.

Figure 70 4PET flakes: clear flakes (left), barrier flakes (middle), flakes with glue residue (right).

Figure 71 Heated bottles: before and after

The Heinz’ bottles were also tested by heating them in an oven for 30 minutes in a temperature of 235°C Figure 71 shows the results. Both bottles showed significant discoloration, the Icon bottle was more discolored than the Top Down bottle. The Icon bottle contained an older version of the barrier, the viscosity of the layers was not correct during co-injection molding, resulting in delamination. Because of this delamination, more oxygen reached the barrier during heating, leading to more discoloration. In the near future the Icon bottles will have the same barrier as the Icon bottle tested. The Top Down bottle showed less discoloration, but would still disturb the recycling results.

Discolored rPET is especially a problem in the production of clear bottles, that often need to be very clear and transparent. Morssinkhof, a PET recycler in Spijk (NL), even states that it will only use bottles from a beverage deposit system to use as rPET for new bottles. They will only use post-consumer PET for the production of strapping and black colored sheet because in those applications more contamination is acceptable. Clear sheet made from rPET has a little less problems with discoloration, slightly discolored rPET is blended with clear blue PET which reduces some of the yellow/brown discoloration, but even producers of clear sheet can not tolerate a batch of rPET with more than 5% discolored flakes. The only products not affected by discoloration in rPET are the products that are colored, this is often the case with strapping and fiber.

Cap (PP)– The cap of both bottles should not disturb the PET recycling process. The flakes from the cap, being PP, will float in the sink/float tank and be separated from the PET flakes. The PP flakes are compatible with recyclers that recycle the floating residue from PET recyclers. However, the Top Down cap contains a silicone valve. If this silicone would get separated (during shredding) from the cap, it would sink and end up with the rPET flakes. When sheet or bottles are made from rPET containing silicone residue, little bubbles appear in the product. This is an unwanted effect.

Labelling (paper) – The glue used on the labels is water soluble, so the paper labels get separated from the container during washing. The ink on the labels is not water or alkali soluble so it will not contaminate the washing water. Thus the labels do not interfere with the PET recycling process. Though a thing to keep in mind is that the paper pulp does not get recycled, but goes for incineration (with energy recovery). The paper pulp also has to be removed from the washing water, which uses up energy. This in contrast to plastic labels with a density <1 gr/cm^3 (e.g. PP or PE), which would get separated from the PET flakes in the sink/float tank, and go for recycling.

9.3. The essential requirements

9.3.1. EN 13431: Energy recovery

To see if the Heinz bottles comply with EN 13431, the standard on energy recovery, the inferior calorific value (q_{net}) of both bottles was estimated in accordance with Annex A and B of the standard. q_{net} has to be greater than 5 MJ/kg.

The complete calculation of the inferior calorific values of the bottles can be found in Appendix H. The estimated q_{net} value of the Top Down bottle was 28.75 MJ/kg and of the Icon bottle was 24.12 MJ/kg. The calculation of the q_{net} values of both bottles is only a rough indicator, because of missing data. But the q^{net} values exceed the minimum value of 5 MJ/kg so much that it can be assumed that both bottles can be classified as recoverable in the form of energy, as stated in the standard EN 13431.

9.3.2. EN 13431: Material recovery (recycling)

Since it can be assumed that the Heinz bottles can be classified recoverable in the form of energy, it is not an obligation for them to also be classified recoverable in the form of material recovery, see Table 4 (page 20). This chapter will look into compliance with standard EN 13431 anyway, because it shows a good summary of this research project. Because the standard is very complex, this chapter will not present a statement of (non-)compliance.

Annex C of EN 13431:2004 shows a list of questions to help asses recyclability, here follows a discussion on these questions.

- Is design and control of all stages of production, packing/filling including the materials used sufficient to maintain the suitability of the packaging for the recycling process?
    - Not within the scope of this research project.

- Does the design and control of components used and of the method of construction facilitate effective emptying?
    - Both bottles can be emptied by the consumer through squeezing, shaking and rinsing.

- Does the design and control of the components used and of the method of construction facilitate the end-user role of separation, when necessary, to assist collection ?
    - o The only separation necessary by the consumer is the removal of the seal before use, this should present no problems. It will not be necessary to assist collection because the consumer is expected to understand the collectability of the bottles through educational campaigns set up by collection agencies. The option of adding logo's to the label for extra clarification has been discussed in chapter 8.3.

- Does the design and control of the components used and the method of construction ensure compatibility with collection and sorting systems?
    - o The bottles are compatible with collection systems. The sorting of the bottles however, presents with problems due to the ketchup residue, as discussed earlier on in this chapter. However the bottles in itself, without ketchup residue, are perfectly sortable. It is unsure if an independent committee would label the bottles as compatible with sorting, because the standard does not make clear if product residue should be taken into account in this question.

- Is the method of construction, and the combination of raw materials and components (including additives) suitable for the recycling process?
    - o Both bottles are mostly recyclable. The labels are recyclable in theory, but in practice will go for incineration/energy recovery. The seal is not recyclable, because of it's multilayer composition. The PP cap is fully recyclable. The PET container is also fully recyclable, but presents a problem of discoloration, because of the barrier, when applied in a new product. Since the standard does mention to take into account substances or materials that are liable to have a negative influence on the quality of the recycled material, this cannot be ignored. The silicone valve is also not recyclable and can have a negative influence on the quality of the recycled material. So unfortunately this question can also not be unambiguously answered.

- Are any necessary systems of sorting, in preparation for the recycling process, suitable for the achievement of material recycling?
    - o The Icon bottle is suitable for sorting: the labels are washed off from the container, and the PP cap is separated from the container in a sink/float tank. The Top Down bottle presents with a problem because of the silicone valve, with current sorting systems it will not be sorted out. However the valve does not damage sorting systems in any way, but it will affect the quality of the recycled material.

- Are the construction, composition and separability of components act as to minimize releases to the environment in the recycling process?
    - o Not within the scope of this research project.

- Is the control of all stages of production, packing/filling sufficient to ensure that the releases to the environment in the recycling system, are minimized?
    - o Not within the scope of this research project.

- Can the packaging be emptied of contents sufficiently to minimize any additional emissions/ residues from the recycling process?
    - o The key word in this question is 'sufficiently'. Ketchup residue always stays behind in the bottles, but is the bottle sufficiently able to be emptied? The ketchup residue will be rinsed off during washing at a PET recycler, because of the organic nature of the ketchup it is not to be assumed that this will harm the environment. A swift benchmark shows that ketchup bottles of competitors will have roughly the same amount of ketchup residue in their used bottles. In conclusion, the ketchup residue will probably not affect compliance with the standard.

- Can the packaging be collected and sorted to minimize any additional residues/emission in the subsequent recycling operations?
    - o Only the labels on the bottles put forward a residue that won't be recycled during the sorting process. This can be improved by changing the paper labels with plastic labels.

The reviewing of these questions shows that compliance with standard 13430 is not simply demonstrated. The ketchup residue, silicone valve and barrier present with problems. The standard does mention that safety, hygiene and consumer needs of the packaging should not be compromised when improving recyclability (B.4.1 of EN 13430:2004). It could be argued that the valve and barrier are consumer needs and that ketchup residue is unavoidable, to qualify for compliance with the standard.

The standard also includes a table (table C.2 of EN 13430:2004) to help determine a declaration of percentage of a functional unit of packaging available for recycling. The recyclability percentages of both bottles were calculated, the calculation is shown in Appendix I.

The containers and caps of both bottles comply with DSD (Duales System Deutschland) specifications for respectively PET and PP plastic waste, according to EN 13430 this means that they can be claimed 100% recyclable, this should however be checked by a jurist. Only the seal is not recyclable. This results in a declaration of percentage available for recycling of 99.6% for the Top Down bottle, and 99.4% for the Icon bottle.

These recyclability percentages can be used to prove compliance with the standard, and make claims on recyclability.

10. RECOMMENDATIONS

This chapter concludes the research project by giving recommendations for the Heinz packaging design team.

10.1. GENERAL

1. Don't let the focus of the packaging development team be only on material reduction, keep the ladder of Moerman (prevention/reduction of food waste) in mind and weigh it against the ladder of Lansink (prevention/reduction of packaging waste).
2. The packaging development team should focus on making Heinz packaging as recyclable as possible and make use of a growing trend in post-consumer plastic packaging recycling, because this complies with Heinz' mission statement. Use the recommendations in this chapter to improve recyclability. Food grade bottles are the most critical rPET application, so this recycling process can be used to set a recyclability goal: Heinz bottles should not negatively influence a bottle to bottle recycling process.
3. The scope of this research project was on the Top Down and Icon bottles and on the Netherlands, Germany and the United Kingdom. Follow-up research can be done on other types of packaging and on other countries. Although it is to be expected that sorting and recycling techniques of PET are generally the same across Europe.

10.2. ESSENTIAL REQUIREMENTS (LEGISLATION)

4. It is to be foreseen that there will be more monitoring from national governments on compliance with the essential requirements, so be prepared for an inspection.
5. Research compliance with the following standards:
    a. EN 13428 (on manufacturing/composition/material reduction): It is obligatory to comply with this standard, document proof of compliance.
    b. EN 13430 (on recycling): It is only obligatory to comply with this standard if the bottles do not comply with EN 13431 (energy recovery) or EN 13432 (composing). It could be that the Heinz bottles are already compliant with this standard. Decide if Heinz desires proof of this compliance, if so document proof of compliance with the help of an expert because this is a complicated standard and there is some ambiguity in it. Also, use this standard as a guidance document to improve recyclability of packaging
    c. EN 13431 (on: energy recovery): It is only obligatory to comply with this standard if the bottles do not comply with EN 13430 (recycling) or EN 13432 (composing). This standard is very straightforward and the Heinz bottles will most likely already be compliant. Decide if Heinz desires proof of this compliance, if so document proof of compliance.

10.3. LOGO'S

6. Check to see if the green dot is on packaging for Portugal, Greece, France and Cyprus, because this is obligated in these countries.
7. The separate collection of plastic packaging by consumers in the Netherlands and Germany is going well, but recovery rates in the United Kingdom stay behind. Consider the use of the 'On-pack Recycling label' (see page 31) on the Heinz bottles for the UK. Research how wide spread the use of this label is in the UK, and if improvement of recovery of the packaging is to be expected when the label is used.
8. The containers of the Heinz bottles currently have a material identification logo on them that states they are PET, though the container is a composite consisting of PET and a small percentage of other materials. Keep in mind that there is no European legislation on the identification of composite materials, no decision has been made on the percentage of non-PET materials allowed in a packaging labeled as PET. German law however has set this percentage to 5%, this means the Heinz bottle containers are allowed to be labeled as PET in Germany. In practice the 5% rule stated in German law is used by companies in Europe for labeling composites.
9. Consider a follow-up research on the consumer perception of recycling logo's, like the Green Dot and Mobius loop, on packaging labels. Maybe the use of these logo's can improve the image of Heinz packaging among consumers.

10.4. Sorting

10. Conduct follow-up research on the sorting problem discussed in this report. The low sortability is caused by the ketchup residue, determine if the problem lies with the color or the composition of the ketchup.
11. Subsequent to the follow-up research, find a solution for the sorting problem. Possible solutions could be designing the bottles in such a way that less ketchup residue stays behind or instructing/encouraging the rinsing of the bottles by consumers.

10.5. Recycling

12. Conduct follow-up research on new barrier options. The discoloration of the current barrier is obstacle interfering with good quality bottle-to-bottle recycling. The new barrier should not show discoloration when heated, but should not jeopardize shelf-life as well.
    The European Pet Bottle Platform tests recyclability of packaging and packaging components: keep an eye on the research results they publish on their website. Consider having your new packaging tested by them or another organization that offers the same service.
13. Prevent partially delaminating plastic packaging. If flakes delaminate partially during shredding at a recycler, they accumulate dirt/contaminants in between different layers and are hard to rinse clean. This deceases the quality of the rPET.
14. Do not use silicone in the caps of the Heinz bottles because the silicone forms droplets in products made from rPET contaminated with the silicone. It is technically possible to adjust the density of the silicone so that it would float in the sink/float-tank of the recyclers. The silicone would then end up with the polyolefins. Still the silicone will hinder the polyolefin recyclers, injection molding of objects with polyolefins contaminated with silicone causes silicone droplets to migrate to the surface of the object.
    a. Conduct follow-up research on a dispensing mechanism for the Heinz bottles that does not require the use of silicone, while maintaining ease of use.
15. Change the paper labels on the Heinz bottles to PE or PP or PET labels, or make sure the paper labels do not pulp in water. This because the current paper labels on the Heinz bottles pulp in the washing water at the recyclers, the recyclers have to clear the water from this pulp. And the paper pulp goes for incineration (with energy recovery), while plastic labels go for recycling.
    If a plastic label is used, don't make it a full body sleeve, because the NIR sorters might mistake the bottle for being the label's material instead of the container's material. Also use glue which is water soluble to ensure removal of the label in the washing tank, and don't use water soluble ink that contaminates the washing water.
16. Make Heinz' packaging technologists aware of recycling issues. Incorporate the use of a document that provides general information on packaging components' compliance with current recycling methods. Various companies have published such guiding documents, a good example can be found in Appendix J.

10.6. In the remote future

17. In the remote future it might become possible and common to reclaim Heinz' plastic packaging from sorters and to oversee the recycling of those bottles yourself. Some options for the detection of the owner of a bottle are being researched at the moment:
    a. The use of a RFID-chip in packaging.
    b. Automated recognition of the shape/color combination of a packaging.
    c. The use of invisible metals in plastic that light up in UV light or that can be detected with X-ray technology

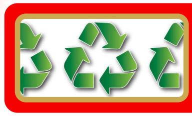
    It might be interesting for Heinz to keep an eye on the development of these techniques for use in the remote future.

10.7. Summary of the most important recommendations

Features of the perfect Heinz ketchup bottle, facilitating bottle to bottle recycling:

The perfect bottle
for B2B recycling

The container uses an oxygen-barrier that does not show discoloration when heated, and ensures a reasonable shelf-life



The container consists of a certain amount of rPET, this closes the loop: bottle to rPET to bottle

The cap cointains no silicone

The labels on the bottle are plastic

Figure 72 The perfect bottle

Summary of the most important recommendations for follow-up research:

Recommendations on follow-up research:

- Research other types of packaging and other countries
- Research sorting problems
- Research compliance with the essential requirements
- Research the effect of using recycling logo's on packaging on the consumer
- Research the use of a diffrent type of barrier
- Research a dispensing mechanism that does not need silicone

Figure 73 Recommendations for follow-up research

11. APPENDICES

11.1. Appendix A Translations in Dutch and German of frequently used terms

Decree management of Packaging and Paper and Board	In Dutch:	Besluit beheer verpakkingen en papier en karton
Waste fund	In Dutch:	Afvalfonds
Ministry of VROM (Housing, Spatial Planning and the Environment)	In Dutch:	Ministerie van VROM (Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer)
Framework agreement	In Dutch:	Raamovereenkomst
The Packaging Ordinance	In German:	'Verpackungsverordnung' or in short 'VerpackV'
Essential requirements	In Dutch:	Essentiële eisen
Tax authorities	In Dutch:	Belastingdienst
Dual System	In German:	Duales System

11.2. Appendix B Country abbreviations

Short name in English (geographical name)	Country code	Former abbreviation
Austria	AT	A
Belgium	BE	B
Bulgaria	BG	—
Croatia	HR	
Cyprus	CY	—
Czech Republic	CZ	—
Denmark	DK	DK
Estonia	EE	—
Finland	FI	FIN
France	FR	F
Germany	DE	D
Greece	EL	EL
Hungary	HU	—
Iceland	IS	
Ireland	IE	IRL
Italy	IT	I
Latvia	LV	—
Lithuania	LT	—
Luxembourg	LU	L
Malta	MT	—
Montenegro	ME	
Netherlands	NL	NL
Norway	NO	
Poland	PL	—
Portugal	PT	P
Romania	RO	—
Russia	RU	
Slovakia	SK	—
Slovenia	SI	—
Spain	ES	E
Sweden	SE	S
Switzerland	CH	
Turkey	TR	
United Kingdom	UK	UK

11.3. Appendix C Overview of European plastic packaging recycling organizations and activities (If no other source mentioned, source is (36))

Country	Organization responsible for the organization of collection/recycling	Financing	Separate collection of plastic household waste?	Grüne punkt?
Austria	Altstof Recycling Austria (ARA)	License fees, by weight	Yes, kerbside and bring sites (in some regions a combination of metal and plastics are collected, easy to separate after)(37)	
Belgium	Fost Plus	License fees, by weight	Yes, kerbside and bring sites	
Bulgaria	Ecopack Bulgaria	If annual packaging on market >10tons: License fees, by weight	Yes, kerbside and bring sites	
Croatia	“Croatian State decided to proclaim itself owner of all the packaging waste and imposed its monopoly on the packaging recovery and it doesn't allow any parallel or competitive packaging waste management systems.” “Eko-Ozra was founded in 2005 by 28 Croatian companies in order to take responsibility for packaging placed on the Croatian market by its founders.” (38) Because of this conflict there is currently no waste being separated in Croatia. (39)			
	Eko-Ozra	License fees, fixed fee for small/medium/large companies	No separate collection	
	Croatian government	Packaging tax, by weight	No separate collection (just PET soda bottle deposit and return system)	No
Czech Republic	EKO-KOM	License fees, by weight	Yes, bring sites(40)	
Denmark	Dansk Retursystem	-	No (just beverage bottle deposit and return system)(41)	No
Estonia	ERO (Estonian Recovery Organization)	License fees, by weight	Yes, plastic collected together with glass, metal and cardboard multilayer beverage packaging. (42)	
Finland	The Environmental Register of Packaging PYR	If annual turnover >1M Euro: License fees, by weight	Depends on the municipality, some collect separately some not (43)	No
France	Eco-Emballages	License fees, by weight	Yes	
Germany	Der Grüne Punkt - Duales System Deutschland	License fees, by weight	Yes, kerbside and bring sites	
Greece	Hellenic Recovery Recycling Corporation (HE.R.R.Co)	License fees, by weight	Yes, bring sites (44)	
Hungary	ÖKO-Pannon	License fees, by weight	Yes, bring sites	
Ireland	Repak	License fees, by weight	Yes, bring sites	
Italy	CONAI	License fees, by weight	Yes	
Latvia	Latvijas Zaļais punkts	License fees, by weight	Yes, bring sites in most cities. Some cities have	

Country	Organization responsible for the organization of collection/recycling	Financing	Separate collection of plastic household waste?	Grüne punkt?
			bring sites for all materials, they are separated later on. (45)	
Lithuania	Žaliasis taškas	License fees, by weight	Yes, kerbside and bring sites (46)	
Luxembourg	VALORLUX	License fees, by weight	Yes, kerbside. Plastic, metal and cardboard packaging is collected in one bag. (47)	
Netherlands	Nedvang	Packaging tax, by weight	Yes, kerbside and bring sites	No
Norway	Grønt Punkt Norge	License fees, by weight	Yes, kerbside and bring sites (48)	
Poland	Rekopol Organizacja Odzysku	License fees, by weight	Yes, bring sites (49)	
Portugal	Sociedade Ponto Verde	License fees, by weight	Yes, bring sites (50)	
Romania	ECO - ROM AMBALAJE	License fees, by weight	Yes, bring sites (51)	
Serbia	Sekopak	License fees, by weight	No, bags and bins for separate collection are being distributed to only 0.5% of households (52)	
Slovakia	ENVI-PAK	License fees, by weight	Yes, kerbside and bring sites (53)	
Slovenia	Slopak	License fees, by weight	Yes, plastic, cardboard multilayer and metal packaging collected together. (54)	
Spain	ECOEMBALAJES ESPAÑA, S.A. (ECOEMBES)	License fees, by weight	Yes, bring sites (55)	
Sweden	REPA	License fees, by weight	Yes, bring sites	
Switzerland	In Switzerland only PET bottles for beverages are collected (bring sites, financed by a tax per bottle). Other plastic consumer waste is not collected separately, but this might change in a few years. Plastics are not separated from other household waste after collection, but incinerated with the rest of the household waste. (56)			
Turkey	ÇEVKO foundation	License fees, by weight	Yes, bring sites (57)	
United Kingdom	The UK in contrast to other EU states has chosen a very unique system. All participants in the chain share the statutory responsibility. The system is open to competition and there are a number of "compliance schemes" to ensure this. The UK does not operate a "Green Dot Scheme" along the lines of its European counterparts. The use of the trademark is licensed in the UK for those organizations wishing to display the emblem but the use of the mark is not obligatory in the UK.			
	Green Dot Licensing Company	-	-	
	Multiple compliance schemes	License fees, by weight	Yes, kerbside and bring sites	No
Russia	In Russia, plastics from big companies and shopping malls are collected and recycled sometimes, but household plastic packaging is not being collected or recycled. This will not change any time soon, because of cultural, infrastructural and regulatory difficulties. Because a lot of plastic packaging waste ends up as landfill, bio-degradable plastics are a short term solution, but not the solution to the big problem of Russia not recycling plastics. (16)			

11.4. Appendix D DSD specification Mixed PET 90/10

DKR
Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe mbH

Der Grüne Punkt – Duales System Deutschland GmbH

Product Specification 04/2009
Fraction-No. 328-1

Sorting fraction: **Mixed PET 90 / 10**

A Specification/Description

Used, residue-drained dimensionally stable, system-compatible packages made of polyethylene terephthalate (PET), volume ≤ 5 litres in the following composition:

1. transparent bottles, e.g. washing-up-liquid bottles, beverage bottles
2. other dimensionally stable PET packages, e.g. beakers, bowls

Clear, coloured, opaque, including ancillary constituents such as closures, labels, etc.

The supplementary sheet is part of this specification!

B Purity

At least 90 % PET bottles, transparent

Maximally 10 % other dimensionally stable packages made of PET

Mass % as per specification/description.

C Impurities

Maximum total content of impurities	2 mass %
Metallic and mineral impurities with a unit weight of > 100 g must not be contained!	
Other metal articles	< 0.5 mass %
Other plastic articles	< 2 mass %
PVC articles	< 0.1 mass %
Other residual materials	< 2 mass %

Examples of impurities:
- Glass
- Paper/board/cardboard
- Paper/board/cardboard composite materials (e.g. cartons for liquids)
- Aluminium-coated plastics
- Foreign materials (e.g. rubber, stones, wood, textiles, nappies)
- Compostable waste (e.g. food, garden waste)

D Form of delivery

- Transportable bales
- Dimensions and density of the bales must be chosen so as to ensure that a tarpaulin truck (loading area 12.60 m x 2.40 m; lateral loading height min. 2.60 m) can be loaded with a minimum loading of 14 t
- stored in a dry place
- produced using commercially available bale presses
- identified by bale tags provided with Sorting Line Number, Fraction Number and production date

11.5. Appendix E Dutch plastic recycling communication tool: leaflet on what and what not to discard in Plastic Heroes containers

WAT WEL...

- plastic tasjes, tassen en broodzakken
- pasta- en rijstzakken
- snoepzakken
- verpakking van vleeswaren en kaas
- folies om tijdschriften en reclamefolders
- blisters voor o.a. tandenborstels, snoeren, schroeven
- boterkuipjes, sausbakjes, smeerkaas-, paté- of koffiemelkkuipjes
- groente-, fruit- en saladebakjes of -zakjes, patatbakjes
- bekers voor yoghurt, vla, slagroom, ijs
- deksels van potten pindakaas, chocopasta etc.
- knijpflessen voor sauzen zoals ketchup en mayonaise
- flacons voor wasmiddelen en schoonmaakmiddelen
- flacons voor bijv. shampoo, douchegel, badschuim en zeep
- tubes voor bijv. gel, crème, bodylotion en tandpasta
- flessen voor olie en azijn
- flessen voor frisdrank, water en zuivel
- potjes voor gel, medicijnen, vitamines
- plantenpotten

Zorg dat alles leeg is en verwijder a.u.b. papier, karton of aluminium (folie)resten.

...WAT NIET...

Verpakkingen met inhoud

Verpakkingen van chemisch afval
make-upverpakkingen, terpentineflessen, kitkokers

Piepschuim
fastfoodverpakkingen, vleesschaaltjes, verpakkingsvulmateriaal

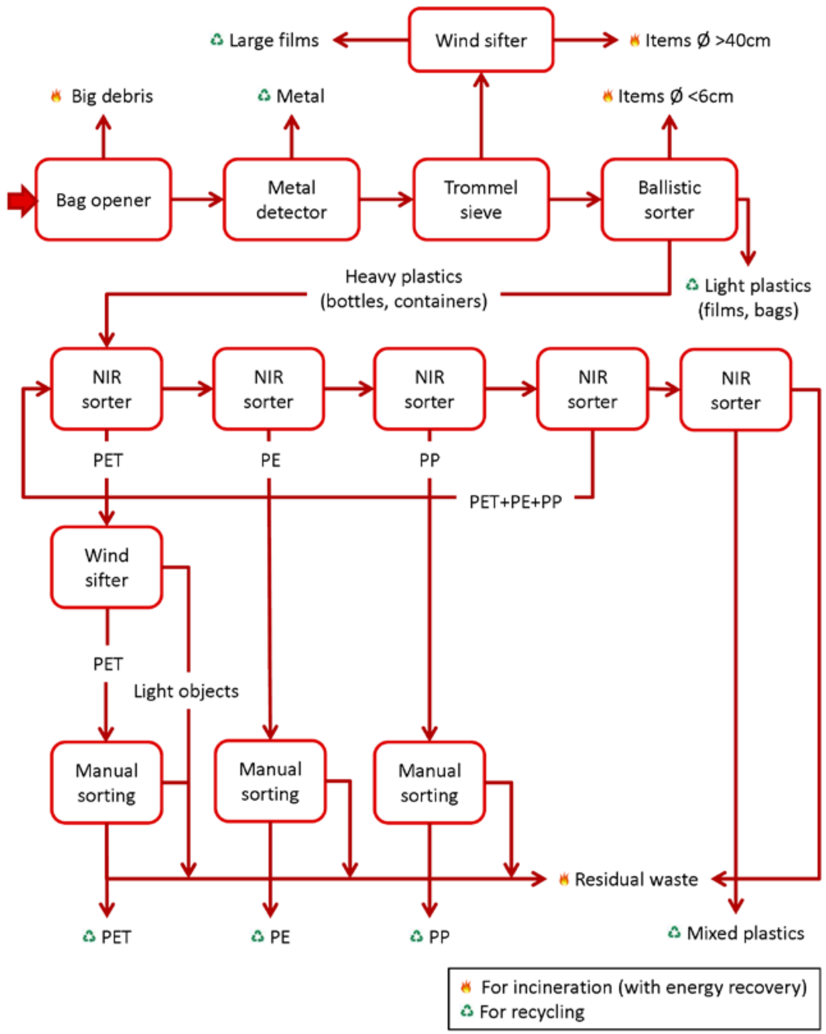
Resten papier, karton of folie
afdekmaterialen, chipsverpakkingen, doordrukstrips (pillen of kauwgom)

Kartonnen (drank)verpakkingen

Andere plastic producten en gebruiksvoorwerpen
tuinstoelen, speelgoed

Houdt u a.u.b. aan deze aanwijzingen, zodat het recycle-proces niet verstoord wordt.

11.6. Appendix F The Sita sorting process



11.7. APPENDIX G COMPLETE DESCRIPTION OF RESEARCH ON SORTABILITY

SORTABILITY

This chapter looks into how compatible the Heinz bottles are with current sorting techniques. As explained in chapter 8.4, the yield of sorting installations is almost never 100%, so a yield of 100% isn't to be expected from the Heinz bottles. WRAP conducted a research on six different sorting installations, 2 in the UK and 4 in Europe, PET sorting yields varied from 53% to 100% (33).

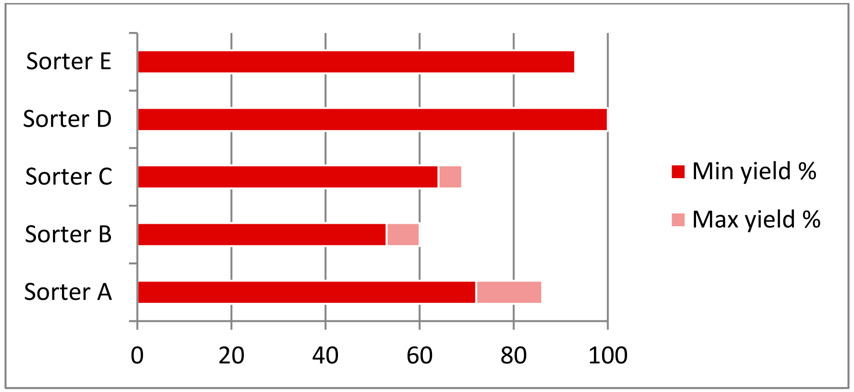


Figure 74 Sorting yield test results (33)

However, the bottles tested contained little to no contamination from the outside, like dirt or entanglement with other packaging, this should improve the test yield results.

A first exploratory test was performed at the Sita sorting installation in Rotterdam. To see how the Heinz' ketchup bottles would be sorted at the Sita sorting installation, a total of 16 bottles were prepared. 10 bottles (5x Top Down, 5x Icon) were squeezed empty as much as possible, then rested and then squeezed empty as much as possible again. 6 bottles (3x Top Down, 3x Icon) were only squeezed empty one time. The bottles that were emptied twice represented bottles from customers that emptied the bottles 'typically'. And the bottles that were emptied only once represented bottles from customers that are more sloppy and leave more ketchup residue behind when throwing away the bottle.

It has to be noted that in hindsight there was a lot of residue in the test bottles, more than a typical customer would probably leave behind. This is because a typical customer lets the bottle rest in between multiple uses, and not just one time like with the test bottles. The resting is an important factor in the emptying of the bottle, because then the ketchup gets time to accumulate, and accumulated ketchup is easier to get out of the bottle than ketchup that is spread across the walls of the bottle. Figure 76 shows a bottle with ketchup that is spread across the walls, and a bottle with ketchup that has accumulated during resting.

Figure 76 Left: bottle after being squeezed empty for the first time. Right: bottle that has rested after the first squeeze

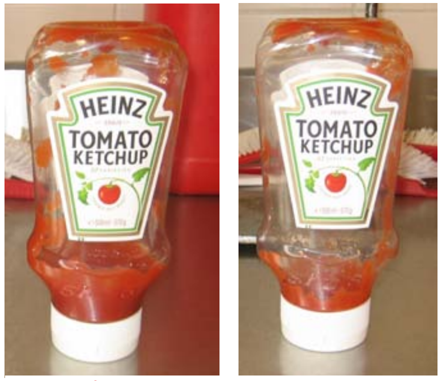


Figure 75 Left: bottle emptied sloppy. Right: bottle emptied typically.

Ten bottles (5x Top Down, 5x Icon) were weighed after being emptied 'typically', to determine the amount of ketchup staying behind in a bottle that is thrown away by a consumer. The average results are shown in Figure 77.

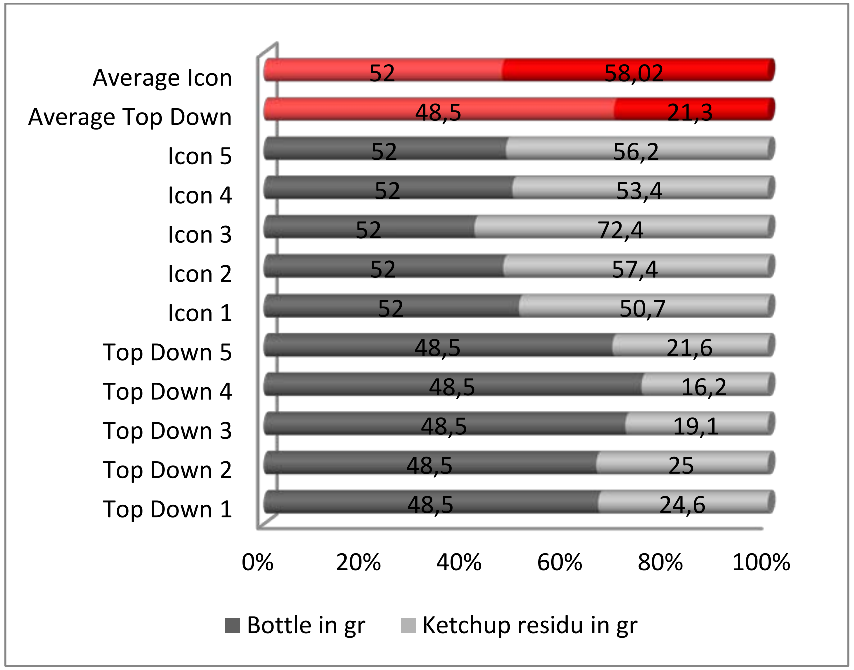


Figure 77 Weight of the empty bottle and the ketchup residue

The weighing of the bottles shows that in the Icon bottles a lot more ketchup residue stays behind: on average 53% of the weight that is thrown away consists of ketchup. If a Top Down bottle gets discarded, on average 30% of the total weight consists of ketchup. These results might be explained by the fact that the Icon bottle has a greater inner surface where the ketchup sticks to, and by the fact that the Icon bottle did not rest with the top down unlike the Top Down bottle.

The 16 prepared bottles were put in the Sita sorting installation, just before the first NIR sorter. In the manual sorting room the bottles were collected at the conveyor belts for PET, Mixed plastics and residual waste.

The results were a bit disappointing: half of the 16 bottles ended up in the residual waste stream, for incineration. Only four bottles made it into the PET bale and two bottles ended up in the mixed plastics bale. Two bottles got lost, they might have been sent back to the first NIR sorter by the fourth NIR sorter.

This results in a yield of 25%, way below the yield to be expected from any sorting installation. The test results are summarized in Figure 78.

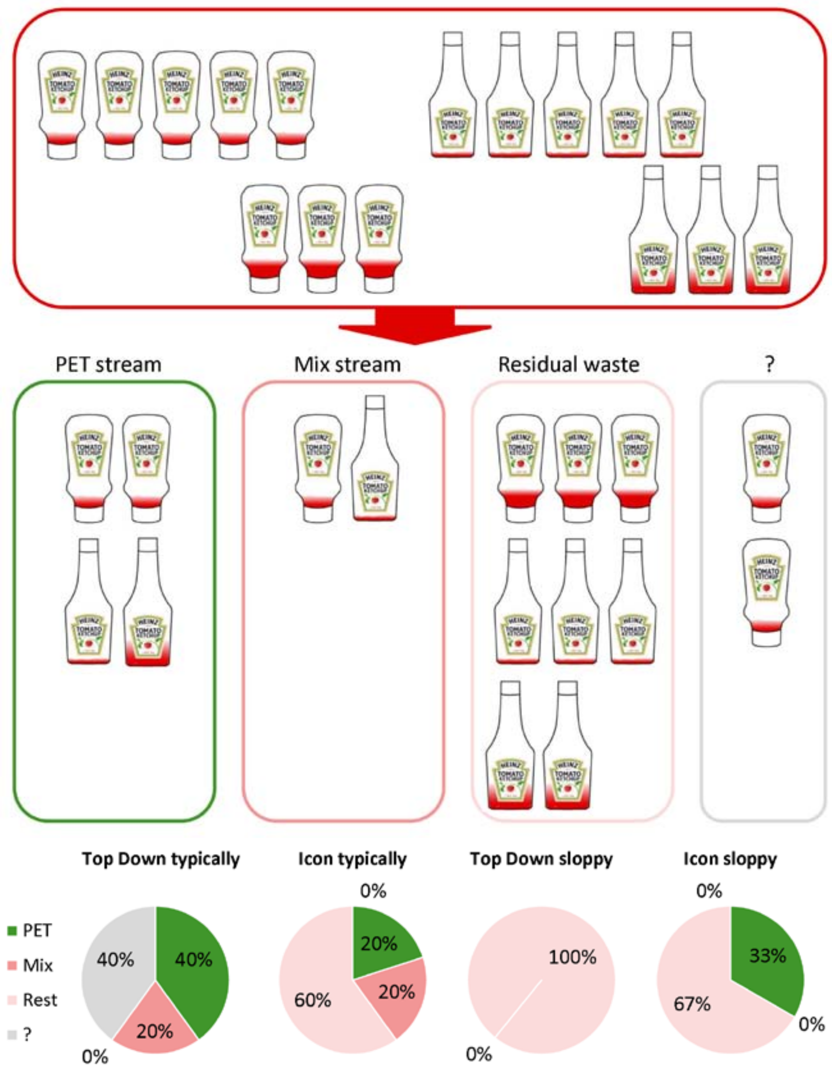


Figure 78 Results Heinz' bottle test at Sita

Because of the small number of bottles tested, the great amount of ketchup residue, and the fact that the bottles were not crushed, this test is not very representative of the real situation. It does however show some indications of bottlenecks in the sorting process of Heinz' bottles. Half of all bottles ended up in the residual waste stream, this means that these bottles were not detected and/or blown out at any of the five NIR sorters.

To try and explain the disappointing sorting results two hypotheses were formed:

1. The air jets of the NIR sorters don't have enough power to blow out the great weight of the bottles with a lot of ketchup residue.
2. The bottle is not detected as PET but as PP (cap) or paper (labels).

To answer these hypotheses TITECH, the manufacturer of the NIR sorters at Sita, was consulted. TITECH stated the following answers to the two hypotheses:

1. The air jets in the NIR sorters can blow out items up to 500 gram, the Heinz bottles with residue only weigh up to 120 gram. Problems with residue only occur with liquid residue like water and soda drinks. When a bottle containing liquid residue gets blown out by the air jets, the liquid inside the bottle splashes, changing the flight direction of the bottle. Because of the more viscous nature of ketchup, this issue does not occur with the Heinz bottles.
2. The NIR sorters scan the whole object that passes on the conveyor belt. The PP cap will be detected, but because a greater area of PET is detected the bottle is considered a PET item. Paper labels do not influence the reflection spectra of the PET, especially since the labels do not cover the whole bottle.

These answers were verified by U. Thoden van Velzen, senior scientist at Wageningen University (NL) and NIR sorting expert.

Since the weight, cap and label did not explain the disappointing sorting results, another hypothesis was suggested by TITECH:

- The ketchup residue inside the bottle changes the absorbed/reflected spectrum of the bottle, the changed spectrum is not recognized as PET so the bottles are not blown out.

This hypothesis was tested at the DELA sorting plant in Beckum (DE). Nineteen bottles with ketchup residue were tested on two NIR sorters, no other waste was sorted on the machines at the time of the test. The first sorter also included a color sorter next to a NIR polymer sorter.

The first part of the test was performed on the sorter with NIR polymer and color detection, it was configured to eject clear PET. None of the Heinz bottles with ketchup residue were detected, the air jets did not blow at a single bottle. The settings were changed to eject clear and red PET, but still no bottles were detected.

In the second part of the test the NIR sorter with only polymer detection was used. Only a very small number of bottles was detected and ejected.

Finally in the third part of the test rinsed bottles were used on the NIR sorters. These bottles without ketchup residue were all blown out as clear PET.

The hypothesis was also tested at the Wageningen University where the bottles were scanned with a hand NIR polymer detector. The parts of the bottle without ketchup residue were correctly detected as being PET, but the parts of the bottle with ketchup residue on the wall were not able to be detected as a polymer type.

In conclusion, the Heinz bottles have a very low sortability. This is not caused by the bottle itself, but by the ketchup residue inside. It is however unclear if the sorting problems are due to the color of the ketchup or due to the chemical composition of the ketchup.

11.8. Appendix H Calculation of the inferior calorific value of the Heinz bottles in accordance with EN 13431

q_{net} is calculated according to the following equation: $$q_{net} = \sum_{i=1}^{n} f_i q_{net,i}$$

Where

q_{net} inferior calorific value of the packaging

f_i mass fraction of component or constituent "i" in the packaging

$q_{net,I}$ inferior calorific value of component or constituent "i" in the packaging

The following values apply to the Heinz bottles:

Top Down bottle			
Component	f_i	$q_{net,I}$ [1]	$f_i\, q_{net,I}$
Container (PET)	0.673	22.0	14.81
Cap (PP)	0.312	44.0	13.73
Labels (paper)	0.011	9.3[2]	0.10
Seal (multilayer)	0.004	27.86[3]	0.11
q_{net} = Sum f_i $q_{net,I}$			**28.75 MJ/kg**

Icon bottle			
Component	f_i	$q_{net,I}$ [1]	$f_i\, q_{net,I}$
Container (PET)	0.87	22.0	19.14
Cap (PP)	0.108	44.0	4.75
Labels (paper)	0.016	9.3[2]	0.15
Seal (multilayer)	0.0028	27.86[3]	0.08
q_{net} = Sum f_i $q_{net,I}$			**24.12 MJ/kg**

Table 9 Mass fraction and inferior calorific value of the Heinz bottles' components

1 q_{net} values come from Table B.1 of EN 13431:2004

2 Paper type is uncertain, the 'worst case scenario', lowest q_{net} value in table B.1 was chosen

3 The seal is a multilayer. The $q_{net,I}$ was calculated as follows, for the unknown q_{net} values the worst case scenario of a value of 0 was chosen:

Component	f_i	$q_{net,I}$	$f_i\, q_{net,I}$
Polyolefin	0.52	43	22.36
Polyester	0.25	22	5.5
Adhesive	0.17	0	0
Aluminum	0.06	0	0
Sum f_i $q_{net,I}$			27.86

The calculation of the q_{net} values of both bottles is of course only a rough indicator, because of missing data. But the q^{net} values exceed the minimum value of 5 MJ/kg so much that it can be assumed that both bottles can be classified as recoverable in the form of energy, as stated in the standard EN 13431.

11.9. Appendix I Calculation of the recycling rates of the Heinz bottles according to EN 13430

Table 10 and Table 11 show the calculation of the recycling rates of both Heinz bottles. First the packaging is divided up into components, a component is a part of a packaging that can be separated by hand or by using simple physical means. The recyclability of all components is assessed, and the sum of the recyclable components gives the total percentage available for recycling.

1	**Functional Unit of Packaging**	**Description: Clear, non colored multilayer PET bottle for sauces, fill volume 570ml, with paper labels and plastic cap, silicone valve, and multilayer seal**		
	(Component see note 1)	Component 1	Component 2	Component 3
2	Description	Bottle with labels	Cap with silicone valve	Seal
3	Weight of component as % of total functional unit	68.4%	31.2%	0.4%
4	If the whole component is accepted for recycling based on national, European, international, commercial standards or specifications, give detailed reference	DSD product specification, fraction No. 238 Mixed PET (58)	DSD product specification, fraction No. 324 Polypropylene (58)	
5	If the component complies with such standard(s) or specification(s) fill in line 6 - and then go to line 11 and note that 100% is available for recycling. If not, continue with line 6			
6	**Intended material stream, see note 2**	**Plastic**	**Plastic**	**None**
7	Identification of constituents within the component likely to create problems in the overall recycling such that alternative recovery is recommended. Reference to CR 13688			
8	Constituents liable to cause problems in collection and sorting	---	---	---
9	Constituents liable to cause problems in recycling	---	---	---
10	Constituents liable to have a negative influence in the recycled material	---	---	---
11	Percentage by weight of component available for recycling	100%	100%	0%
12	Percentage by weight of functional unit available for recycling (Line11 x Line 3 / 100)	68.4%	31.2%	0%

13	**Total percentage available for recycling (Sum line 12)**	**99.6%**

Table 10 Percentage available for recycling: Top Down bottle

Note 1: Component defined in EN 13427 - part of packaging that can be separated by hand or by using simple physical means.
Note 2: Intended material recycling stream - aluminum, glass, paper, plastic, steel. wood, other.

1	**Functional Unit of Packaging**	**Description: Clear, non colored multilayer PET bottle for sauces, fill volume 875ml, with paper labels, plastic cap, and multilayer seal**		
	(Component see note 1)	Component 1	Component 2	Component 3
2	Description	Bottle with labels	Cap	Seal
3	Weight of component as % of total functional unit	88.6%	10.8%	0.6%
4	If the whole component is accepted for recycling based on national, European, international, commercial standards or specifications, give detailed reference	DSD product specification, fraction No. 238 Mixed PET (58)	DSD product specification, fraction No. 324 Polypropylene (58)	
5	If the component complies with such standard(s) or specification(s) fill in line 6 - and then go to line 11 and note that 100% is available for recycling. If not, continue with line 6			
6	**Intended material stream, see note 2**	**Plastic**	**Plastic**	**None**
7	Identification of constituents within the component likely to create problems in the overall recycling such that alternative recovery is recommended. Reference to CR 13688			
8	Constituents liable to cause problems in collection and sorting	---	---	---
9	Constituents liable to cause problems in recycling	---	---	---
10	Constituents liable to have a negative influence in the recycled material	---	---	---
11	Percentage by weight of component available for recycling	100%	100%	0%
12	Percentage by weight of functional unit available for recycling (Line11 x Line 3 / 100)	88.6%	10.8%	0%

13	**Total percentage available for recycling (Sum line 12)**	**99.4%**

Table 11 Percentage available for recycling: Icon bottle

Note 1: Component defined in EN 13427 - part of packaging that can be separated by hand or by using simple physical means.
Note 2: Intended material recycling stream - aluminum, glass, paper, plastic, steel. wood, other.

A component, in the above tables, is a part of a packaging that can be separated by hand or by using simple physical means. Because the labels cannot be easily removed from the bottle, and the silicone valve cannot be easily removed from the cap, these items are a component together. This actually increases the recycling percentage of the bottle. The bottle with labels and cap with silicone valve both comply with DSD (Duales System Deutschland) specifications, the labels and valve are considered contaminants and do not exceed maximum contaminant levels. The instructions state that once a component complies with such a national standard the table allows to state a 100% recycling percentage for that component. So the bottle with labels and cap with valve are both 100% recyclable in this calculation, this leaves only the non-recyclable seal. Resulting in a 99.6% availability for recycling for the Top Down bottle and a 99.4% availability for recycling for the Icon bottle.

11.10. Appendix J Guidance table on compatibility of packaging components with PET recycling (59)

		YES	CONDITIONAL[1]	NO
BODY[2]	Material	PET		PLA / PVC / PET-G
	Colour	Clear / Light-blue / Green	Other transparent colours	Opaque[8]
	Barrier / Coatings	Clear plasma coating	External coating / PA - 3 layers (e.g. MXD6 3 layers),	EVOH / PA monolayer blends
	Additives		O_2 scavengers / UV stabilisers / AA blockers / Nanocomposites	
CLOSURE	Caps	PP[4] HDPE, LDPE - Europe only	HDPE, LDPE - USA only	Steel / Aluminium / PS / PVC / Thermosets
	Liner	HDPE / PE+EVA / PP		PVC / EVA with aluminium
	Seals	PE / PP / OPP / EPS / Foamed PET	Silicone[6] (density <1 g/cm^3)	PVC / Aluminium / Silicone (density $>=1$ g/cm^3)
DECORATION	Direct Printing	Production or expiry date		Other direct printing[9]
	Labels	HDPE / MDPE / LDPE / PP / OPP / EPS (density <1 g/cm^3) / Paper[5]	PET Metallised labels[7]	PVC / PS (density >1 g/cm^3)
	Sleeves (incl. tamper resistance)	PE / PP / OPP / EPS (density <1 g/cm^3) Foamed PET / Foamed PET-G	PET	PVC / Full body sleeves PS (density >1 g/cm^3) / PET-G
	Glue[3]	No adhesive on body Water-soluble adhesive or alkali soluble adhesives (<80°C)		Adhesive not removed in water or alkali at 80°C
	Ink	EuPIA good manufacturing practices		Inks that bleed and dye wash-solution
OTHER COMPONENT			HDPE / PP / Uncoloured PET	PVC / RFID / Non-plastic

[1] Some materials / bottle components are recyclable under certain conditions. Please check with recyclers or recycling organisations.

[2] All materials must meet the legal requirements for materials and articles intended to come into contact with food.

[3] Ref. EUPR positive glue list

[4] PP caps are very much preferred over PE caps in USA as there is a good market for this secondary PP material stream.

[5] Acceptable provided firstly they are attached using water soluble adhesives and are not coated in a manner that prevents separation and removal during reprocessing (see Labels & Adhesives section of General Guidelines for more details) and secondly they do not pulp in the wash tank. Paper labels that do not satisfy these criteria should be avoided.

[6] Provided density is <1 g/cm3 and it has been demonstrated that cap liner does not cause any issue in conventional PET recycling facilities.

[7] Provided metalisation is 'light' metal detectors should not be triggered and recyclate acceptable.

[8] Main issue is when recycling back into bottles. Less of an issue when recyclate being reprocessed into fibre. In general fibre production is not affected with up to 500 ppm TiO2 and mica present (average particle size less than 50microns). TiO2 and mica-based opacifying master batches, however, significantly disrupt PET recycling into strapping and bottle applications. Opaque bottles containing these master batches are systematically removed by recyclers from the part of the coloured stream intended for strapping and bottle applications.

[9] Experience from Mexico indicates that direct printing (generally black) at present it is not acceptable: It is very difficult to fully remove ink pigment (generally black),resulting in pinholing during reprocessing and residual solvent can also leads to yellowing. This position could change in future, depending on the outcome of testing currently ongoing within COTREP.

For the whole document on designing plastic packaging for recycling, visit: www.recoup.org/design/rbdv2

11.11. Appendix K Persons consulted for this research project

Company name	Name and function of contact	Contacted about	Business card / contact details
4PET Recycling	Michael Krekemeyer	Gave a tour of recycling facilities, explained PET recycling.	 4PET RECYCLING Michael Krekemeyer P.O. Box 2042 6802 CA Arnhem Westervoortsedijk 73 6827 AV Arnhem The Netherlands E-mail: michael@4petrecycling.com Tel. +31 26 750 23 45 Fax +31 26 750 23 46 Web: www.4petrecycling.com
Artenius PET Recycling France APPE	Frédéric Blanchard Plant manager	Very good PET recycler, tried to contact but did not succeed	Secretary: Gabrielle Rawlinson Gabrielle.rawlinson@arteniuspackaging.com +33 380265870
AVK plastics Polyolefine recycler	Sjouke Stapersma	Had telephone conversation on silicone in polyolefine float rest from PET recycler that they process	0514-604604

Company name	Name and function of contact	Contacted about	Business card / contact details
DELA GmbH (recycler)	Florian Clever Quality manager	Main contact at DELA. Tested the bottles at the DELA sorting installation together.	
DELA GmbH (recycler)	Helmut Kasper Manager	Was present during the bottle test.	

Company name	Name and function of contact	Contacted about	Business card / contact details
Der Grüne Punkt – DSD GmbH DKR, Deutsche Gesellschaft für Kreislaufwirtschaft	Gisela Jörn, M.A. Head of international plastic trading department	Met at Nedvang conference Oct 13th 2011. Referred me to Bernd Fathmann.	 Gisela Jörn, M.A. Head of International Plastic Trading Department Frankfurter Straße 720-726 51145 Köln (Porz-Eil) Tel.: +49 2203 9317 - 424 Fax: +49 2203 9317 - 828 Mobil: +49 171 2010985 www.dkr.de gisela.joern@dkr.de DKR Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe mbH
Der Grüne Punkt – DSD GmbH	Bernd Fathmann Sales, Key-Account-Manager Food	Organized a tour in a german recycling factory and a meeting to talk about making Heinz packaging more recyclable. Heinz' attendees: E. Boesveld, C. Haveman, M. Havermans.	 Der Grüne Punkt – Duales System Deutschland GmbH Dipl.-Ing. Agr. Bernd Fathmann Sales Key-Account-Manager Food Frankfurter Straße 720-726 51145 Köln (Porz-Eil) Tel.: +49 2203 937 - 431 Fax: +49 2203 937 - 397 Mobil: +49 170 3090320 www.gruener-punkt.de bernd.fathmann@gruener-punkt.de
Der Grüne Punkt – DSD GmbH	Ursula Denison Head of Sales Strategy and Marketing	Telephone consultation about the organization of plastic recycling in Germany	Tel.: +49 2203 / 937-183 Fax: +49 2203 / 937-198 E-Mail: ursula.denison@gruener-punkt.de
European Plastic Recyclers	Antonio Sursari	Spoke briefly about PET recycling on the phone.	Antonio.sursari@upr.org +32 27418258

Company name	Name and function of contact	Contacted about	Business card / contact details
Indorama	Wim Hoenderdaal Technical Services and Application Manager	We spoke on the Nedvang Convention about PET recycling and barrier solutions.	
Morssinkhof Plastics BV (recycler)	Eric Morssinkhof	Talked on the phone and emailed about PET recycling	E.Morssinkhof@morssinkhofplastics.nl tel. +31 (0)544 372306
Nedvang	Eugene Rudolf	Meeting on the organization of plastics recycling in the Netherlands.	
Nedvang	Karen van de Stad Packaging Technologist	Arranged the meeting at Nedvang, was supposed to be there, but could not attend.	+31 104206161

Company name	Name and function of contact	Contacted about	Business card / contact details
PakOp verpakkingsadvies	Cathrien Ruoff Owner	Did a presentation on designing for recycling on the Nedvang Convention. We barely spoke.	 MALAKKASTRAAT 115 2585 SL DEN HAAG TEL 070 358 47 62 FAX 070 358 47 66 INFO@PAKOP.NL WWW.PAKOP.NL [PAKOP IR CATHRIEN RUOFF TECHNISCH EN JURIDISCH VERPAKKINGSADVIES
Pellenc ST (sorting techniques)	Luc Mallinger Country Sales Manager	Telephone contact on sorting problems. Sent him Heinz bottles for testing, results came in too late to mention in report.	l.mallinger@pellencst.com Mobile : +44(0)7703 611 827
Recoup	Stuart Foster Deputy CEO	Spoke on the phone and email about organization of plastic recycling in the UK. Proposed that Heinz joins Recoup (they already have had contact with Robin Air at Heinz UK), so they could give more information. I did not accept the proposal, not in my jurisdiction.	stuart.foster@recoup.org t: + 44 (0) 1733 390021 Direct Dial: 01733-375673 Mobile : 07738 542853
Sita (sorter)	Albertino Pereira Mota	Gave a tour and explanation of sorting facility.	+31 104287760 albertino.pereira@sita.nl
Sita	Freek van Eijk directeur Strategy en Public Affairs SITA NEWS	Spoke on phone about plastic sorting	Secretary: tel. +31 (0)26 4001466 fax. +31 (0)26 4001440 patricia.damen@sita.nl
TITECH (sorting techniques)	Wim van de Graaf TITECH Sales Agent Belgium and The Netherlands	Talked on the phone and emailed about sorting problems. Got a statmenet that the problem is the k etchup. I did not accept proposal to test bottles at TITECH because I also had contact with TITECH via DELA at the moment.	Direct dial: +31 543 562705 Fax +31 543 562706 Mob +31 646 338776 wvandegraaf@titech.com
Valpak	Emma Pledger Technical Advisor	Spoke on the phone and emailed about the organization of plastic recycling in the UK.	info@valpak.co.uk Tel: + 44 8450 682 572

Company name	Name and function of contact	Contacted about	Business card / contact details
Wageningen University	Ulphard Thoden van Velzen Senior Scientist	Spoke at Nedvang conference. And meeting on sorting and recycling practices in Europe	 Wageningen Campus P.O. Box 17 6700 AA Wageningen Building 118 Bornse Weilanden 9 6708 WG Wageningen The Netherlands T +31 317 48 01 70 ulphard.thodenvanvelzen@wur.nl www.fbr.wur.nl FOOD & BIOBASED RESEARCH WAGENINGEN UR Ulphard Thoden van Velzen Senior Scientist
Wellman Recycling	Mark Ruesink Plant manager	Gave a tour of recycling facilities, explained PET recycling.	 Mark Ruesink Plant Manager WELLMAN RECYCLING Telephone: +31 (0) 316 566 250 Fax: +31 (0) 316 566 251 E-mail: markruesink@wellman-intl.com Website: www.wellman-intl.com Tengnagelwaard 5 6917 AE Spijk Netherlands P.O. Box 51 6916 ZH Tolkamer Netherlands

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16. **Musora Bolshe (a public ecological organization, which grew out of private initiative in 2004), Mr. Stark.** Founder. *Telephone Interview by E. Boesveld.* St. Petersburg, Russia, Oktober 4, 2011.

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