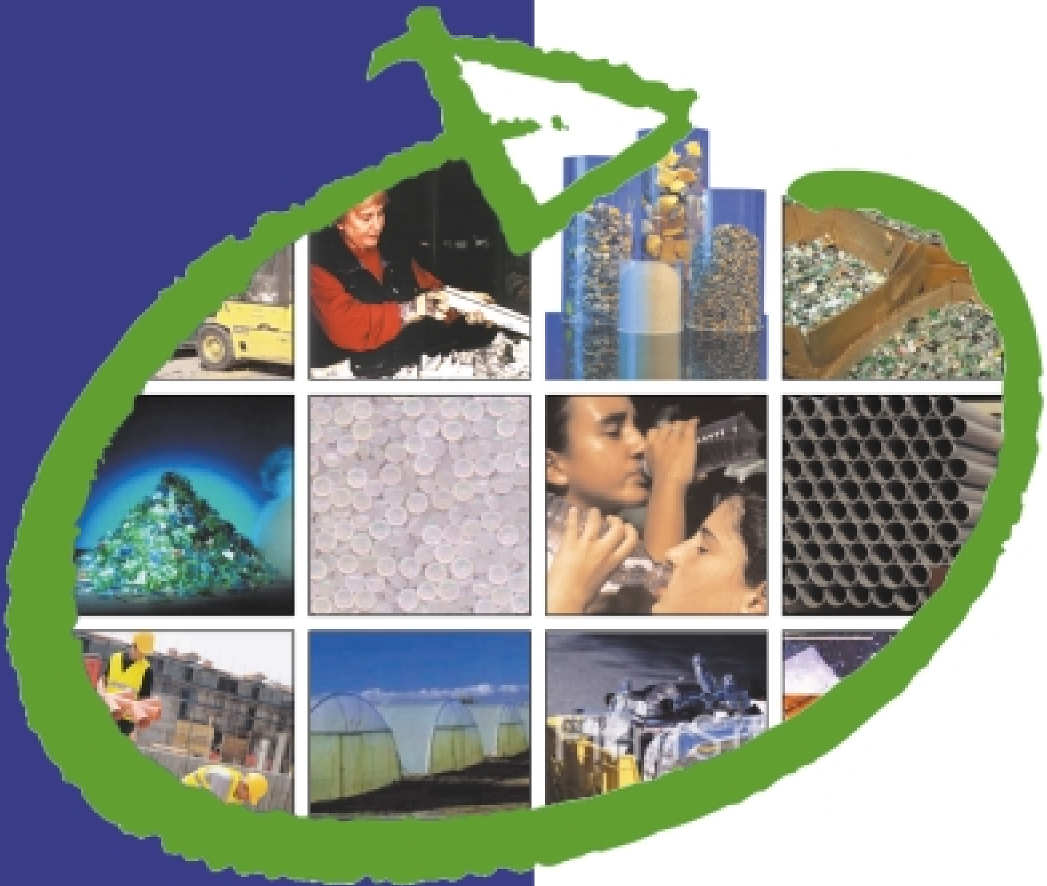
GOOD PRACTICES GUIDE ON WASTE PLASTICS RECYCLING

A GUIDE BY AND FOR LOCAL AND REGIONAL AUTHORITIES



ACRR

APME
ASSOCIATION OF PLASTICS MANUFACTURERS IN EUROPE

ECVM
EUROPEAN COUNCIL OF VINYL MANUFACTURERS

EuPR
European Plastics Recyclers

EuPC
EUROPEAN PLASTICS CONVERTERS

FOREWORD

History may view plastics as one of the most important technical developments of the 20th century. Plastics have opened the way for new inventions and have replaced other materials in existing products. They are light, durable and versatile, as well as resistant to moisture, chemicals and decay.
Yet these properties can also bring challenges to waste managers in local and regional authorities.

Worldwide, policies are being introduced that demand recycling, diversion from landfill of untreated wastes and greater levels of resource conservation. This is being achieved through the development of local, national and international strategies, new regulations setting targets and economic, market-based instruments and taxes, and new technologies to collect, sort, treat and recycle waste plastics.
It is clear that the use of plastics reduces the mass of materials needed in many applications and many sectors. However, the more numerous, specialised, engineered and differentiated become plastics materials, the more difficult will be their recovery especially by material recycling which must be a first choice after reuse and prevention.

The ACRR has been created for the purpose of providing support to L/RAs. Of course, this Guide does not pretend to be exhaustive, but we hope it will provide the reader with practical insights, experiences and guidelines for the proper management of waste plastics.

This guide is also an exercise of partnership between ACRR and the European Plastics Industry Federations.

Jean-Pierre Hannequart

President of the Association of Cities and Regions for Recycling

The Association of Cities and Regions for Recycling

The Association of Cities and Regions for Recycling (ACRR) is an international network of local and regional authorities across Europe and beyond. Established in 1994, the association provides a resource through which the exchange of information and experiences on municipal waste management can be facilitated, particularly in the areas of prevention at source, recycling and recovery.

The activities of the ACRR are based on three key principles:

- the management of waste and resources with a view to sustainable development
- the prevention and recovery of waste, in respect of the waste hierarchy
- developing partnerships between local and regional authorities and between the public and private sectors

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CHAPTER 1

Objectives of the guide

This guide has been prepared by ACRR members, with the support of the European Plastics Industry Federations. It reflects the growing interest amongst local and regional authorities (L/RAs) concerning the management of waste plastics.

L/RAs are responsible for some or all of the following activities:

- planning waste management strategies
- implementing waste management plans (including collection and/or disposal)
- monitoring the effectiveness of these plans and strategies
- meeting various targets for landfill diversion and/or resource recovery

The rising proportion of plastics in municipal solid waste (MSW), a result of increased consumption, has been the focus of growing interest since the early 1990s, and many L/RAs are now familiar with the need to put in place proper systems for their collection and management.

However, waste plastics do exist in other waste streams and L/RAs are turning their attention to recovering materials from these flows for a number of reasons:

- the performance and price advantage of plastic is increasingly recognised by product designers and becoming the material of choice for many new products - the potential demand for plastic recyclate is therefore increasing
- long-lived products (for example electrical equipment or window frames in houses), which were sold decades ago are reaching the end of their lives - increasing volumes of plastics from these sources are beginning to join the waste stream
- a wish to reduce the need for additional waste disposal facilities, which require significant investments and which may generate substantial public opposition

Given these issues, local and regional authorities are right to become more interested in recovering waste plastics from non-household sources, such as construction and demolition sites, farms and the retail sector.

This guide seeks to bring together information from many sources to help L/RAs identify the practical issues associated with collecting and processing waste plastics, while identifying the approaches needed to manage and exploit these wastes in ways which best suit their individual characteristics.

This report does not aspire to be a strategic guide to the development of a waste plastics management policy as this is dependant on a number of local factors, including:

- waste availability (quality and quantity)
- enthusiasm of the authorities
- awareness and participation of the citizens

- facilities available for sorting and recycling, and the availability of markets for recycled products
- legal obligations

Public authorities have adopted many approaches to collect and treat plastics waste and it would be pointless – perhaps even undesirable - to attempt to develop a universal strategy for all L/RAs.

The objective of this Guide is to offer L/RAs an insight into the socio-political, environmental, economic and technical aspects of waste plastics management, with reference to practical examples and case studies. This Guide will:

- explain the environmental, economic and social dimensions of waste plastics collection, sorting and recovery
- help bring about an improvement in the recycling performance of waste plastics in those L/RAs where schemes already exist
- encourage the development of a broader commitment by L/RAs to plastics recovery and recycling

An independent report[1] , commissioned by APME (Association of Plastic Manufacturers in Europe) has investigated the feasibility of mechanically recycling plastics from a number of waste streams and identifies a number of economically (and environmentally) viable waste plastics and recycling schemes. Supported by that study, this guide does not address all plastics waste streams, only those considered the most significant for L/RAs. These include:

- general plastics from municipal waste
- waste plastics from the distribution and the smaller-scale retail sectors
- waste plastics from small industries and businesses
- waste plastics from the construction and demolition (C&D) sector
- waste plastics from the agricultural sector

This Guide has a three-fold structure. The first element gives a general description of waste plastics management in Europe. The second develops more specific information focusing on specific flows or techniques. The third provides illustrations through descriptions of local experiences.

1- " Best Practice for the Mechanical Recycling of Post-user Plastics " (2000). TNO Report (Commissioned by APME)

CHAPTER 2

Why recycle plastics ?

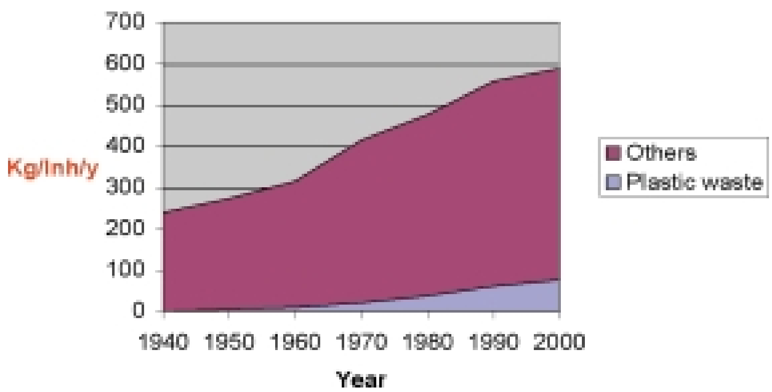
Since the 1970s, the consumption of plastics has grown dramatically and, consequently, so has the creation of waste plastics. Associated with this growth and reflecting changes in production and consumption, the composition of the waste bin has also changed; the proportion of organic matter has declined, while plastics have increased.

GROWTH IN WASTE PLASTICS ARISING

Between 1991 and 2002, the per capita consumption of plastics increased in Western Europe from 64 to 95 kg/inh/year, an average growth of 3 per cent per year (pa) .

The example of the evolution of municipal waste in Paris is illustrative. In the 1940s, the Parisian citizen created 240 kg pa MSW. This contained almost no plastics, which started to appear in the 1950s. By 1970, waste arising had grown (to 415 kg per inhabitant pa) and plastics comprised almost 5 per cent of the average rubbish bin. In 1980, the proportion had risen to 8 per cent (of 477 kg). In 1990, 11 per cent (of 558kg) of the waste comprised plastics and in 2000 the figure had reached 13 per cent (of 588 kg).

Figure 1 : Evolution of the plastics in the Parisian waste bin



In USA[1] , the evolution of the waste plastics is similar. In 1960, waste plastics formed no part of MSW, while today they represent 9.9 per cent. During this same period, total MSW arisings grew from 88 million tonnes per annum (Mtpa) - 491 kg/inh/year to 217 Mtpa (775 kg/inh/y), while the plastic component increased from 0.4 Mtpa (2.2 kg/inh/year) to 21 Mtpa (76 kg/inh/year). In 40 years, the total weight of waste plastics increased by a factor of 55 and per capita waste plastics generation rose by a factor of 35.

In 2002, the Organisation for Economic Cooperation and Development (OECD) estimated that the waste plastics represents 8 per cent of the mass – but 20 per cent of the volume - of MSW in Western Europe.

Plastics are increasingly becoming the material of choice by product designers. An indication of this trend can be seen in the increased use of plastics in products such as cars and refrigerators over the last 20 years (see Table 1 for data on refrigerators).

Table 1: Composition of refrigerators (kg and per cent) over time (with estimated years for eventual waste)

Material		1972 (1991)			1980 (1999)			1988 (2007)		
		kg	kg	%	kg	kg	%	kg	kg	%
Steel		147.6			138.3			129.0		
Compressor		30.3			28.2			26.0		
Aluminium	NON PLASTICS	7.9	192,1	84,2	10.4	184,5	81,6	13.0	177,0	79,0
Copper		0.6			0.8			1.0		
Misc.		5.7			6.8			8.0		
ABS		3.6			13.5			23.3		
PS		2.4			1.2			0.0		
HIPS	PLASTICS	8.0	35,9	15,8	6.9	41,5	18,4	5.7	47,0	21,0
Fibreglass		17.9			8.9			0.0		
PU Foam		4.0			11.0			18.0		
Total		228.0	228.0	100	226.0	226.0	100	224.0	224.0	100

Source = American Plastics Council
(http://www.plasticsresource.com/reading_room/reports/r_recycled_fridge.html

In the face of increasing waste generation and the increasing contribution of plastics to a number of waste streams, L/RAs are confronted with a number of environmental, economic and social issues, not only concerning the management of waste plastics, but solid waste in general. These issues include:

- the saturation of traditional waste disposal facilities – landfills and incinerators
- public demand for selective material collection services
- visual pollution and the effects on tourism
- legal obligations to comply with legislative targets (e.g. for recovery, recycling and landfill diversion)

Saturation of Traditional Waste Disposal Facilities

Landfills

Establishing a new landfill site is a major challenge for any L/RA. A report for the UK Government's Cabinet Office[2] noted that:

> "Negative reactions to landfill are evident even without detailed knowledge, because of an instinctive negative reaction to the idea of burying things in the ground. The image of the plastics in particular appears to be a powerful symbolic image of landfill in the public consciousness"

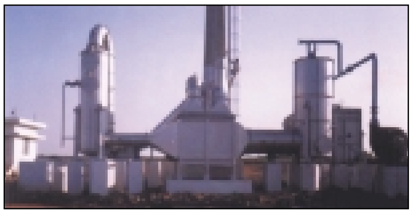
2- "Public Attitudes Towards Recycling and Waste Management – Quantitative and Qualitative Review" Research Study for the Strategy Unit, Cabinet Office – September 2002

In such an environment, it is understandable that L/RAs will wish to prolong the life-span of existing landfill sites when this is related to public sector activities, yet seek to minimise waste disposal costs where the private sector is used.

Constraining factors in landfilling plastics (apart from issues of longevity) concern the volume of space that plastics occupy in relation to their weight. Plastic bottles are estimated to occupy twice as much space in landfill than mixed waste.

Legislative pressure directed at landfill practices and economic incentives to divert waste from landfill aims to aid the management of existing and future landfill capacity. However, an effective waste recycling and recovery strategy is necessary to achieving these objectives.

Incinerators



Plastics are the most significant contributors to the energy content - calorific value - of MSW. Most waste plastics have a high calorific value (CV) – at about 40 MJ/kg - similar to fuel oil (see Table 2).

Table 2: Typical calorific values

Polymers, Fuels & Mixed waste plastics	Net calorific Value (Mj/kg)
HDPE/ LDPE/ PP	45
Oil	40
Coal	25
PVC (wide variations between rigid and flexible PVC)	22
Mixed food Packaging	45
Mixed non-food packaging	37

However, municipal solid waste incinerators (MSWIs) have two main operational constraints: the material flow, and the CV of the waste. With the growth in the waste plastics fraction, MSWIs reach their CV limits more rapidly, and sometimes operators need to dilute the waste with material of a lower energy content. L/RAs with incinerators face a choice: whether to limit the high calorific fraction to the incinerator (through selective collection and recycling programmes) or whether to build a new incinerator. The construction of a new incinerator will usually provoke the same Nimby *(not-in-my-backyard)* reaction as a proposed landfill site.

A 2002 UK Cabinet Office study[3] estimated that acceptance of new incinerator

"appears....to be conditional upon several requirements, including:

- that it is part of a recycling-led strategy where everything that can be recycled has been recycled
- that certain materials are separated out and not directly incinerated (for example plastics)"

3- "Public Attitudes Towards Recycling and Waste Management – Quantitative and Qualitative Review" Research Study for the Strategy Unit, Cabinet Office – September 2002

IN BRUSSELS AN ACTIVE RECYCLING PROGRAMME REMOVED THE NEED FOR AN ADDITIONAL INCINERATOR

In Brussels, at the beginning of the 1990s, the three furnaces of the waste incineration plant were operating at full capacity. A technical-political debate was launched: should Brussels build a new line for its incinerator; or should progress be made on alternative strategies?

The decision was taken to initiate selective collection for paper, cardboard and household packaging waste (plastic bottles, metal cans and beverage cartons). In 1993, the first kerbside selective collection started in Brussels for a quarter of the population, residents were invited to separate their waste into three streams:

- paper and cardboard in a yellow bag
- beverage and other non-hazardous container packaging in a blue bag
- the remaining fraction (for incineration) in a grey bag

Separated materials were collected once a week. In 1998 the selective collection was extended to the whole population of Brussels. Initially public participation was low (about 60 per cent), but technical improvements and a better communications programme have increased participation rates to 75 per cent today.

Public demand for selective collection

The recovery of materials for recycling through selective collection has many advantages and is often a constructive response to public demand. Certainly, the introduction of a selective collection service is usually well received by the population.

A UK Cabinet Office[4] study quoted that:

> "the public perceive a strong association between recycling and the environment, and consider it to be one of the few activities where people can make a real difference.... Demand for kerbside collection services is high; three in four say they would recycle more if this was available to them."

However, the population often fails to understand why certain wastes are selectively collected and others are not. In the case of the waste plastics, the sorting instructions given to householders - for sound reasons of eco-efficiency - limit the collected quantity of plastics to a greater extent than is the case for paper or glass.

In addition, in many countries the familiar Green Dot symbol is put on virtually all packages, which can lead people to infer wrongly that all packaging will be recycled, or is recyclable (or even that they are made from recycled materials). L/RAs are becoming more enthusiastic for kerbside recycling. For example, the most recent waste plan from the UK municipalities Cambridgeshire[5] and Peterborough mentions that

> "public pressure for plastic container recycling is considerable".

4- Ibid
5- "Sustainable Recycling and Waste Management for the 21st Century"

Visual pollution and the effects on tourism

Nobody likes to see landscapes polluted with waste. In tourist locations, the uncontrolled disposal of litter, including plastics, is not only a problem of public cleanliness but also a problem of image, which can have negative economic repercussions.

It is noticeable that much of the litter visible in towns, the countryside and especially near rivers, lakes or seas. In 1998, 81,000 tonnes of street cleaning waste was reported in Ireland. One survey (quoted in Fehily, Timoney and Co. for the DOELG Consultancy Study on Plastic Bags, 1999) estimated that 15 per cent of all litter in Ireland was plastic.

Another UK study (Marine Conservation Society Beachwatch 99: nationwide beach-clean and survey report 2000) on coastal and beach litter found that over 60 per cent of all that litter was plastic. Over 1,000 items of plastic were found per km beach surveyed — a total of 108,300 plastic items. Impacts on local amenities from littering can be mitigated by L/RAs, within a general anti-litter policy or even a specific plastics waste management policy.

ANCONA

In the Italian province of Ancona, tourism is an important economic activity. The Provincial authorities found it necessary to take action against visual contamination due to the uncontrolled disposal of plastics and other wastes.
In order to reduce the scale of this problem, the Province built into its waste plan the objective to collect selectively 3,200 t of plastic packaging for 2004 – significantly more than the 1,435 t collected during 2001.
In order to reach this objective, the Ancona Province established among others:

- an agreement with CO.RE.PLA[6] , the Italian association for the collection and recycling of plastic packaging
- two awards for the promotion of the plastic collection and recycling

CORSICA

In September 2002, the Territorial Community of Corsica (CTC) began to consider banning plastic shopping bags. Fifty million such bags are used on the island each year, and the CTC has deemed them an environmental nuisance - whether incinerated or landfilled - and are physically hazardous to marine fauna when thrown into the sea. Those negative aspects (real and perceived) are unhelpful for an island for which tourism is a vital sector of the economy.

In Ireland, 1.2 billion plastic bags were typically used each year – an annual average of more than 300 bags per inhabitant. Those bags were claimed to create a visual impact and to obstruct drains. Since 2002, a fee of € 0.15 was imposed in order to promote the use of reusable shopping carriers.

Within three months, the use of disposable plastic shopping bags had fallen by more than 90 per cent and generated an income of € 3.5 million.

6 CO.RE.PLA. : Consorzio Nazionale per la Raccolta, il Riciclaggio e il Recupero dei Rifiuti di Imballggio in Plastica (National Consortium for the collection, the recycling and the recuperation of the waste plastics packaging)

Evidence suggests that the use of other types of plastic bags increased significantly, as householders buy bags to use for purposes previously fulfilled by free supermarket bags.

So while it cannot necessarily be claimed that plastics consumption has fallen because of this economic instrument, it is likely that littering has reduced.

Legal obligations

A well established legal framework governing many aspects of waste management and environment protection provides a powerful driving force to use resources more sustainably and to increase recycling. The European Union directive on Packaging and Packaging Waste (94/62/EC) is a pertinent example of this effect (see below). As a result, all EU member states have national systems to collect, recycle and recover packaging wastes.

However, the approaches adopted when implementing these pan-European Union policies is not the same in every country. There are some cases, such as the Netherlands, where the culture favours voluntary agreements (although these too need to be supported by legal instruments); in these countries, it is less important to rely on legislative instruments alone to reach high recycling rates. In contrast, countries such as Germany have chosen to adopt command-and-control policies that introduce mandatory targets to ensure that national and European obligations are met.

In order to reduce the environmental impacts of growing waste streams, the European legislature has introduced a number of obligations on certain waste products, which must be respected by all the member states. Those Directives that incorporate aspects relating to waste plastics include:

- Packaging and Packaging Waste Directive (94/62/EC)
- End-of-Life Vehicles Directive (2000/53/EC)
- Waste Electrical and Electronic Equipment Directive (2002/96/EC)
- Landfill Directive (99/31/EC)

Directive on Packaging (94/62/EC)

At the European level, the only explicit reference concerning the recycling of the waste plastics is Council Directive 94/62/EC (15 December 1994) on packaging and packaging waste [Official Journal L 365, 31.12.1994]. This directive covers inter alia plastic packaging waste and obliges Member States to recover 50 - 60 per cent, and to recycle 25 - 45 per cent of all the packaging sold.

A minimum recycling rate of 15 per cent by weight for each packaging material must be reached. The deadline to achieve those objectives was 30/06/2001, except for Ireland, Portugal and Greece for which the deadline is the 31/12/2006.

This Directive is currently being revised and recycling objectives will be modified, and the mandated recycling rate for plastics is likely to be set at 22.5 per cent in weight, effective from 31/12/2008.

Directive 2000/53/CE on End-of-Life Vehicles (ELV)

This directive does not refer directly to a plastic recycling obligation. However, the Directive defines a global recycling and reuse target of 80 per cent for 2006, and 95 per cent for 2015. It is estimated that a typical car manufactured in 1989 contains about 70kg, while a car made in 2000 contains around 106 kg[7] .

7- "Information System on Plastic Waste Management in Europe – European Overview 2000 Data" Taylor Nelson – Sofres for APME – March 2002

In the long term, the ELV directive will demand the recycling of an increasing fraction of the plastics contained in vehicles.

It will be important to identify those components which can be recycled in an eco-efficient way, or otherwise recovered as a source of fuel.

Directive on Waste Electrical and Electronic Equipment (2002/96/EC)

The Directive on waste electrical and electronic equipment (WEEE) will force distributors to ensure that such waste can be returned at least free of charge. Ten categories of WEEE are defined by the instrument, with mandatory reuse and recycling rates varying between 50 and 75 per cent by weight, and recovery rates of between 70 and 80 per cent.

This directive will lead to the need to recycle at least parts of the plastic from the WEEE.

Directive on landfills

The EU landfill directive does not address plastics, although it sets diversion targets for municipal biodegradable wastes. Through increasing of the costs of traditional final disposal, recycling in general will become increasingly attractive from an economical point of view.

Issues affecting the recycling of waste plastics

The broad variety of different types of plastics

The variety of different polymers must be taken into account as an important element in planning waste collection, separation and reprocessing activities. A particular plastic type can have many different appearances and characteristics. For example, PVC can be hard (window frames, pipes) or soft (insulation for electrical wires or flooring). Polystyrene (PS) may be transparent (CD boxes) or opaque (coffee cup), and can be expanded (EPS) to serve as thermal insulator or as shock resistant packaging.

To be mechanically recycled into valuable goods and to optimise recycling efficiency, collected materials must be as homogeneous or pure as possible. The best way to achieve this objective is to apply selective collection, and to eliminate unsuitable resins at a sorting plant.

Collection, Sorting and Contamination

It is more difficult to obtain homogeneous streams from household waste plastics because of the variety of products and polymer types used. Despite the presence of identifying marks on plastics packaging, complete manual separation is difficult to achieve because of the speed of sorting lines and the variety of materials.

The main obstacle is the presence of thin, lightweight plastics contaminated with food residues. For these items, the energy and resources needed for cleaning and recycling may not be justifiable in economic or environmental terms. This is the reason that virtually all selective collection schemes for household waste focus on plastic bottles; these constitute a significant proportion by weight of plastic household packaging waste, mostly polyethylene terephthalate (PET) or high density polyethylene (HDPE). Moreover, they are relatively easy to identify and to separate by automatic methods, often based on infra-red detection.

By contrast, in the case of industrial or commercial waste plastics, there is a greater constancy of supply, and it is easier to collect a clean homogeneous stream.

Quality of the sorted fraction

The wide variety of waste plastics and the difficulties of sorting and cleaning, the process can yield low quality materials and a high reject rate at the sorting plant. This has an adverse impact on waste management costs, due to the extra work required to manage a fraction for which disposal costs are high.

However, there are alternative destinations for the mixed plastic fraction; the production of plastic lumber or composite tiles (plastic/wood). However, it is necessary to judge the overall environmental impact of such wood or concrete substitutes. For example, one *life cycle assessment* (LCA)[8] mentioned in Annex 1 suggested this type of product may lack real environmental benefits.

In any event, it is essential to find a market for new applications, which have to demonstrate their economical and technological advantages in comparison with traditional materials. The market for park benches is finite! Feedstock recycling is an option for mixed plastics fraction.

Composite goods

The presence of composite goods complicates recycling. These goods are made of different material mixes (plastics/metal, plastics/wood, plastics/plastics etc). While sometimes offering advantages in use (in functional and resource efficiency terms), these more complex products cannot be recycled easily using conventional techniques, because of the difficulties in isolating the different components. However, feedstock recycling and novel technologies such as Vinyloop (for PVC) are well suited to this kind of waste.

The need for a critical mass

The variety of polymer types complicates the sale of sorted waste plastics made from scarce plastics types. One can include in this category all resins marked with the international code number 7 (others). Those responsible for the waste must find the right buyers, with the technical capacity to transform the sorted material. It can be impractical to find an outlet for small quantities of a low volume, usually mixed, type of plastic.

Poor knowledge of local plastics recycling issues

L/RAs are not always well informed on the potential for plastic recycling or the demand for plastic recyclate at a regional or local level. They may not have accurate data on their arisings, which plastics can be recycled, the range of collection methods and sorting systems available, the quality requirements of reprocessors, where the markets for sorted materials are, or their prices.

The answers to many of these questions can be addressed by establishing a dialogue with European and national environmental authorities, industry and other L/RAs. Policy-making at the European and national level can dictate future product specifications and requirements. A dialogue is necessary to identifying future policy developments. This may include areas such as the promotion of product 'eco-design,' which encourages product developers to market products more amenable sorting and dismantling with a view to recycling. At a local level, liaising with industry is essential if local authorities are to keep up with current practices. Industry ought also to be aware of innovative collection, sorting or processing technologies and practices, and could provide assistance in education and staff training.

8- " Comparing feedstock recycling of plastics waste to mechanical recycling methods " - Dr A. Tukker – TNO - 2002

L/RAs can work with one another to explore practical problems relating to collection and sorting. The ACRR is keen to promote this and provide opportunities for L/RAs to meet and discuss issues of common interest.

Plastics recycling & sustainable development

The recycling of waste plastics can be a positive contribution to a sustainable development policy, integrating *environmental, economic and social* aspects, within a framework of effective legislative instruments.

Continuing advances in sorting and processing technologies is increasing the accessibility of waste previously deemed unsuitable for recycling. Greater ranges of materials are now accepted for recycling, while developments in collection and sorting systems continue to increase the quality of recyclate generated. This is supported by R&D into new markets for secondary plastics, which is essential if plastics recycling is to be sustainable. Research into new and existing practices will expand opportunities for secondary materials; what is currently not technically or economically viable may be so in the future.

L/RAs should look towards the material needs of the present, using best available technologies and practices to meet market demands, while appreciating the impacts that future technological and material quality requirements will have on current practice.

Table 3: Oekobilanz – summary of waste management scenarios

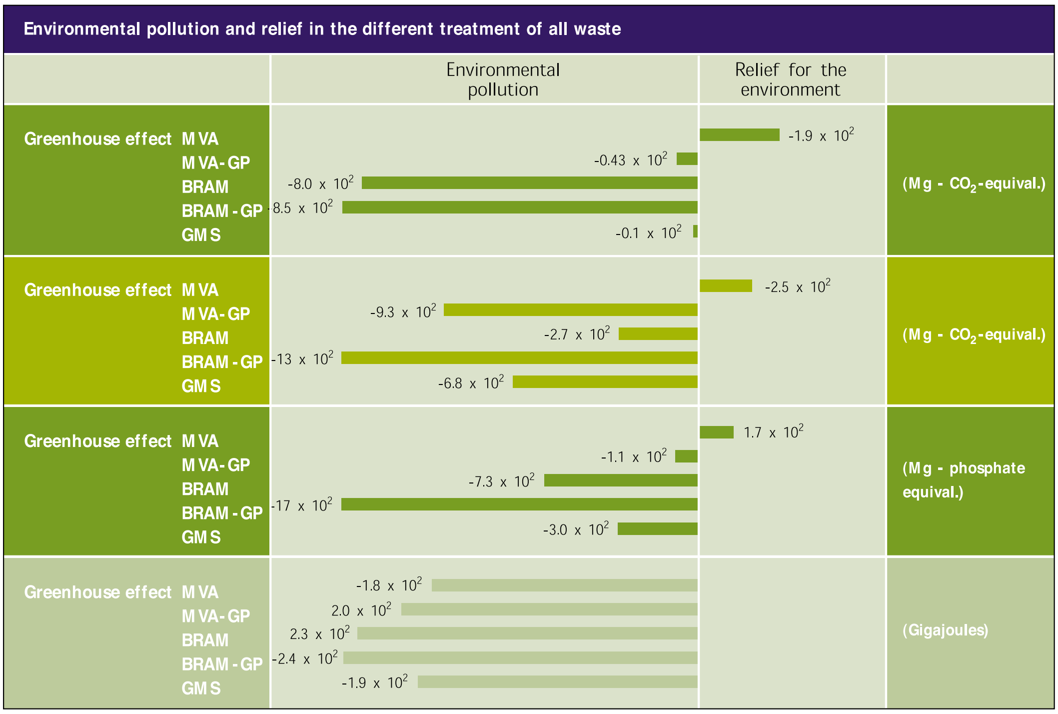
Code	Scenario	Collection	Recycling/disposal
1. GP	Green dot	Collection of lightweight packaging in a kerbside system within easy reach of the households; residual waste in grey bins	Automatic sorting of the lightweight packaging fraction by materials (SORTEC principle) with subsequent reprocessing of all materials. Model 1 for plastics: 40% feedstock recycling (blast furnace) and 60% mechanical recycling
2. GP	Green dot		As above: with model 2 for plastics; 100% high quality mechanical recycling; treatment of residual waste: 100% incineration
3. MVA	Waste incinera-tion	Collection of light-weight packaging together with residual waste via the grey residual waste bin	Incineration with 50% energy use (electricity, steam, district heat, scrap reprocessing from waste incineration slag)
4. RP	Red Dot	Reduced collection of light-weight packaging via bring system (large plastic packaging); residual waste and small plastic packaging in grey bins	Mechanical recycling of plastics; residual waste in waste incineration plants
5. BRAM	Fuel from waste	Collection of lightweight packaging together with residual waste via the grey residual waste bin	Separation of ferrous metals and a fraction with a high calorific value, reprocessing as fuel for com-bustion in cement factories and coal power stations; residual waste in waste incineration plants
6. GMS	Sorting of overall waste	Collection of lightweight packaging together with residual waste via grey residual waste bins	Sorting of all waste and separation of the recyclable components (not only packaging) and subsequent feedstock recycling of plastics; residual waste to incineration plants

ENVIRONMENTAL BENEFITS OF RECYCLING

To investigate the ecological effects of the German DSD system, an analysis of the future material flow was carried out for the DSD (2010 to 2020) by the Öko-Institut e.V.
The major elements of the study were:

- a system analysis which examined the question of how the Green Dot can contribute to sustainable development
- a comparative evaluation of the achievable ecological effects. To this end, the entire consumption of energy and raw materials in the disposal of lightweight packaging and the associated burdens on the environment were calculated and analysed

The study only dealt with lightweight packaging because it is uncontroversially accepted that glass and paper recycling has a positive ecological effect. A total of five different waste management scenarios with a number of sensitivity considerations were studied (see Table 3, below). The costs were analysed in a separate study. The following illustrations show the life cycle values for complete mechanical recycling of the plastics.



Environmental aspects

Recycling waste plastics can be helpful for L/RAs wishing to make local environmental improvements, locally, regionally, nationally and globally through:

- avoiding wastage of resources.
- reducing the need for new waste disposal facilities
- limiting greenhouse gases emissions

Avoiding wastage of resources.

Plastic manufacturing, which largely uses crude oil as the raw material, is estimated by industry to account for four per cent of the global consumption of crude oil. For every kilogram of plastic that is produced, roughly two kilograms of oil are needed. However, the resulting product (because of its lightweight, insulating and protective properties) can often save more oil - through reduced transport and energy use processes - than is required in its manufacture. By replacing crude oil in plastics manufacture with recyclate, raw material consumption decreases, whilst the efficiency of plastic at 'end-of-life' increases.

However, the main benefit of plastics recycling rests in the savings associated with primary energy consumption. Polymer production accounts for the largest proportion resource use in plastic product manufacture, ranging from between 72 – 91 per cent of total energy consumption, depending on the polymer[9] . This compares with process energy usage of between 6 - 20 per cent, dependant on the product being manufactured (i.e. bottles, pipes or films).

By contrast, the process energy necessary to produce recycled PET flakes can be reduced to 62-92 per cent of the energy required to produce virgin resin[10] . Similarly, reported energy savings of ~38 per cent can be achieved by processing LDPE films into granulate and 77 per cent process energy savings made by reprocessing rigid HDPE bottles, compared to the production of virgin material[11] .

Oil and gas are converted into monomers (e.g. ethylene). The successive steps in production (of e.g. polyethylene PE), are very energy-intensive, requiring both high temperatures and refrigeration. Ethylene consumes around 20 megajoules (MJ) per kilogram of ethylene produced[12] . If the entire production process is taken into account from the extraction of raw material from the earth to the end product, the energy use is between 60 and 120 GJ/t for the different plastic types (see table 4)[13] :

9- considering HDPE, LDPE, PET, PVC and PP. " Eco-profiles of the European Plastics Industry Report 10 : Polymer Conversion. " I. Boustead (1997) A technical paper from APME.
10- " Life Cycle Assessment - LCA and the PET Bottle " V. Matthews (1998). Referenced in :
11- " An Analysis of the recycling of LDPE at Alida Recycling Ltd " M. Henstock (1992). A Report by Nottingham Univeristy Consultants Ltd, Nottingham, UK and " Assessment of the environmental imapct of plastic recycling in P&G packaging " T. Deurloo (1990). Procter and Gamble European Technical Centre, internal Report. Referenced in : " Integrated Solid Waste Managment : A life Cycle Inventory " (2nd Edition, 2001) by F. Mcdougall, P. White, M. Franke and P. Hindle. Blackwell Science, Oxford, UK.
12- Report of the Berkeley Plastics Task Force 1996, http://www.ecologycenter.org/plastics/report1996/report1996_toc.html
13- "Eco-Profiles of Plastics and Related Intermediates – Methodology", I. Boustead, Brussels 1999, and Association of Plastics Manufacturers in Europe, LCA/Eco Profile fact sheets, www.apme.org , and "Assessing the environmental potential of clean material technologies", EC/IPTS, Sevilla, publication foreseen end 2002.

Table 4: Energy use for polymer production in Europe

Monomer type	Energy (GJ/t product)	tonnes CO_2 (fossil/t product)
LDPE/LLDPE[a]	78	1.8
HDPE	80	1.7
PP[b]	111	3.4
PVC	57	2.0
PS	87	2.6
PET	78	2.3
Amino[c]	60	2.9
PUR	105	3.9
Others	117	5.1

(a) Assumed product mix: 5/7 LLDPE, 2/7 LDPE

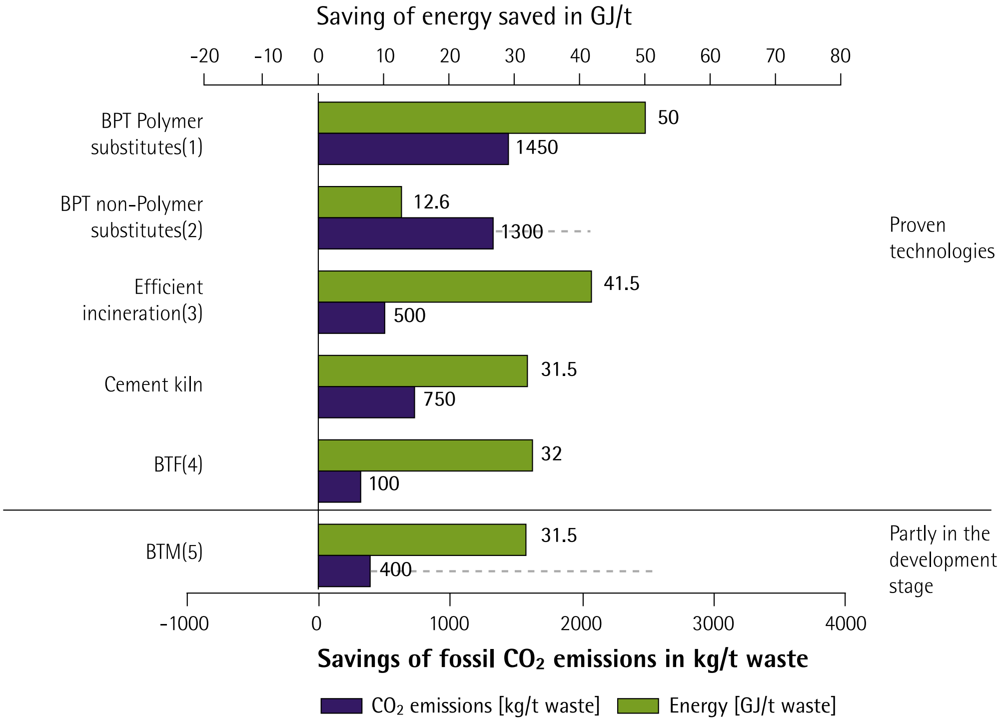
(b) Assumed product mix: 1/2 PP Injection Moulding, 1/2 Oriented PP Film

(c) Assumed product mix: 2/3 urea resin, 1/3 melamine resin.

Sources:
Eco-Profiles of Plastics and Related Intermediates – Methodology", I. Boustead, Brussels 1999, and
Association of Plastics Manufacturers in Europe, LCA/Eco Profile fact sheets, www.apme.org
"Assessing the environmental potential of clean material technologies", EC/IPTS, Spain

Figure 2 shows the achievable energy savings and CO_2 reductions if one tonne of waste plastics is recycled or if it is incinerated in highly efficient processes (including cement kilns)[14].

Figure 2: Energy savings from waste plastics management options



(1)Figures represent the weighted average of various types of mechanical recycling. Individual datasets are (substitution factor = 1,0): PVC (38 GJ/t, 1800 kg CO_2/t), PE (51 GJ/t, 1000 kg CO_2/t).
PS (57 GJ/t, 1650 kg CO_2/t), PUR (68 GJ/T, 3100 kg CO2/t), PMMA (66 GJ/t, 3400 kg CO_2/t).

(2)These processes are characterized by a extraordinarily wide range of data depending on the primary production process.

(3)These are only very few municipal waste incineration plants of this efficiency in Europe.

(4)Blast fumace process. For gasification and subsequent methanol production production (SVZ) the figures are : 19 GJ/t and 1200 kg CO_2/t.

(5)The solid bar give the values for the Hamburg pyrolisis of PE. Much higher savings are feasible for other polymers (dashed line), e.g. for PS (52 GJ/t, 1250 kg CO_2/t), PMMA (64 GJ/t, 3300 kg CO_2/t), PAS (79 GJ/t, 4200 kg CO_2/t).

Reducing the need for new waste disposal facilities

The best form of waste management is waste prevention. However, for wastes which are created, there is a more or less agreed hierarchy of management options. In general terms it is expected that material recycling and re-use should be considered before energy recovery. Increased attention to the higher choices will inevitably reduce the need for new waste disposal facilities. Of course, there are circumstances where factors (such as geographical location, contamination, local markets and reprocessing capacity) can mean energy recovery becomes the best practicable environmental option (BPEO).

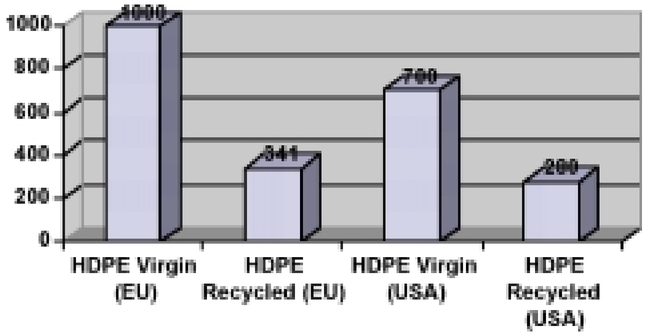
14- For information on the methodology look at:
"Recycling and recovery of plastics from packagings in domestic waste – LCA-type analysis of different strategies", Heyde, M.; Kremer, M., Fraunhofer Institut für Verfahrenstechnik und Verpackung (IVV), Freising. LCA Documents, Ecomed publishers, Vol. 5, 1999.
"Closing Carbon Cycles: Carbon use for materials in the context of resource efficiency and climate change", Patel, M., PhD thesis, Utrecht University, The Netherlands, December 1999

Limiting greenhouse gases emissions

In view of the application of the Kyoto Protocol and the general wish to reduce the impact of society upon the climate, it is important to consider the global environmental aspects of waste management.

When compared with the processes of producing virgin resins, recycling processes produce less CO_2. A study for the European Commission[15] provides some figures for these savings.

Figure 3: CO_2 emissions for virgin and recycled HDPE



Other environmental arguments and conditions to reach environmentally sound recycling are developed in the review of LCAs, presented in Annex 1.

Economic aspects

Creating employment

Recycling can be an opportunity to create local jobs in collection, sorting, communications, administration and reprocessing. The reprocessing can be undertaken locally, regionally or beyond, and consequently the positive economic aspects of increased employment can be local or dispersed further a field. Job creation obviously brings many positive social effects.

According to the German waste packaging recovery organisation, DSD, 170,000 jobs (or two jobs per 1,000 inhabitants) were created in Germany through the introduction of the selective collection and sorting system.

A UK study made in 2002 by ReMaDe Kernow[16] estimated there are enough plastics in the Cornwall to create 150 jobs and boost the economy by € 23.5 millions. Compared with the Cornish population (470,000 inhabitants), the potential of job creation is one job per 3,100 inhabitants and the potential of economical benefits for the region is € 50/inhabitant.

The results of a UK research project, funded by London Remade (2003), into the number of jobs created through recycling, found that the recycling of PET bottles, creates the highest number of potential jobs compared with processing other recyclable materials.

15- " Waste Management Options and Climate Change " - Final report to the European Commission, DG Environment - A. Smith et al. - July 2001
Source: Plastics material specific strategic business plan prepared for Remade Kernow (May 2002)
16- http://www.remadekernow.co.uk/plastics_report.pdf

Reducing waste treatment costs

Waste plastics recycling can help reduce waste treatment costs in two ways. During the last decade, European obligations to control the environmental impacts of waste incinerators (Directive 2000/76/CE) and landfills (Directive 1999/31/CE) have led to an increase in the costs of these waste management options. These costs will increase as tighter controls are introduced and as taxes on landfill (and incineration) escalate, further stimulating recycling.

According to a study by Juniper Consultancy for ASSURRE (European Incineration Profile 2000), costs of incineration in Europe rose significant during the 1990s, from a normalised level of 100 in 1993 to 114 in 1995, 132 in 1997 and 141 in 1999. The same study reported costs, or gate-fees, ranging between € 25–160 per tonne (in Spain and Germany, respectively) with an average across Europe of € 75 per tonne.

This is not to say that plastics recycling will remove the need for incineration or other forms of energy recovery. These technologies will inevitably be required for the fraction of plastics that cannot be recycled.

NAMUR

The Province of Namur in Belgium collects agricultural films through a voluntary drop-off system. The Province must pay recyclers € 60/t for washing and grinding the collected films. This compares with the average cost of the incineration in Belgium of € 83/t.

Social aspects

The Nimby reaction

As has been mentioned earlier, householders often express enthusiasm for recycling, and are keen to participate in selective collection schemes (though their actual participation often falls short of initial aspirations).

The introduction of an intensive recycling strategy can avoid the need of new or additional incineration or landfill capacity. The setting up of such facilities is a challenge for the public authorities, which will inevitably face some degree of Nimby phenomenon, although this can be mitigated through effective, sustained public communications. However, in many cases recycling costs are higher than incineration, hence the cost for the citizen will go up.

Environmental awareness of the population

The introduction of recycling programmes will heighten public environmental awareness. As a consequence, a significant fraction of population feels motivated to participate in schemes where they are offered. There often follows an increased demand – with local elected representatives targeted - to improve and extend the existing services to a wider variety of waste plastics.

This enhanced awareness can be linked beneficially to plastics in general, improving the image of these materials (which are often associated with wastage, the throw-away society and litter). In addition, including plastics in multi-material collection schemes can raise the overall amount of materials collected from kerbside collection schemes by between 20 – 30 per cent.

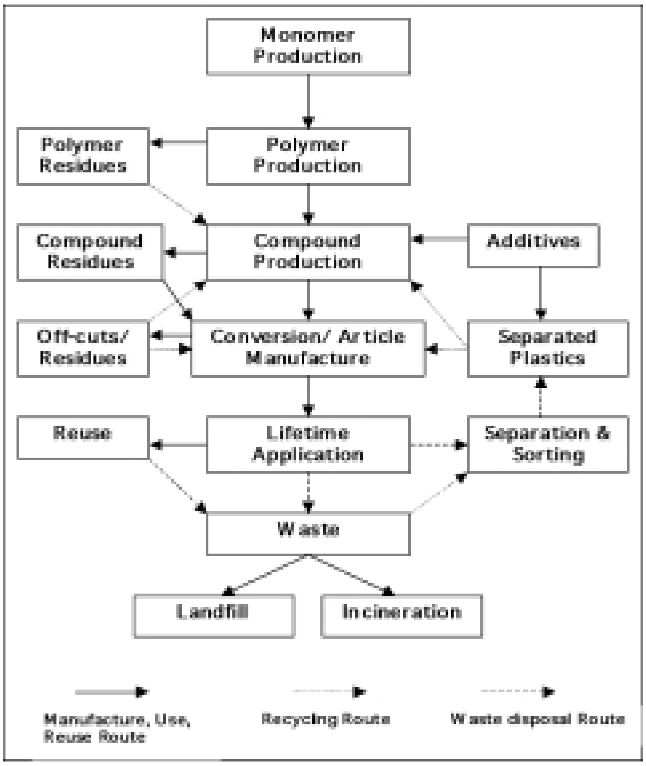
CHAPTER 3

Plastics & waste plastics

Definition

The worldwide production of plastics has grown from virtually zero to almost 100 million tonnes pa (Mtpa) in the last half century. The term plastics describes a vast range of materials and compounds. There are about 50 different families and hundreds of varieties. Most plastics are made from simple hydrocarbon molecules (monomers) derived from oil or gas. These undergo polymerisation to form more complex polymers from which products are manufactured (figure 4). Additives are used to give the plastic specific properties.

Figure 4 : The Manufacture, use, reuse and recycling of plastics[17]



Types of plastics

There are two main types of plastics: **thermoplastic**s and **thermosets.**

Thermoplastics soften when heated and harden on cooling. More than 80 per cent of plastics are thermoplastics, examples of which include:

- high density polyethylene (HDPE) : used for bottles for detergents, food products, pipes and toys.
- low density polyethylene (LDPE) : for products such as cling-film, bin liners and flexible containers.

17- United Nations Environmental Programme - Technical guidelines for the identification and environmentally sound management of plastics waste and for their disposal (2002)

- polyethylene terephthalate (PET) : used in bottles, carpets and food packaging.
- polypropylene (PP) : used in yoghurt and margarine pots, auto motive parts, fibres, milk crates.
- polyvinyl chloride (PVC) : is made from oil and salt and is used for window frames, flooring, pipes, wallpaper, bottles, medical products.

Thermosets are hardened by a curing process and cannot be re-melted or re-moulded. Examples of thermosets (which comprise 20 per cent of all plastics), include:

- polyurethane (PU) : used in coatings, finishes, mattresses and vehicle seating.
- epoxy : adhesives, boats, sporting equipment, electrical and automotive components.
- phenolic : used in ovens, toasters, automotive parts and circuit boards.

Annex 2 gives more detailed information on polymer types and describes[18] the major thermoplastics with their identification numbering, most common applications, and some recyclate applications.

Characteristics and Identification

The physical and chemical characteristics of individual polymers are very different and influence end-use applications. PET has good gas barrier characteristics and therefore is suitable for packaging carbonated drinks. HDPE is not, but it is resistant to impact, electricity and chemicals. PP can be "hot-filled", but it also has good tensile strength and can be extruded to produce fibres and filaments, while PVC has good insulating properties.

There is no legislation governing the marking of plastics. The European Commission prepared a voluntary identification system - (97/129/EC) - for packaging, which established that:

> "the numbering and abbreviations on which the identification system is based, indicating the nature of the packaging material(s) used"

The use of this system is voluntary for plastics. Numbering and abbreviations are as follows:

Table 5: EC voluntary scheme for plastics identification

Material	Abbreviations	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
Others	Unallocated	7–19

18- Based on: http://www.ecorecycle.vic.gov.au/aboutus/infosheet_plastic.asp and "An analysis of plasticsconsumption and recovery in Western Europe 2000" - APME - Spring 2002 (Available on www.apme.org)

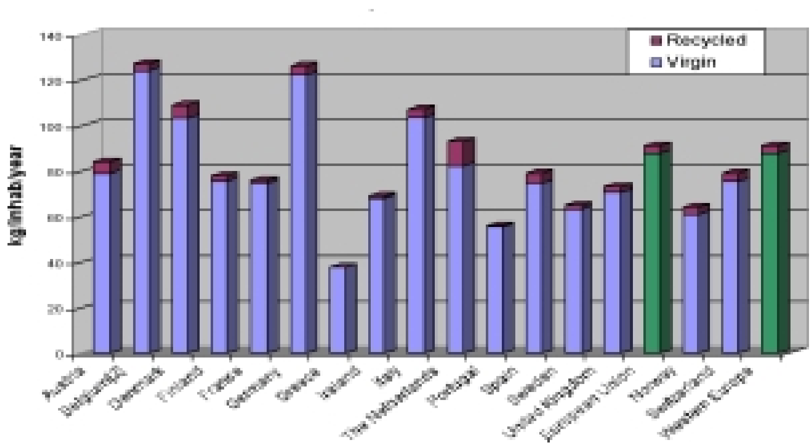
Plastics consumption in Europe

The Association of Plastics Manufacturers in Europe (APME) tracks the consumption of plastics across Western Europe, and collects data on the waste plastics generation, recycling and recovery. APME's statistics are for Western Europe as a whole and have been derived according to methodologies agreed by independent consultants Taylor Nelson Sofres.

Consumption of plastics in Europe

Plastics consumption varies strongly from one European country to another (see Figure 5, below). With per capita consumption at 127 kg/inh/y, the average Belgian consumes more than three times more than a Greek (38 kg/inh/y). However, within the same country, regional differences are also observed. For example in Spain, this plasticulture is highly developed in Andalusia, but not in the north of Spain.

Figure 5: Plastics consumption in Europe



Source: Taylor Nelson Sofres - 2000 Data[19]

The proportion of post-user recycled plastic in production also varies strongly from a country to another. Plastic transformers in Greece use 0.3 per cent post-user recycled materials, while in The Netherlands they use 11.4 per cent. The EU 2000 average was 3.6 per cent.

When adjusted for imports and exports, average consumption of plastics in Europe is 91 kg/inh/y (2000).

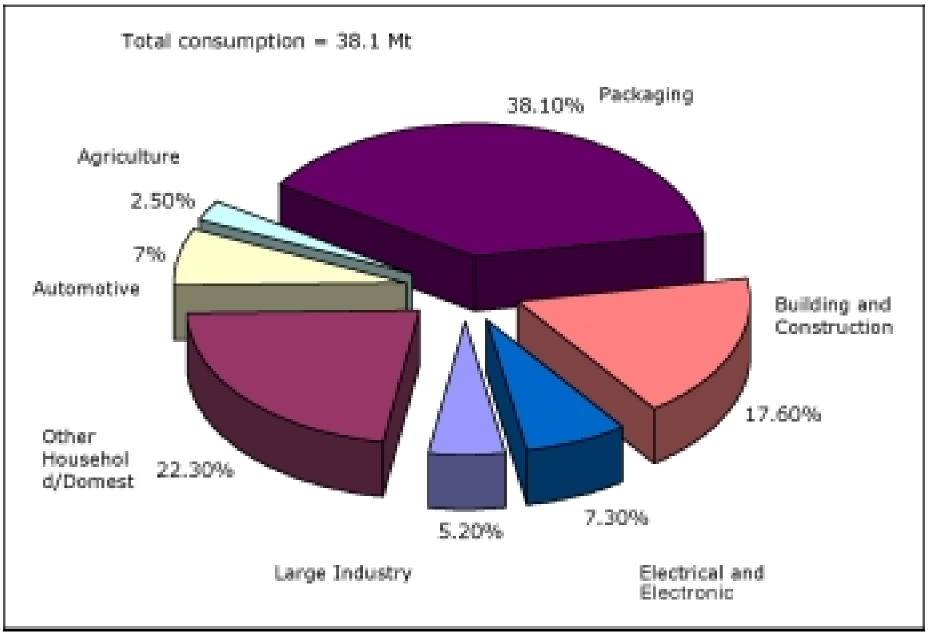
Plastics consumption in Europe by activity sector

Figure 6 presents the European consumption by application. Packaging is the main application for plastics, with more than one third of the total used for these purposes (38.1 per cent, 14.5 Mt). Earlier data from APME[20] suggests that around 73 per cent ends up at the household whilst the remaining 27 per cent is used as distribution packaging in industry. Packaging applications are usually short-lived with the exception of packaging which is designed to be reused, such as pallets, crates and drums.

Source APME (2003)[21]

19- "Information System on Plastic Waste Management in Europe – European Overview 2000 Data" Taylor Nelson – Sofres for APME – March 2002
20- 'A material of choice for packaging' - APME 1999
21- "An analysis of plastics consumption and recovery in Western Europe 2001/2" – APME – Summer 2003

Figure 6: Plastics consumption by sector



Domestic and building applications use similar quantities of plastics, 20 and 18 kg/inh/y, respectively. These are usually medium or long-term applications. The types of plastics encountered in building applications are relatively restricted, while domestic products contain a wide variety of plastics.

Electrical and electronic equipment (E&EE) applications, with plastics consumption of 6.5 kg/inh/y, have a lifespan typically up to 15 years. Many composite elements (multi-material) are found in this sector, so dismantling and recycling is a new challenge for many.

Similar quantities (6.5 kg/inh/y) are used for automotives. The plastics present in vehicles need to be separated from the rest. As for E&EE, new techniques are being developed, in order to fulfil the EU directive on ELVs.

Agriculture, with an average plastics consumption of 3 kg/inh/y appears as the least important application. However, this sector uses products with typically short (or medium) term life spans, such as films or packaging. There are very wide variations in consumption between different regions and countries in Europe (for example, the use of plastic sheeting in greenhouses in the Spanish region of Andalusia). These situations can involve sufficient material flows to justify producer responsibility schemes.

Consumption of plastics by resin type

It is reasonable to assume that the most common plastics resins are also the most common waste plastics. While all resins will become waste sooner or later and therefore require treatment, the time-span over which this may occur is dependant on the type of product into which the polymer is manufactured and the polymer itself.

Over 90 per cent of all PET manufactured is used as packaging, as carbonated drinks bottles for example and therefore the majority of PET manufactured within a given year becomes waste in the same year.

In contrast, only 10 per cent of PVC is used in the manufacture of packaging; the remainder is predominantly used in the manufacture of longer-life products such as pipes and windows, which may not enter the waste stream for 30 – 50 years. More than 60 per cent of the consumed plastics are made of these polymers:

- LDPE - 19 per cent
- PP - 15 per cent
- PVC - 14 per cent
- HDPE - 13 per cent

Table 6: Consumption of plastic by resin (Western Europe)

Polymers	Recycled polymers, post-consumer only (per cent)	Virgin polymers (per cent)	Total (kt)	Proportion (per cent)
LLDPE	10	90	7,121	19
PP	1	99	5,524	15
PVC	0	100	5,243	14
HDPE	7	93	4,837	13
PS	2	98	2,278	6
PET	1	99	1,695	5
EPS	4	96	788	2
Other thermoplastics	1	99	4,287	12
Sub-total thermoplastics	4	96	30,763	84
Thermosets	0	100	6,006	16
Total	**4**	**96**	**36,768**	**100**

Source: Taylor Nelson Sofres for APME – 2000 Data[22]

APME reports that in 2002, 10.3 Mt (27 kg/inh) of thermosets were consumed in Western Europe. In 2002, APME also reported that 37.4 Mt of thermoplastics were consumed in Western Europe, of which around 86 per cent was utilised in plastics applications (non-plastics applications include the manufacture of textiles and coatings). The proportions of the different types of the consumed thermoplastics are:

Table 7: Consumption of Thermosets in Western Europe (2000[23]and 2001/2[24])

	Aminos	Phenolics	Epoxy Resins	Polyesters	Polyurethanes
2000 (per cent)	36.1	14.1	5.5	6.7	32.7
2000 (kg/inh)	9.4	3.8	1.5	1.8	8.8
2002 (per cent)	25.2	9.5	3.9	4.6	23.3

22- "Information System on Plastic Waste Management in Europe – European Overview 2000 Data" Taylor Nelson – Sofres for APME – March 2002
23- " An Analysis of Plastic Consumption and Recovery in Western Europe 2000. APME, Spring 2002
24- " An Analysis of Plastic Consumption and Recovery in Western Europe 2001/2. APME, Summer 2003

Table 8: Consumption of Thermoplastics in Western Europe (2000[25] and 2001/2[26])							
	LDPE	**PP**	**PVC**	**HDPE**	**PET**	**PS/EPS**	**Others**
2000 (per cent)	21.8	19.6	16.0	13.8	8.6	8.5	11.7
2000 (kg/inh)	20.1	18.0	14.7	12.7	7.9	7.8	10.8
2002 (per cent)	21.2	20.9	15.5	14.1	8.7	8.8	10.8

Waste Plastics Generation and Management in Europe

Waste plastics generation and management by application

APME provides European figures for waste plastics generation and data as to how this waste is managed, given below. Not all plastics waste is collectable; a large proportion of plastic consumed is held in long-term applications such as pipes and windows. Therefore APME uses the notion of available collectable waste which can be defined as follows: **Available collectable waste =**
[total quantity of end life product]
minus
[quantity of product not available (e.g. pipe in the ground)]
minus
[quantity of product not collectable for economical/technical reasons]

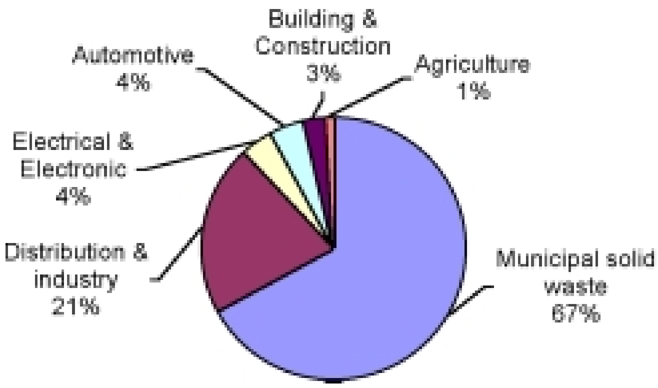
According to the 2000 figures for consumption and waste production, 41 kg/inh were accumulated in the built environment.

MSW appears as the main source of waste plastics, about two third of the total generated. This estimation is made on the basis of national statistics and the definition of MSW varies from one country to another. Regardless of these variations (which may be significant), L/RAs remain the sector facing the greatest arisings of waste plastics.

The second waste plastics stream in importance comes from the distribution and industrial sectors, with 10.5 kg/inh/y. This stream is mainly packaging, usually both homogeneous and clean.

25- " An Analysis of Plastic Consumption and Recovery in Western Europe 2000. APME, Spring 2002
26- " An Analysis of Plastic Consumption and Recovery in Western Europe 2001/2. APME, Summer 2003

Figure 7: Waste plastics generation by activity (50kg/European/year)



Source APME, 2000[27]

Quantities of waste plastics from E&EE and ELVs are similar (2 kg/inh/y). The recovery of these streams calls for dismantling to separate plastics from the rest. For waste E&EE, many composites are found and their dismantling presents a new challenge for which solutions are investigated to comply with the European directive on E&EE.

Table 9: Total Consumption & Recovery of Plastics by End-use Sector (x1,000 tonnes)

	Consumption	Available to collect	Recycling	Energy Recovery	Landfill Incineration
Agriculture	953	286	161	0	125
Automotive	2669	851	61	35	755
Building & Construction	6710	530	58	0	472
Industry Incl. Packaging**	1982 3987	4130	1418	441	2271
Electrical & Electronic	2783	854	34	4	816
Household/ Domestic Incl.Packaging**	8501 10538	13324	1087	4103	8139
TOTAL	**38123**	**19980**	**2819**	**4583**	**12578**

Source: APME 2002[28]

27 & 28- "An analysis of plastics consumption and recovery in Western Europe 2000" – APME – Spring 2002

C&D activities may be divided into construction, renovation and demolition activities. Construction activities generate mainly packaging waste which can be contaminated by cement, sand and plaster. They generate also off-cuts and damaged materials. The renovation and demolition waste comprise long-lived applications (e.g. roofing, flooring, pipes and frames). The difference between renovation and demolition waste plastics is that the waste from renovation are easier to collect because their collection does not need, or needs only little extra work for its dismantling or separation.

The agriculture sector (1 kg/inh/y) is the sector with less waste plastics production. However, most applications here are short or medium lifespan (packaging, silage film, greenhouses etc).

Data on waste management practices identifies the weight of material that is currently being land-filled/ incinerated. There is considerable scope to divert much of this material into viable collection and recovery operations.

Waste plastics generation and management by country

The waste plastics generation is not uniform across Europe, but differs between countries from 29 kg/inh/year in Greece to 73 kg/inh/year in Switzerland. These differences can be explained in part by differences in the consumption patterns of specific polymers and plastic products (PVC with long life applications is common in Germany but not in Greece).

This variation can also be seen in the management of waste plastics between European countries. Plastic recycling (including feedstock recycling in Austria and Germany) varies between ~2 per cent in Greece to ~29 per cent in Germany whilst energy recovery practices range between ~6 per cent in the UK to ~75 per cent in Denmark. It is estimated however, that of the amount of waste plastics available to collect (~19.5 Mt in 2000), 12.4 Mt (EU-15 countries) was disposed to landfill or sent to incineration (without energy recovery) equivalent to 66 per cent of collectable plastics.

The figures above were estimated by consultants Taylor Nelson Sofres for APME.

Table 10: Total waste plastics management in Western Europe 2001 (x 1,000 tonnes)

	Collectable	Recycling	Recovered	Landfill/ Incineration
Austria*	350	67	73	210
Belgium	553	85	164	304
Denmark	351	36	242	73
Finland	162	22	29	111
France	3120	287	998	1835
Germany*	3161	983	806	1372
Greece	317	6	0	311
Ireland	204	16	0	188
Italy	3396	438	428	2530
Netherlands	1027	166	542	318
Portugal	453	13	110	330
Spain	2095	314	266	1515
Sweden	384	32	173	179
United Kingdom	3682	295	295	3093
TOTAL EU	19254	2465	4120	12669
Norway	181	19	77	85
Switzerland	545	40	378	128
WESTERN EUROPE	20391	3018	4690	12683

*In Austria and Germany, recycling includes feedstock recycling
Source: APME, 2002[29]

Waste plastics generation by resin type

There is a parallel between plastic consumption and waste plastics generation, except for PVC which is mainly used for medium or long term applications. As the most common polymers used by plastic converters are the most common waste plastics, it would be possible to find an outlet for the sorted and clean waste plastics.

The OECD estimated that the weight of the plastics in MSW stream in Western Europe[30] has reached 8 per cent by weight and 20 per cent by volume.

According to the figures above, in 2000, 45 kg of plastics by inhabitant were accumulated in the human environment . Typical short-lifespan applications are packaging and some films applications. Typical medium- lifespan applications are electric and electronic goods, some building applications (roofing, roller-shutter, flooring) and vehicles, while the typical long-lifespan applications are building and public works applications like the window frames, the pipes and the electrical wires.

29- " An Analysis of Plastic Consumption and Recovery in Western Europe 2000. APME, Spring, 2002
30- " Working Group on Waste Prevention and Recycling " - OECD - 2002

Table 11: Waste plastics generation by resin type		
Polymer	**Kg/inh/y**	**per cent**
LLDPE	12.4	24.7
PP	9.1	18.2
HDPE	8.1	16.1
PVC	4.3	8.5
PS	3.7	7.5
PET	3.6	7.3
EPS[31]	0.6	1.1
Other thermoplastics	3.7	7.3
Thermosets	4.7	9.3
Total	**50.1**	**100**

Source: Taylor Sofres Nelson – 2000 Data[32]

31- EPS is the expended form of the PS. The chemical composition is the same but the form is very different.
32- "Information System on Plastic Waste Management in Europe – European Overview 2000 Data" Taylor Nelson – Sofres for APME – March 2002

CHAPTER 4

Identification & assessment of important waste plastics flows for local & regional authorities.

Identifying Waste Plastics Flows

The figures presented in this guide reflect only national/European trends and do not specifically represent individual local/regional conditions. Given this, it is useful for individual L/RAs to identify, at a local/ regional level:

- which are the most common waste plastics
- what is the order of magnitude of the waste stock
- which are the activity sectors that have a potential waste stock
- what are the most common waste plastics in each activity sector

It is possible to make extrapolations from European, national or local figures, but, as mentioned, the local/regional variations can vary strongly and the results of extrapolations can be far from a local reality. By looking at European and national data, the waste plastic sources of greatest significance for L/RAs appear to be:

- households
- the commercial sector, the small industries and business
- the construction and demolition sector
- agriculture

Household Waste plastics

Collecting and processing waste plastics from the household waste stream appears to be one of the most difficult flows to manage, not only because it contains a wide variety of different materials, but also because the low bulk density of plastic (~ 20-30 kg/m^3 for unflattened post-consumer plastic bottles[33]) means that a large volume of waste plastics must be collected to achieve a worth-while mass of material.

For Western Europe, Taylor Nelson Sofres[34] gives the figures below for the amount of plastic in municipal waste. This includes household waste and wastes generated by small shops, retailers, cafes, restaurants and hotels. However, it is noted that the definition of municipal waste varies considerably between individual European countries and may distort real data comparisons.

While inconsistencies in waste definitions may, in part, explain the observed variations in waste arisings and compositions between countries, there are certainly important differences in the rates of consumption of plastics.

The three main polymers present in the household waste are LDPE, LLDPE, PP and HDPE which represent around 60 per cent of waste plastics from households, while the six main thermoplastics represent nearly 90 per cent of the total.

33- " Plastic Bottle Recycling in the UK " WRAP (March, 2002)
34- "Plastic packaging consumption waste and recycling" 1994 Data – Sofres Conseil for APME – September 1996 "Information System on Plastic Waste Management in Europe – European Overview 2000 Data" Taylor Nelson – Sofres for APME – March 2002

Table 12: Plastics content in Municipal Waste (2000)

	(per cent)	(kg/inh)	(kt)
Austria	12.5	28	228
Belgium[35]	9.5	26	264
Denmark	8.0	41	216
Finland	5.0	17	87
France	10.5	36	2,108
Germany	5.5	24	1,934
Greece	7.5	20	214
Ireland	10.5	31	118
Italy	11.5	40	2,315
The Netherlands	11.0	44	693
Portugal	10.0	26	263
Spain	10.5	37	1,450
Sweden	7.5	24	216
United Kingdom	10.0	41	2,430
European Union	9.1	37	12,536
Norway	8.0	25	112
Switzerland	15.0	56	402
Western Europe	9.1	34	13,050

Source: Taylor Nelson Sofres – Data 2000

Table 13: Plastic content (by polymer type) in Municipal plastic waste (MPW) (2000)

	(per cent)	(kg/inh)	(kt)
LDPE/LLDPE	20.6	6.9	2,685
PP	20.0	6.7	2,609
HDPE	17.4	5.9	2,273
PET	11.7	3.9	1,528
PS/EPS	10.9	3.7	1,418
PVC	6.9	2.3	906
PU	2.7	0.9	356
Others	9.8	3.3	1,276
Total	**100.0**	**33.7**	**13,050**

Source: Taylor Nelson Sofres – Data 2000

35- Includes the data from Luxembourg

These same polymers not only account for the largest proportion of plastics consumed and therefore are the most commonly recycled, but are also those polymers for which there is a market demand for secondary materials.

Around 70 per cent of waste plastics disposed of through households is packaging. This can be categorised into rigid plastics such as bottles and films, and flexible plastics such as bags and wrappings. The range of packaging plastics in household and municipal waste available is considerable, but not all are suitable, available in sufficient quantities (weight) or feasible for collection and recycling, although this is dependant on the method of recycling employed.

Plastics used to package oils, solvents and garden products may be unsuitable for recycling due to the difficulties associated with the removal of trace product compounds on waste processing; so may alcoholic beverage bottles due to the multi-layered natural of the materials that are typically used to enhance the packaging performance of the containers. Other considerations such as waste plastics colour and odour may impact on the cost of the baled product, whilst collection costs of films (due weight/ volume issues), as well as issues of cleanliness, restrict the attractiveness of film collections from 'dirty' household sources.

However, examples show that it is possible to isolate particular homogeneous, clean flows, which are suitable for recycling and many of these focus on plastic bottles. In the UK, 90 per cent of plastic bottles are made from one of three polymers; PET, HDPE and PVC. The proportion of these polymers and their relative colours in the bottle fraction of household waste does vary between countries.

Table 14: Proportion of the Bottle Fraction (per cent)

Polymer type & colour	Italy	UK
PET, of which:	77	44
Clear	40	44
Light blue	19	-
Other	18	4
HDPE	22.5	50
PVC	1.5	6

Source: TNO (2000)[36]

PET (used to package carbonated drinks) and HDPE (used for milk, detergents, toiletries) are the most recyclable fractions. Mono-material, single coloured waste plastics reach the highest market price, and inclusions such as PP caps, unsorted coloured material and highly 'perfumed' plastics impact on processing, associated costs and value of the material.

Barriers to recycling

The barriers facing plastic recycling from waste arising within the household waste stream are:

- High dispersion of material
- Potentially heavy contamination
- Polymer colours and end markets
- Prohibitions on closed loop recycling

36- " Best Practices for the Mechanical Recycling of Post-user Plastics : Appendices Report " TNO-report (2000) for APME

Plastic bottles are the main products that are targeted for recycling from the waste stream, for reasons that have previously been mentioned. Despite the high dispersion of material, successful recycling schemes have been established, although the cost of collecting these materials is often quoted as being the main barrier towards bottle recycling. Films are typically disregarded because of the high levels of contamination that are associated with these materials, and the low weight to volume ratio, compared to bottles.

PET has experienced limitations in the amounts of material recycled due to a lack of supply, coupled with saturation of current markets. New markets need to be developed in order to sustain the potential amounts of material available for collection. 90 per cent of PET is used to manufacture packaging products and the vast majority of this is associated with food, yet closed-loop recycling (the manufacture of post-use plastic bottles back into plastic bottles) is restricted in many countries. Additional barriers also concern the colour of PET; consumer and market trends have increased the penetration of coloured PET onto the market and yet there is no market for coloured PET bottles (with the exception of blue).

Colour is also an issue for HDPE recycling, which restricts the market outlets for the material, as is contamination by PP caps and lids, however, improvements in current sorting technologies will reduce the impact of these on the recyclate produced.

Distribution and retail sector

Commercial sector, small industries and businesses:

The waste plastics generated by the commercial sector, small industries and businesses produce is largely packaging waste. The most common waste plastics generated by these sectors are:

- stretch films
- drums and containers
- large bags
- pallets
- crates
- EPS

Unlike packaging collected in household waste, of which around 85 per cent is disposed of in the same year in which was manufactured, a greater percentage of plastic packaging associated with distribution activities, such as crates, pallets and drums is designed for re-use and held in longer-term applications. As a result proportionately less plastic is available for collection per annum.

The figures below from Taylor Nelson Sofres[37] concern collectable packaging waste from supermarkets, large shops, industries, and also agriculture, building and construction. Figures for non-packaging also relate to the collectable waste plastics fraction. Non-packaging waste includes, amongst others, insulation films, protection covers etc. These are medium to long applications, whilst packaging is typically much shorter.

37- "Information System on Plastic Waste Management in Europe – European Overview 2000 Data" Taylor Nelson – Sofres for APME – March 2002.

Table 15: Distribution of waste plastics: packaging verses non-packaging			
	Packaging kg/inh	Non-packaging kg/inh	Total kg/inh
Austria	7.0	4.3	11.3
Belgium[38]	9.8	4.2	14.0
Denmark	12.2	4.9	17.1
Finland	4.6	2.5	7.1
France	7.1	1.7	8.8
Germany	7.9	1.1	9.0
Greece	5.2	0.6	5.8
Ireland	8.7	5.6	14.3
Italy	10.3	0.8	11.1
The Netherlands	12.9	4.2	17.1
Portugal	9.6	4.0	13.6
Spain	7.0	0.7	7.7
Sweden	10.6	0.7	11.3
United Kingdom	10.7	2.5	13.2
European Union	8.8	1.8	10.6
Norway	5.6	4.7	10.3
Switzerland	8.4	1.8	10.2
Western Europe	8.7	1.8	10.5

Source: Taylor Nelson Sofres – Data 2000

Packaging represents more than 80 per cent of the collectable waste plastics produced by those sectors. For packaging, the European average is 8.7 kg/inh/year, with strong variation between countries. The Netherlands is the highest waste producer for this category with 12.9 kg/inh/year, while Finland is the lowest with only 4.6 kg/inh/year. The same source indicates that the most common polymers used for these packaging applications are LDHE and LDPE.

Table 16: Polymer types in packaging applications			
	LDPE/HDPE	PP	PS/EPS
Stretch and shrink film for goods	•	•	
Heavy duty bags	•		
Crates, pallets, pails, boxes	•	•	•
Drums and containers	•		

Source: Taylor Nelson Sofres – Data 2000

38- Includes the data of Luxembourg

It is important to note that in contrast to household packaging, commercial/ industrial packaging has a higher rate of re-use; pallets, crates, drums and heavy-duty bags may all be specifically manufactured for re-use. In Belgium, it is estimated that for each kg of one-way industrial plastic packaging, there is an equivalent 3.5 kg of reusable industrial plastic packaging. Reusable packaging is easier to collect and to recycle than one-way packaging because it:

- is homogeneous (and clean flow)
- often retains an economic value
- remain in the same distribution circuit (no geographical dispersion)
- can be recycled for the same applications, which avoids the search of new outlets

However, the material/product which plastic drums and other containers package may prevent the material from being recycled, i.e. when it is used to package hazardous substances. In such cases, mechanical recycling is not recommended (and even prohibited in some countries) leaving feedstock or energy recovery the best environmental option.

Barriers to recycling

The main barriers affecting commercial and industrial waste plastics concern commercial and distribution films and EPS, as opposed to rigid plastic applications, such as pallets, drums and crates (with the exception of containers used for the packaging of hazardous substances).

Commercial and distribution films are mainly LDPE (stretch and shrink wrap) and HDPE (bags and sacks). Barriers towards recycling include:

- down-gauging
- low weight/volume ratio

The main features that makes the recycling of commercial and industrial films attractive is that the waste is relatively homogenous, clean and is concentrated amongst a limited number of outlets. Packaging weight reduction, or down-gauging reduces the thickness and therefore weight of the film, in order to optimise resource efficiency. However, as the films become thinner, and weigh less, collection and recycling efficiency may be compromised.

For EPS, the main barriers are associated with the low volume to weight ratio of the material and the costs involved in collection and transport if efficient systems are not established. Contamination is also an important issue and usually only clean, dry label-free material is accepted.

Agriculture

The use of plastics in agriculture has grown dramatically in recent years. It has replaced glass in greenhouses and become the material of choice for many packaging applications; it is also used widely for animal food conservation (silage) and agricultural (crop cover) applications.

Although agricultural plastics account for just 2.5 per cent , 953,000 tonnes, of the total plastics consumed in Europe in 2002, they have a pivotal role to play in this sector. Plastics-based irrigation and drainage systems provide effective solutions to crop growing. For example, in the Almeria region of Southern Spain, plastics-based irrigation systems, greenhouses and films have helped boost horticultural output three-fold. Plastics' growth between 2000 and 2002 in this sector was 3 per cent.

Agricultural practices in Ireland reflect this trend; in 1990, 2-3 per cent of all farms used plastics for silage conservation; by 1994, this had increased to 56 per cent.

Waste plastics from agricultural applications are mainly drums and films, although pallets are also present. Most non-packaging agricultural waste plastics comprise of the following types of film:

- silage wrap
- silage tarpaulin
- crop sheeting
- tunnel and greenhouse covers

The Anglo-Welsh Environment Agency[39] estimated that in 1998, agricultural waste plastics arisings for the UK was 1.04 kg/inh/y, with the following breakdown.

Table 17: Agricultural waste plastics in England & Wales (1998)

Packaging plastic film	**Accuracy**	**tpa**	**Kg/ha**	**per cent**
Agrochemicals Packaging	Medium	2,400	0.15	3.9
Fertiliser Bags	Medium	12,200	0.75	19.6
Seed Bags	Medium	1,000	0.06	1.6
Animal Feed Bags	Medium	11,400	0.71	18.3
Animal Health Packaging	Medium	750	0.05	1.2
Oil containers	Low	669	0.04	1.1
Miscellaneous Packaging	Medium	3,800	0.24	6.1
Total Plastic Packaging		32,219	2.00	51.8
Non-packaging plastic film				
Silage Plastic	Medium	25,000	1.55	40.2
Silage Plastic + Contamination	Low	50,000		
Greenhouse and Tunnel Films	Medium	500	0.03	0.8
Mulch Films and Crop Cover	Medium	4,500	0.28	7.2
Mulch Films and Crop Cover + Contamination	Low	22,500		
Total Films		**30,000**	**1.86**	**48.2**
Total Plastics		**62,219**	**3.86**	**100**

Silage films

Silage films provide a means of conserving animal feed. Forage is baled with thin PE stretch film or is accumulated in long rows covered by thick PE film.

Contamination of silage films is estimated at 50 per cent of the total weight.

39- " Towards sustainable agriculture waste management " - Environment Agency - 2001

In the case of the silage films collected in the Department of Aveyron[40] (France), the most common contaminants are clods of earth, vegetable fragments, barbed wire and moisture.

Greenhouse and Tunnel Films

Plastic films have replaced glass in many greenhouse applications: they are cheaper and easier to install and remove. The obstacles to recycling these plastics include the degradation of the film under UV radiation, the presence of pesticide residues, moisture and dirt.

Mulch Films and Crop Cover

These films are in contact with the ground and as they are usually thin, the level of contamination is high (high ratio surface/volume) and the grinding for recycling is difficult. Contamination of mulch films and crop cover is estimated at 80[41]per cent of the weight, with soil, dirt vegetable fragments and moisture being the main contaminants.

DRUMS

Due to their potentially hazardous content, drums that contained agrochemical and animal drugs are not recycled. There are some collection schemes for them, like Phytophar-Recover, but collected drums are incinerated with energy recovery.
Drums which have not contained hazardous products, can be mechanically recycled. In the Department of Aveyron[42](France) , the collection scheme for agricultural plastic films includes HDPE drums used for washing of milking machines.

Bags

In agriculture, plastic bags are used for the packaging of fertiliser, feed and seed. Feedbags can be contaminated by medicinal additives, seed bags by chemical dressing agents and fertiliser bags by the fertiliser itself.

Pallets

As with pallets used in the commercial and retail sectors, agricultural pallets can easily be reused or recycled.

Barriers to recycling

Agricultural films, which can have a number of applications as previously mentioned, are largely PE (LDPE, LLDPE) films. The main obstacles to recycling these are:

- Degradation by UV radiation
- High levels of contamination
- Low density (~30-50 kg/m^3)
- Wide dispersion of stock

Agricultural films have a short life-span and are largely used in out-door applications, which means that they are exposed to UV radiation, which alters the physical and chemical properties of the material and impacts on its recyclability.

40- See annexe*** : Case Studies****
41- Plastretur and " Towards sustainable agriculture waste management " - Environment Agency - 2001
42- See annexe: Case Studies****

Contamination, by soil, vegetable matter, and moisture increases processing (washing) costs and residue disposal costs. In the Plastretur scheme, Norway, contamination levels of 20 per cent (5 per cent soil and 15 per cent moisture) have been reported.The low density of the material also impacts on the amounts of waste that can be collected, however, the seasonality of waste arisings and the large volumes of material handled by individual farms can off-set this barrier.

Recycling agricultural containers is more restrictive, as many are used for the containment of hazardous agro-chemicals. This contamination is the main barrier restricting the recycling of these agricultural plastics.

Construction and demolition waste plastics

From insulation to piping, window frames to interior design, plastics are a widely used in the construction sector. This is reflected in the data showing that this sector consumed 6.7 Mt plastics in 2002, accounting for 17.6 per cent of total consumption of plastics in Western Europe.

However, there was a slight average decrease in plastics consumption between 2000 to 2002, due to the broader economic downturn.

Construction waste

Construction waste can be categorised into one of groups, dependant on origin:

- damaged materials and off-cuts
- excess materials (i.e. gas bottles, sealant, paints etc.)
- intermediate and pre-cursor waste products (i.e. waste oils)
- packaging waste

While some waste plastics arises in the form of damaged products, such as piping, insulation and window etc. construction waste plastics largely comprises of packaging products, such as films and pallets. Packaging waste accounts for around 2 per cent of all construction and demolition waste, with ADEME estimating that around 10 per cent of construction packaging waste is composed of polypropylene and polyethylene polymers. In a study undertaken by the Building Research Establishment in the UK, plastics were identified as accounting for 25 per cent of the packaging fraction composition of which can be seen below.

Table 18: Plastics packaging composition

Plastic packaging product	Proportion of total packaging (per cent)
PE wrapping	11.6
Containers	4.1
PS filling	3.6
Bubble wrap	3.0
PP bags	2.3
Other (include sealant tubes, sand bags etc.)	0.9
TOTAL PLASTICS	**25.5**

Source: Anderson et al. (2002)[43]

43-" Construction Site Packaging Waste : A Market Position Report " by : M. Anderson, A. Conroy and C. Tsiokou, 2002. Building Research Establishment, UK

Demolition waste

The use of plastics in construction has continued to grow since the 1950s. Generally, more recent the building, the more plastic it contains.

Most of the plastics used in construction are for long-term applications (e.g. window frames, pipes, insulation foam, electrical wires, wall coverings). For instance the lifespan of PVC items (such as pipes and window frames) ise stimated at 50 years and beyond. Consequently, estimating the potential waste stock of this particular stream is difficult. Forecasts on the amounts of waste, by application, which would be in entering the waste stream in 2000 were 1,178,000 tonnes.

Table 19: Forecast of Waste plastics Generation from Building & Construction (x1,000 tonnes)

	1995	2000	2010
Floor & Wall Coverings	274	258	370
Pipes & Ducts	96	240	380
Insulation	84	132	400
Profiles	72	105	160
Lining	59	84	150
Windows	6	12	65
Fitted Furniture	250	320	450
TOTAL	**841**	**1,178**	**1,975**

Source: APME 1998[44]

Selective collection of demolition waste is complicated and expensive, stemming from the resources (mainly labour) necessary to separate the material.

Within the EU, arisings of C&D waste vary between 189 kg/inh/y for Sweden (where the wooden buildings are common) to 720 kg/inh/y for Germany. Data on waste plastics (Report to DGXI, European Commission construction and demolition waste management practices, and their economic impacts: Final Report February 1999 Report by Symonds, in association with ARGUS, COWI and PRC Bouwcentrum) from other countries show the following:

- The Netherlands, waste plastics represents 13 kg/inh/y (1.9 per cent of C&D waste), from which five per cent are recycled
- Belgium, waste plastics represents 1 kg/inh/y (0.15 per cent of C&D waste) from which ten per cent are recycled
- Denmark, waste plastics represents 1.9 kg/inh/y (0.4 per cent of C&D waste) from which 20 per cent are recycled

The Swedish National Testing and Research Institute studied[45] the recycling potential of plastics from buildings constructed in the 1960s and 1970s.

44- " Plastics a Material of Choice in Building and Construction : Plastic consumption and recovery in Western Europe 1995 " APME 1998
45- "Determination of the potential for recycling of polymeric products found in building from the 1960s and 70s – a case study" N. Yarahmadi et al .- SP Swedish National Testing and Research Institute – January 1999

They measured the mass by apartment, the difficulty of dismantling and removing stripped material and the level of cleanliness of the plastic. An average of 2.2 kg/m^2 of plastic was collected, with flooring materials representing about 75 per cent of this quantity.

The study concluded that the oldest buildings contained very little polymeric products apart from floor coverings (which were heavily degraded), with window profiles, door frames, pipes, cables and conduits considered to be the most suitable products for recycling. Plastic floor coverings constituted the largest part in all buildings, but the cleanliness of the materials was poor.

Removal of most products took 10 – 60 minutes per apartment, using simple tools. In most cases, materials were contaminated and to achieve materials of a cleanliness level suitable for recycling, additional simple or advanced separation and cleaning procedures would be needed. One problem in collecting and sortingproducts is presented by replacements made during the service of the buildings (e.g. PVC flooring glued to earlier linoleum flooring).

Pilot projects initiated by the ACRR in collaboration with the European Plastics Federations explored the recovery of waste plastics during demolition and construction in Porto, Portugal and in Barcelona, Spain during 2002/3 concluded that recovery rates were likely to be low, given that older buildings tend to contain little, if any, plastics materials. What there is, is better removed selectively during a dismantling process (along with any potentially hazardous materials). There is clearly more scope for source separation of waste plastics during construction activities.

In the US, the NAHB Research Centre estimated, for the construction of a typical 185 m^2 house, 68 kg of PVC waste (1.9 per cent of the total) is required with a density of 90 kg/m^3. Note that this 'typical' house has three sides of PVC materials, which is uncommon in Europe.

Barriers to recycling

Recycling in this context means the entire recycling scheme (disassembling, collection, pre-treatment, recycling).

The construction and demolition sector is the second largest plastic user after packaging, however, as much of the material is held in long-term applications, the amounts of plastics currently available for collection is restricted. Aside from this, specific recycling barriers include:

- Low landfill costs and controls
- Fragmented nature of the industry
- Time required for on-site material separation
- Costs of collection and transport to recycling sites

The low cost of landfill in many countries and sector responsibility means that there is little economic incentive to engage in more costly waste separation and recycling activities. This situation is being addressed, with some countries introducing legislation that prohibits the landfill or incineration of wastes which can be recycled.

There is also no obligation for underground pipes to be recovered upon demolition which therefore restricts the recycling potential of these materials. The major blocking factor is however, the fragmented nature of the industry; full coverage of the sector would require the establishment of on-site sorting and a complicated collection infrastructure which is presently widely dispersed and includes a large number of low quantity waste arising sites.

As with agricultural films, contamination and UV-degradation of the plastic may also restrict the recycling potential of materials in this waste stream.

Assessing Local and Regional Waste Plastics Flows

The only way to assess the local/regional waste stock with a certain degree of accuracy is to undertake a local/regional waste characterisation analysis. The characteristics of the waste stream that should be considered are the:

- quantities of waste
- composition of waste
- geographical repartition
- daily and seasonal variation
- eco-efficiency of the whole system, in comparison to other options

Waste characterisation is helpful in order to define the practical aspects of the collection scheme, which include:

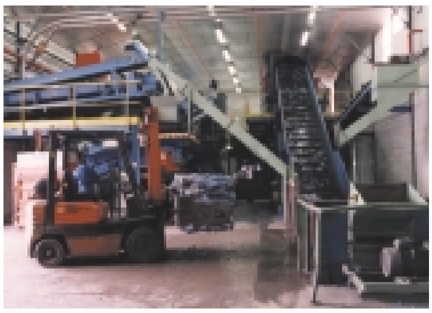
- type and size of the containers
- type of collection equipment
- frequency of the collection
- assess the spatio-temporal variability
- assess the evolution of the waste stream

A report for the European Commission[46], identified four common methodologies used for the waste characterisation. The choice between which method to use will depend of the wanted accuracy of the results, the available budget, and the available time, however, it is possible to combine these different methods. The accuracy and the reliability of the results depends not only on the size and the constitution of the sample, but also on variations in daily, seasonal and spatial factors.

MODECOM - a sampling and manual sorting methodology developed by the ADEME (France) - consists of five steps:

- Preliminary inquiry for the collection of the data necessary for an analysis campaign.
- Choice of the trucks and/or containers to sample
- Constitution of the samples to sort
- Sorting of the samples in two steps: large and medium size fractions
- Laboratory analysis

In 1993, ADEME carried out a detailed national estimation of the waste plastics stock from MSW using the MODECOM model. This characterisation showed that PE and PP plastic films comprised more than 50 per cent of municipal waste plastics. Unfortunately, this operation was not repeated for budgetary and organisational reasons. Today, PVC bottles and packaging have nearly disappeared and a new classification would be used.



In the EU, there is a wealth of experiences of municipalities which collect plastic bottles made of HDPE and of PET.

46- "Identification and Comparative Evaluation of Waste Analysis Methods" – iC-interdisciplinäre Consulenten ZT Gmbh, Austria et al. December2001

These experiences will not be described further in this guide because most of the national Green Dot systems provide valuable technical information.

However, it is interesting to analyse the factors which makes the selective collection, sorting and recycling of plastic bottles possible and one of the most targeted waste plastics for L/RAs:

- plastic bottles represent the **main plastic packaging from** households (46 per cent of household plastic packaging in Belgium, 40 per cent in the UK).
- most are made with **only two kinds of polymer**: PET and HDPE. There are still PVC bottles but their use is declining.
- The **waste holder can easily recognise and separate** plastic bottles from the rest of the waste.
- The plastic bottles are **easy to recognise at the sorting plant**. They can easily be separated by resin or optically by colour.
- There is a developed **market for the sale** of the sorted plastic bottles.
- With increasing disposal costs, the selective collection and recycling of plastic bottles is an option which is **economically interesting.**

L/RAs which want to extend the collection of waste plastics should look for streams which present the same characteristics as those presented for plastic bottles:

- **Sufficient quantity**: The waste agencies know by experience the main streams present in their waste. It is necessary to identify the most common waste plastics. A waste characterisation can confirm and define the figures.
- **Homogeneous, clean and identifiable:** The relevant waste plastics stream must be as homogeneous and as clean as possible. For example, plastic toys are difficult to identify because they are made of different resins. Films or flowerpots are made from only a few of resins, which are quite easy to separate at the sorting plant and coffee cups can easily be collected at catering establishments. EPS is also easy to identify by the waste holder.
- **Possibility of sale for the sorted materials.** It is important to check if there is a market for the collected and sorted material and the quality requirements. Contacting the plastics industry or a plastic recyclers association is helpful in order to define which are the accepted streams, under which conditions.
- **Avoided disposal costs.** The avoided disposal cost is certainly a strong driving force in the decision to launch a recycling programme. While collection costs can be considerable because of the high volume, low weight nature of plastics, selective targeting of specific waste plastics and waste flows can be profitable with little or no additional support. Therefore when evaluating the economic costs of introducing a selective collection programme, avoided disposal costs must also be integrated.

A number of local and regional authorities have successfully established selective non-bottle plastic collection schemes, encompassing a range of waste streams by applying the indicators noted above. These include Plastretur in Norway; LIPOR in the Porto region of Portugal; BEP and IMOG in the provinces of Namur and Courtrai in Belgium respectively; The Department of Aveyron and the Syndicate of Municipalities of the Region of Rambouillet (SYMIRIS) in France. Further details of these schemes can be found in the following chapter.

CHAPTER 5

How can local/regional authorities improve waste plastics collection?

Household Waste Plastics

Collection schemes serving households include:

- kerbside collection
- neighbourhood containers
- container parks

The type of collection scheme that L/RAs choose to adopt is influenced by the types of waste and waste flows that are targeted; kerbside collection and neighbourhood containers are aimed towards the collection of smaller plastic products, typically the packaging fraction; plastic bottles and, to a lesser extent, films. Container parks however, enable larger plastic products to be collected, including plastic furniture, pipes, window frames etc., which not only arise in household waste, but also the commercial and industrial waste streams.

The choice of scheme will affect the collection rate for plastics within a L/RA. In Norway, a study by the Østfold Research Foundation compared two municipalities, Drammen and Hamar, which are collecting plastic bottles using two different types of collection scheme. In Drammen, a neighbourhood collection system was achieving a collection rate of 18 per cent. In Hamar, where a kerbside collection system was being used, collection rates reached around 55 per cent.

Kerbside collection

Most kerbside collection schemes collect plastic bottles. With the exception of the German DSD scheme, no kerbside collection schemes for the collection of plastic films or other non-bottle waste plastics from household were identified.

THE DSD AND WASTE PLASTICS

The work of Duales System Deutschland AG is based on the stipulations of the German Packaging Ordinance, which came into force on 12 June 1991 (amended in 1998). The privately run company organises the collection and sorting of sales packaging bearing the Green Dot. The disposal services provided by the Dual System are financed by the "Green Dot" licence fee. Retailers and manufacturers are thereby discharged from their individual obligation, laid down in the German Packaging Ordinance, to take back used packaging.

There are two main types of system: kerbside and drop-off systems. The most widespread collection system is the kerbside system using Yellow Bags or Yellow Bins. Consumers use these to collect lightweight packaging (e.g. yoghurt pots) bearing the Green Dot at home. With drop-off systems, the consumer can use recycling containers located near his home. Glass and paper packaging are also collected in this way in many places. Central collection centres also come under the drop-off category.

- Yellow bag or bin - after sorting, separate bales of aluminium, tinplate, composite, sheet plastic, plastic bottle, mixed plastic and polystyrene packaging are ready for recycling
- Glass - is sorted according to colour at the preparation plants
- Paper - is sorted according to various waste paper quality criteria at special sorting plants

In 2002, German consumers consigned 6,32 million tonnes of used sales packaging to collection containers marked with the Green Dot. This is equivalent to a collection quantity of 76.7 kg per person.
Since the German Packaging Ordinance came into effect in 1991, the amount of sales packaging the average shopper takes home each year has fallen from 94.7 kilos to 82.3 kilos in 1997. There are also signs of a trend towards waste-avoiding and recycling-oriented packaging solutions, as is evident from a glance at the supermarket shelves:

- Manufacturers are cutting down on packaging materials by reducing the packaging weight or doing without packaging altogether
- Changing choice of packaging material, e.g. from blister packs to cardboard
- More refill packs and concentrates, particularly in the washing and cleaning detergents sector

Some waste plans, like that of Barrow-in-Furness Borough Council (UK) aim to extend kerbside collection to plastic films. One of the advantages of kerbside systems over neighbourhood containers, beside the greater collection rate, is that they generally accept a greater range of materials and permit visual quality control of collected waste by collection teams. Where waste is badly sorted, collection may be refused and a sticker or label attached to the container explaining why the material has been rejected. This also installs a greater awareness of the recycling requirements of the scheme on the householder and affords them greater responsibility for their waste.

The types of containers typically used in a kerbside collection scheme are either boxes, transparent bags or wheeled-bins. The choice of container for kerbside collection has important implications on the diversion rates for materials and system costs. Although in terms of cost per unit plastic bags are by far the cheapest method of containment, they are also single-use containers; boxes and wheeled-bins are not.

Mono versus multi-materials collection

The objective of any collection scheme is to collect, at reasonable cost, materials of good quality. If the collection scheme is a multi-material system, then collected quantities will be greater than in a mono-material collection scheme. Indeed, there is less hesitation by the householder in placing material into multi-material systems than selective collection schemes. However, a balance must be achieved, between the costs and benefits of these systems. Multi-material systems have higher collection rates and therefore lower associated costs of disposal than selective collection schemes, yet this may be off-set by the quality of the received material, increased processing costs and/or lack of markets for the resulting material. In contrast, selective collection systems may have lower collection rates and therefore higher residual disposal costs, yet the quality of material and processing costs maybe more favourable.

Most kerbside collection schemes target a range of recyclables, and typically plastics, metals and cartons (PMC) which are subsequently sorted. The plastic fraction is generally limited to bottles only.

Neighbourhood containers

As with kerbside collection systems, most of the plastics collected through the neighbourhood containers are plastic bottles. In the UK, Tameside has, amongst a total of 54 neighbourhood container sites, two locations equipped for the collection of plastic films and three equipped for plastic bottles.

The siting of neighbourhood containers are typically locations which are routinely visited by householders: civic amenity sites, large supermarket sites, recreation or community areas. The choosing of an adequate site is important in order to reach good collection rates and to avoid the degradation of the containers. Container design must include a clear indication, with pictogram if necessary, of the accepted materials. It must also avoid the deposit of undesirable materials; this can be achieved by the careful design of the openings through which the material is deposited.

Container parks

A container park is a collection facility most typically used for the collection of non-bottle waste plastics. There is usually a separate container for the collection of plastics, which are subsequently sorted into valuable and refuse fractions. For some polymers where cleanliness of the material is important, such as EPS, plastic polymers may be collected separately. Large sized containers and disposal apertures permit the collection of bulkier goods such as furniture, pipes, windows etc. They also enable some degree of control to be exerted over the types of waste deposited.

Container parks can be used for temporal or fixed deposits.

SYMIRIS - SYNDICATE OF MUNICIPALITIES OF THE REGION OF RAMBOUILLET

SYMIRIS is the Syndicate of Municipalities of the Region of Rambouillet (77 Department of Seine et Marne – France). It gathers together 183 municipalities, encompassing around 160,000 inhabitants.

From the first of July 2002, Law n° 92-646 comes into force which specifies that only final waste can be landfilled. This is waste that cannot be technically and economically recycled or recovered any further. The definition of the ultimate waste is still not well established and can vary from one departmental waste plan to another.

The president of the SYMIRIS was the promoter of this initiative. The idea was to extend the logic of selective waste collection to waste streams other than packaging, and to divert waste from the incineration. Since 2000, plastics have been collected in the 19 containers parks of SYMIRIS, which are open to private householders, small retailers and artisans. Materials can be deposited free of charge. All plastics are accepted.

Each container park has a container for plastics. This is transported to the sorting plant of SYMIRIS where plastics are sorted manually. SYMIRIS recovers the fractions for which outlets were found: PE films, rigid PE and PP (pieces of garden furniture, bucket, bins), pipes, windows frames. Most of the plastics present are PP and PE. PE films represent about 50 per cent of the collected plastics. As the pieces of PVC are usually big, their sorting is easy. The residual fraction for all the waste plastics is about 30 per cent. The main characteristics of this fraction are that it is dirty and/or composed of metal inclusions (e.g. screws) and multi-materials pieces.

Each year 800t plastics are collected. The PVC fraction is marginal, amounting to around 2-3 t/month of post and pre-consumer waste plastic. The first transport of PVC pipes contained 5.5t from three containers of 30m^3 and goes to The Netherlands (Wavin – Zwolle). They are transformed into new pipes (see FKS). The frames are sent in the south of France (Albaplast – Montauban). Frames are more difficult to recycle than pipes because of the metallic and rubber elements, which must first be separated.

PP and PE elements are sorted by colour and are subsequently granulated by extrusion. These granulates are commonly used for the fabrication of massive plastic pieces such as fence posts, garden furniture and lumber. The collection cost, which corresponds to the container and its site, is € 45/t. Transportation from the container parks to the sorting facility also costs € 45/t. The sorting costs are € 75/t, which means total costs for SYMIRIS are € 165/t. For PVC, those costs are covered by the French Syndicate of Pipes and Fittings in the framework of a pilot programme of voluntary commitment of the European Plastics Pipe and Fitting Association (TEPPFA).

The economic logic of funding for the residual fraction is based on avoided costs and incomes from the sale of sorted materials. The materials are sold for € 45 - 60/t, while avoided costs are € 62 for landfilling (plus transportation) or € 76 (transportation included) for incineration. Incomes are € 107-138, which must be compared with the above recycling costs.

Currently, there are no specific communications made to the public concerning waste plastics collection. Residents learn of the facility when they visit container parks. Professionals from the retail and small businesses sectors are informed about wastes acceptable in the container park, through a booklet published by their professional association.

ECO PSE (FRANCE)

ECO PSE is the French branch of EUMEPS (European Manufacturers of EPS Packaging, www.epsrecycling.org), which has the sole objective of collecting EPS. Experience from commercial collection schemes is being used, in partnership with the L/RAs to develop collection points of EPS in municipal container parks. ECO PSE, in association with local authorities, will implement a network of collection points to which small quantities of EPS, from small businesses or households can be brought.

The collection points are located in container parks or in the transformation plants. In a first step, ECO PSE wants to develop the collection points near reprocessing facilities, in order to avoid long transportation (a critical factor with EPS). ECO PSE has designed and built forty special containers and informative panels on collection of EPS. Currently, they distribute them free of charge to collection points.

The quality of the EPS collected is usually good. There is a marginal contamination by adhesive tape and by labels, which can be easily removed. As this experience is recent, no data are available on the collected quantities.

ECO PSE has financed the design and the construction of specific containers. The price by container is € 460, all included (specific design, informative panel and construction). In the example below, the recycler has financed the laying out of the Point PSE in the Municipal Container Park. Nevertheless, the financing of the laying out varies from one case to an other.

ECO PSE prepared a communication on PSE:

- at Pollutec 2000, which is the biggest French environmental fair
- through the professional and trade associations. ECO PSE published a booklet for the newspapers of those associations that have local sections. The folder gives general information on how to establish a collection point and encourages partnership with the industry
- locally, ECO PSE recommends the use of press releases, explaining the type and the quality of the material accepted as well as the site of collection

Industrial/Commercial Waste Plastics

The collection schemes established for industrial and commercial sectors usually have better results than for the household waste and municipal waste (from retail, small business). There are two main reasons for this. Firstly, the waste is concentrated in a reduced number of places; this is in contrast to household waste arisings, which are geographically more dispersed, making collection more difficult. Secondly, wastes from industry are cleaner and better identified than wastes from households, which gives a better value to this waste. Nevertheless, some professional sectors, like the agricultural or construction sectors, do generate quantities of films contaminated by such as earth, humidity etc. Examples of industrial and commercial collection systems operated by L/RAs are illustrated below.

Professional sectors generally use the services of private collectors with which they establish the collection modalities, the quality criteria and the price, however in certain cases, the L/RAs organise collection schemes using existing facilities and expanding upon the public infrastructure. Examples of these (see below) include the Province of Namur (Belgium).

Industrial

FKS INITIATIVE TO RECYCLE PLASTIC PIPES IN THE NETHERLANDS

Since 1991, FKS has organised a national collection scheme for plastic pipes in the Netherlands. FKS is the association of the Dutch plastic pipes industry. The objective of the industry was to offer a complete environmental friendly service for pipes users, from the factory to the grave, through a voluntary commitment.
The targeted audience are professionals using plastic pipes, from major construction and demolition enterprises to the individual plumber or repair-person.
Collected materials are plastic pipes made of PVC, PE or PP, and only pipes that are clean and free of chemical contamination will be accepted. The instructions specify materials that are not accepted (but are commonly found with pipes), such as polyester goods, plastic films, hose pipes, sand, cables, iron, garden chairs and buckets.
The objective of FKS is to collect 50 per cent of collectable pipes by the year 2005.
There are two collection schemes offered by FKS. For the small quantities, a network of containers is available. The containers are situated in 57 locations across the Netherlands. The deposition of plastic pipes is free and is open to the general public. For the large quantities of pipes that are potentially available at major C&D sites, FKS offers a service of container renting ; used plastic pipes may then be purchased.
FKS undertakes to give a second life to collected pipes, either through recycling or by reusing them. For PVC pipes, FKS aims to make the most of the recyclable properties of this material. The PVC is recycled into new multi-layer pipes (core of recycled PVC and external layer of virgin PVC), which are marked with a FKS logo. This FKS logo is a certificate of guarantee which certifies that the pipes respect the technical European norms and is made with recycled materials.
For PVC pipes, the associated costs of the FKS system are the following:

- € 0.10/kg for collection
- € 0.35/kg for sorting & recycling (in this case, flake production)
- € 0.15/kg for micronisation (reducing flakes into a fine powder)

The costs of the FKS recycling scheme can then be estimated to € 0.60/kg. These are the global costs of the FKS system and they do not make any distinction between commercial C&D collections (i.e. by container renting) or collection made from the general public (i.e. at points of sale). Financing for FKS comes exclusively from the payment of the users for its services.
In the near future, FKS wants to develop a partnership with municipalities for the collection of these materials and the associated communication of the scheme. One idea is to put a dedicated FKS container into municipal container parks.

Commercial

BUREAU ECONOMIQUE DE LA PROVINCE DE NAMUR (BEP) – BELGIUM

While there is no legal obligation to collect EPS in Belgium, the BEP offers a fixed service for it's collection. At the beginning 2002, the BEP launched a test for the selective collection of the EPS in 14 container parks of the region of Namur. In four months, 910 m^3 (about 20t) was collected. With such results, the BEP decided to extend, based on this experience, into the 31 container parks of the Province. In the container parks, the EPS is collected in large capacity (about 1m^3) transparent bags. These bags are put on a support with a cover and allows for a visual control of the deposited materials. Only material that is clean (typically from E&EE packaging) and without labels is accepted; food containers, EPS chips, dirty or damp EPS and insulations rolls of EPS are not accepted. Collected EPS is mixed with cement to make acoustic and/or thermal insulation panels

ECOFONE COLLECTION SCHEME – LIPOR, PORTUGAL

In the region of Porto (Portugal), the waste agency, LIPOR, has equipped its container parks with specific containers for plastics. They are particularly sited near to industrial areas, and so the material that they collect include plastic films, EPS, plastic furniture, pipes, roller shutters etc. Dependant on the region, LIPOR also receives through its container parks plastics that surround large capacity wine bottles. LIPOR also organizes a phone (Ecofone) service for households and the trade and small businesses sector. Most of the material collected through the Ecofone service is plastic film from the commercial sector.

In June 2000 Lipor introduced a dedicated telephone service Ecofone, in which waste-holders can telephone Lipor to make an appointment to collect recyclables (paper/card, glass, plastic and metal packaging). Initially, this system was intended to household and small retailers. However, Lipor has since extended it to schools and plans to extend it further to serve industry.
In Portugal, there is no specific law on waste plastics. The legal obligations come from the application of the European Directive on packaging waste. The targeted audiences are:

- service and commerce (advertising agencies, public offices, banks, pharmacies copy centres, restaurants, hotels, etc)
- schools and teaching institutions
- households

The collection of recyclable materials is made by teams, whose staff are easily identified. They use light commercial cars in order to ensure good mobility in the city's busy streets. The phone service works from 9:00 am to 8:00 pm, from Monday to Saturday. Calls made outside this schedule are recorded. Collections are made between 7:00 am and 8:00 pm, Monday to Saturday.
Lipor also supplies free plastic bags for the selective collection of materials; yellow for metal an plastic packaging, green for glass packaging and blue for paper and card.
One incentive to use the Ecofone service is that it is free, in comparison with an incineration fee of € 75/t. Once materials are collected, they are taken to Lipor's sorting plant where they are processed and baled for sale. Ecofone carries out around 2,000 collections monthly, from which about 75 per cent are from services and commercial stores. Total monthly collection amount to around 100 t, of which approximately 50 per cent is paper/cardboard, 35 per cent is glass, 9 per cent is plastics and 6 per cent is metal packaging. The plastics stream is principally PET bottles and PE films, the percentage split of which is around 40:60. The quality of the material collected by the Ecofone service is excellent. The collection costs associated with the Ecofone Project are around € 140/t , with sorting costs at around € 50/t. The overall cost of the communication campaign was € 299,000, with the support of the Portuguese Green Dot Society contributing 50 per cent.
A specific communication campaign was developed to encourage participation in this service. This was aimed at consumers, small commerce and service organisations, as well as reinforcing several other environmental awareness actions.
The strategy, including the service's name, is based on the image of a phone and the act of making a phone call – simple, comfortable and fast. Lipor has opted for a system that has a high visibility, a strong public presence (buses, outdoor advertisements), and which is informative (direct mailing), accessible (radio, press) and easily comprehensible.
The communication campaign started with the outdoor communication, following up with the distribution of a generic mailing to all the residents services and shops of the town of Porto.

Agricultural waste plastics

Agricultural waste plastics offers many of the characteristics as commercial and industrial plastics; sources are geographically concentrated and the waste is generally cleaner and of a higher value than household wastes. However, the agricultural sector does generate film wastes that can be contaminated by such as earth,moisture, vegetable fractions etc. and container waste contaminated by hazardous substances, i.e. herbicides, fungicides, fertilizers which restricts the ability to recycle them. A number of L/RAs have however established successful recycling schemes:

BUREAU ECONOMIQUE DE LA PROVINCE DE NAMUR (BEP) – BELGIUM

Agricultural plastic films are subject to legal obligations in Belgium; since July 2002, a regional bylaw on the take-back obligation has been in force, which includes, amongst others a chapter on agricultural plastics. It obligates the retailers to take back free of charge the agricultural waste plastics. Wholesalers and importers must organise or finance this mechanism. They can also directly organise or finance collections, which must be free of charge. The bylaw imposes a recycling rate, based on the collected quantities, of 20 per cent for 2003 and of 50 per cent for 2005. The residual fraction must be energetically recovered. Only PE films, used for the ensilage of forage material in bunker (or corridor) silo or in bales are targeted for collection, although films used for frost protection are also accepted. The typical film used for bunker silo is dark and thick, which has a positive value, while film used for forage bale is usually white, thin and stretchy. These can present high levels of contamination by glue and dirt. Its value is low or negative due to its contamination and its thinness.

Collection is organised at the inter-municipal level. Throughout the municipalities collection is annual and lasts for one week. In 2002, the collection was organised in the entire Province between the 23rd and the 27th of April. Some municipalities offered a phone service for this collection. The site of collection is usually a designated place at a municipal container park, which is often managed directly by the BEP, or in a municipal deposit. Farmers must bring their waste films there and the collection is free of charge. Collection instructions specify that the accepted films are stretch silage films, frost-protective films and bunker silage films. The films must be dry, brushed, free of contaminants (for example, beet, forage, barbed wire, rope) and conditioned in bales of up to 20 kg. The stocking of films is not advised because they adsorb humidity and the BEP pays the recycler on the base of the weight.

In the Province, the collected quantities are growing each year : 75t in 1999, 150t in 2000, 250t in 2001 and 263t in 2002. Three-quarters of all film collected are stretch films. Every year, BEP launches a call for tender to select the company to be in charge of the transformation of the collected films.

The authorities responsible for collection, which may be the municipalities or the BEP, receive a grant from the Walloon Region's Government. For each collection, they receive a subsidy of up to € 1,250, which must cover the implementation of the temporary collection point, transport and treatment costs. Usually, reception costs are considered as nil or equivalent to the renting of the container. For equivalent distances , transportation costs also vary depending on the compaction of the films. If the subsidy is not sufficient to cover those costs, the administrator of the containers park pays the difference. The new bylaw will probably modify the financing scheme.

In addition, in 2002 the BEP paid € 60/t for the take back of the collected plastics. In 2001, the BEP paid € 22.5/t. The company that takes back the waste films must also wash and grind them, before the flakes can be sold on the recycled product market.

Farmers are informed of this system through the local press and by mail from the municipality. This mail also contains a form for the annual agricultural census. The information in the press is made via press releases, which have a very low cost. This year, following the press releases, which contained the collection instructions, the sites and the dates of collection, eight articles in the regional and professional newspapers were published. In addition BEP published a booklet, which contains the collection instructions as well as the collection places. For the year 2001, 5,000 booklets were published. They are distributed by the municipalities, which solicit them from the BEP. The BEP devoted one full time person, four days a year for the communication of this scheme.

AVEYRON (FRANCE)

Since 1999, a collection scheme for the agricultural plastic films has operated in the Department of Aveyron (South of France).
The General Council of the Aveyron initiated a convention between the different actors: SOPAVE and the Local Agricultural Syndicate. The Syndicate is responsible for coordinating collection, while SOPAVE undertakes to receive and recycle collected films. Initially planned for three years, the scheme has been extended to run throughout the fourth year (2002), with a renegotiation due.

The collection is organised twice a year - in April and October - during two or three weeks. The collection point may be a public or a private place (e.g. a farmyard). Plastic films are unloaded on a platform, then loaded onto a container with compaction, in order to reduce the volume for transportation.

As the collection scheme is not economically self-sufficient, the General Council gives a grant of € 38/t collected films. This grant is paid directly to SOPAVE, which organises transportation, on the basis of the collected quantities.

CHAPTER 6

How can local/regional authorities improve sorting and related activities?

Sorting activities

Waste plastics that arrive at a sorting facility originate from a number of different collection schemes (kerbside collection, neighbourhood containers and container parks) and waste streams (household, construction and demolition, industrial, commercial and agricultural).

The quality, quantity and the size of the collected waste plastics is variable and dependant on the collection scheme. Kerbside collection schemes and neighbourhood containers typically collect small waste plastics (generally plastic bottles), while the plastics collected in the containers parks are usually larger plastic items, such as pipes, windows, etc.

In general, the quality of the sorted materials will determine its price: a clean material (mono-material, mono-colour, low impurities) will be more valuable than a bad sorted material (multi-material, multi-coloured, with a high level of impurities). However, the responsible of the sorting facility must check with the buyer of the sorted materials what the quality requirements are, the required quantities, frequency of supply and what price each material, dependant on its quality will demand. A balance must be established between the additional effort and cost involved in sorting the material and the potential increase in value for a cleaner material.

Waste plastics sorting activities can be separated into two main categories; the sorting of small pieces like bottles and other household packaging, and the sorting of the bulky items, like pipes and films.

Small waste plastics

Small waste plastics fractions are usually packaging products collected with other materials (multi-material collections). However, in Italy schemes do exist that solely collect plastic bottles. A typical sorting chain for the mixed packaging waste has the following lay-out:

> Unloading of the collection trucks on a provisional stocking area => alimentation of conveyor with a loader => separation of the different fraction: metallic fraction (magnetic and Foucault current separators), light fraction (air classification), size separation (trommel and vibrating table), hand sorting on belt conveyors => baling => stocking

The sequence of the material separation varies from one sorting plant to another; some plants have equipment additional to those described above, whilst others do not. For more information on multi-material sorting plants, the report "Guide du centre de tri des déchets recyclables" by the Centre National du Recyclage (2002) is recommended.

In multi-material waste streams early separation of plastic films is recommended as their presence can clog equipment and interfere with the efficiency of the ferrous magnet separation system by wrapping around ferrous cans.

Plastic bottles are generally sorted by polymer, but they can be also sorted by colour; which method is used is dependant on the requirements of the market.

In traditional multi-material sorting plants, separating plastics into the various different categories is reliant on hand-sorting. It is therefore important to ensure a good formation for the workers and good job conditions. The key points to check are:

- appropriate working clothes
- acoustic insulation of the local where the workers are sorting
- installation of blowers to renew the air of the locals
- provision of adequate ventilation systems for employers
- adequate height of the conveyor and adequate disposition of the reception vats

In these sorting plants, the amount of material that can be processed (sorted) is around 80 kg per employee per hour. Automated sorting plants however, have a material throughput in the region of 1-2 tonnes per hour. Therefore, when large volumes of material are being collected, automated techniques may be more cost-effective. This technology can, to varying degrees, separate plastics based on the physical properties of the material[47]. One of two feed systems are typically used; single feed systems or binary (mass) feed systems. Single feed systems are able to identify and eject objects one-by-one with sensors able to identify multiple polymers. Binary systems however, are able to handle a higher throughput, but require at least one sensor for each type of polymer sorted.A whole host of technologies are available for separating high volumes of waste plastics at relatively low cost. The most commercially available of these technologies employ the use of a Near Infrared Detector (NIR) which is particularly suited for used in dirties MRF applications.

SORTechnology[48], developed by the DSD in Germany is an example of fully automated sorting plant. Mixed waste plastics is separated from the rest of the waste using air separators. The waste is then passed through a spectroscopic[49] identifier, which can identify up to ten different classes of plastic and additional optical devices can be incorporated which sort plastics by colour. Spectroscopic identifiers can also serve to separate plastics from non-plastics. Based on the information recorded, computerised air jets are activated which isolate the object to be separated. This kind of sorting plant can be coupled with a plastic preparation plant, which includes wet-mechanical preparation (washing) and processing technologies that reduce the sorted plastics into granulates.

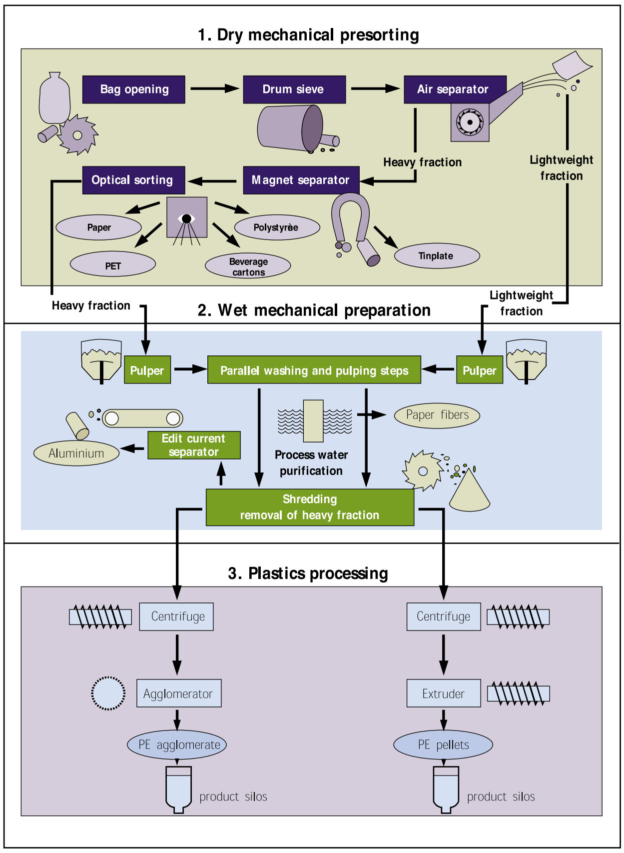
Following the implementation of this technology by DSD, SORTechnology has the potential to reduce the sorting cost of the lightweight packaging by up to 30 per cent and the cost of sorting and processing by up to 50 per cent.

47- See "Automatic identification and sorting of plastics from different waste streams – A status report" B. Krummenacher et al. – APME – November 1998 and the abstracts of "Identiplast – International Conference on the automatic identifications sorting and separations of plastics – Brussels 23rd and 24th April 2001" APME

48- http://www.systemtechnologie.com/en/index.php3?choice1=sortierung & choice2=sortierung

49- Spectroscopic method: method which permit the material identification through its specific pattern of light absorption or reflection. The equipment is made of a light source (infrared, X-ray, visible light,...) and a detector. The light is directed toward the object to identify and the detector analyse the transmitted light or the reflected light.

Figure 8 Sortec 3.1



Some precautions must be taken into account when employing automated plastic sorting equipment:

- if they permit high mass flow, a degree of sorting error still exists (contamination level of between 5 to 10 per cent maybe expected) and a visual checking system seems helpful. The future development of those technologies will probably increase their performance
- in general, the flow of material that reaches the automatic sorter must be free of contaminants such as paper, glass and metals
- as they represent an high capital investment, they must be used intensively to economically viable
- the maintenance of this equipment requires computer and electrical systems knowledge and maintenance skills

The cost of a binary feed system including a feed conveyor, a perforator/flattener, and two separation modules is approximately € 200,000 without accessories (compressed air, electrical box, support etc).

There are other technologies that have been developed for the separation of the plastics from a multi-material feed stream. The most commercially available of these include:

- *hydro-pulping:* A pulper - a large, agitated water tank - is used to separate paper. In the water, a rotor - similar to a blender - turns constantly. The rotor tears the composite materials apart and separates them into paper fibres, plastics, and aluminium-plastic composites.

- *centrifugal separation:* In a gravitational field, shredded plastics are sorted based on density. Polystyrene and PVC can largely be removed.

Among the other separation methods used for the plastic separation, floatation technologies are quite common. This is based on the differences in density between plastic polymers, but it can be difficult to separate plastics with similar density. The disadvantage of these methods however is that they are 'wet' sorting methods and therefore generate wastewater.

The sorting of plastic granulates has also improved in recent years as spectroscopic methods have developed. These processes are however, more the concern of reprocessors, although, they can influence the quality requirements at the exit of the sorting plant.

Bulky waste plastics

Large items of waste plastics will arrive at the sorting plant through the container parks or other waste collection services for bulky waste, such as the phone service offered by Lipor in Portugal. These items are usually large enough to be effectively and efficiently hand sorted at point of collection/ deposit. As such, little capital investment is required to sort these wastes, although public communication, awareness and education systems do need to be more developed.

The cleanliness of the sorting platform is important in order to avoid the contamination of the waste plastics by foreign material. For the films, the absence of dust and moisture is essential because their large surfaces can retain contaminants such as these more easily than the other wastes.

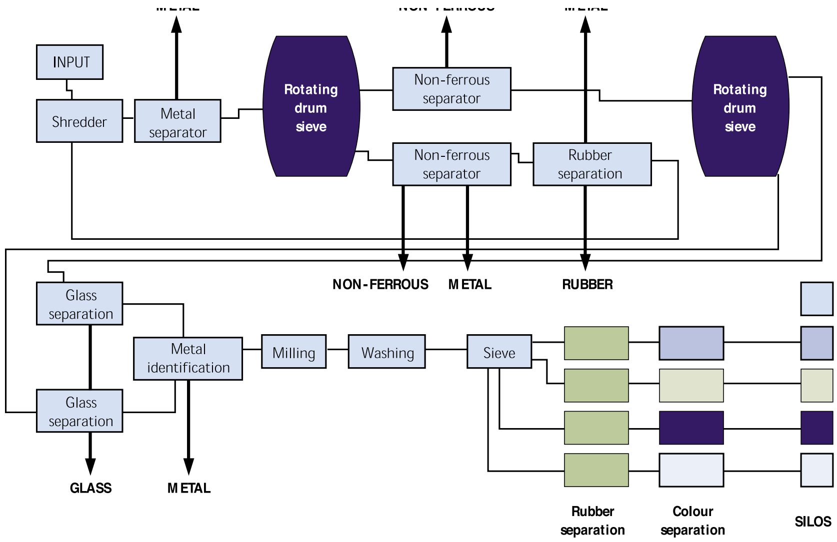
IMOG, the inter-municipal waste agency of the region of Kortrijk (Belgium) has adopted the following procedure for sorting mixed wastes from its container parks.
The wastes from the mixed bulky waste fraction are first manually sorted in a shed in order to separate big pieces from mono-material items and wood. Big pieces in PVC (tubes, roller shutter and frames) and flowerpots in PP are, among others, separated at this stage. The remaining fraction is grinded in pieces of about 40cm. Then, they pass through a magnetic separator and a sieve in order to separate out iron and the fine dusts. The residual fraction is sorted manually and, among others, pieces of PP and PVC are recuperated.

The procedure of LIPOR for the sorting of the plastics collected in the plastic skips from their container parks consist of a manual sorting of the big pieces on a clean and covered platform. The plastics are separated in function of the type of goods and stocked in skips.
More sophisticated methods can be used, like the near infrared spectroscopy methods. or example, DSM has developed a piece of equipment for the determination of the carpet face fibre type. There is a light-weight portable version (about 3 kg) which works on rechargeable battery. Its determination time is inferior to that of the fixed version at approximately 2 seconds; for the fixed version this is around 0.1 seconds. This equipment is able to recognise and distinguish between PA-6 (polyamide), PA-6,6, PP PET and wool.
The sorting plant for used carpets of CRE in Ginsheim-Gustavsburg is automated. The layout of this sorting plant is:
Reception of the unsorted carpets on a platform => alimentation of a belt conveyor with a loader => manual hanging of the carpets on automated conveyor system on rails => automatic identification of the carpets by infra-red => separation of the carpets in function of their polymer.

In Germany, VEKA Umwelttechnik has developed a fully automated plant for the processing of PVC windows. Complete windows are collected through container systems, (which include glass, rubber and metals as well as PVC) and dismantled through the process illustrated below. A special characteristic of this plant is that it includes colour separation.

In contrast, the FREI recycling system also involved in the recycling of PVC windows in Germany utilises a 'low-tech' processing system. Major sorting and separation (including colour) processes are done manually, with the mechanical unit restricted to shredding, grinding and metal separation.
The VEKA & FREI systems are now combined into the REWINDO scheme
(**http://www.rewindo.de**).

Figure 9 :
PVC windows recycling plant (VEKA Umwelttechnik)



Quality control

As already mentioned, the quality of the sorted plastics has a direct influence on its sale price. In order to maintain the desirable quality, routine quality control must be established. Samples of sorted materials should be analyzed in detail and the results compared with the requested quality. This enables streams that have sorting deficiencies to be identified. A more detailed analysis will identify the cause of a bad sorting: misunderstanding of the sorting instruction, equipment failing etc. The installation of video network can be helpful to identify the failures in the sorting chain.

Reduction of volume and storing sorted waste plastics

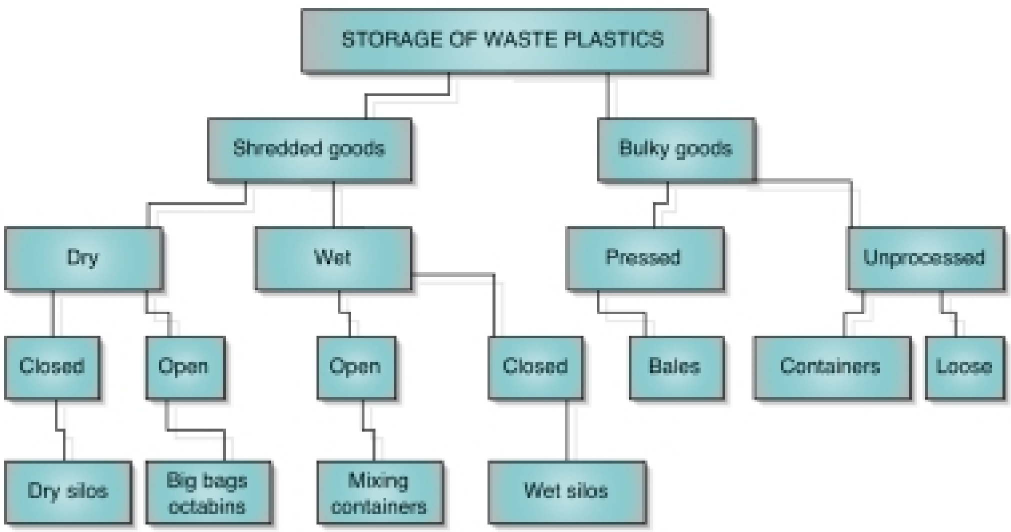
Sorted waste plastics can be bulky to transport and store. To make these activities more economical, some type of volume reduction process is necessary.

Baling

Baling is a suitable option for both films and bottles, providing a reduction in volume that aids storage and management of the waste plastics. The baler must be compatible with the baled materials and with the flow. Over-compaction may weld the waste together making it difficult to separate whilst under compacted bales will be unstable and difficult to stack. Most balers can be used for several materials, but adjustments may be necessary. The choice of baler strapping is also important; it must be strong enough to contain long-term baled material and particularly if the material is to be stored outdoors, be rust-resistant. Polyester strapping or stainless steel are commonly used.

For plastic bottles, previous perforation of the bottles improves the density of the bales.

Figure 10 :
Alternative waste plastics storage options



Source: RAPRA (2002)

Pre-shredding

For the big pieces of waste plastics, such as pipes or window frames, pre-shredding can be an interesting option in order to reduce the stocking area and the transportation costs. However, it is the responsibility of the sorting plant to evaluate the benefits of such equipment in relation with ts price. This type of equipment can also be helpful in reducing the volume of other waste. As for the baler, the two important points to check are the material compatibility and the outflow of materials to shred. It is important to note that shredded material, particularly mixed shredded plastics are not accepted by some markets because quality standards beyond common sorting processes are required and therefore assured applications for the shredded material should be investigated.

Compaction

EPS is 98 per cent air. Large areas and vehicle capacities are needed to stock and transport very small weights of material. It is possible to compact EPS and reduce its volume by a factor of 20 by means of a compactor. The price of this kind of equipment is around € 30 000. However, there are outlets for which the compaction of EPS is not desirable.

Storing sorted waste plastics

Rain does not affect the quality of plastics, however, UV light does degrade the physical and chemical structure of most plastics. The effect of UV degradation varies according to the virgin polymer, therefore if plastics are to be stored outside, they should be protected by tarpaulins or other UV-protective material. To avoid contamination by dust and dirt, plastics should be stored on clean concrete floors; storage of the material on pallets can also reduce contamination.

Table 20: Storability of plastics

Resin/Virgin Polymer	Maximum Unprotected Outdoor Storage Period
PET	6 months
HDPE	1 month
PVC	6 months
LDPE	1 month
PP	1 month
PS	6 months
PTFE	Indefinitely

Source: UN Environment Programme 2002[50]

Where plastics are to be stored indoors, fire-safety and prevention systems should be installed. Plastic is flammable and while it is difficult to ignite baled plastics, it is much easier for non-baled material. As such, these considerations must be integrated into the planning stages of storage areas.

50- Technical guidance for the identification and environmentally sound management of plastic wastes and for their disposal – United Nations Environment Programme 2002 (UNEP/CHW.6/21)

CHAPTER 7

How to promote and support the development of supply of and demand for recycled plastics?

The development of markets for any recycled material is often stimulated by a number of factors, including industry initiatives and policy drivers, rather than by an inherent need for the recyclate itself. In such an environment, maintaining the momentum of recycling schemes is highly difficult where mandatory targets are absent or where there are no clear short-term economic benefits. Where such schemes exist, and presently this concerns most waste plastics that are currently being recycled, maintaining efficient participation rates in local schemes and minimising contamination is dependant on the promotion and communication of local schemes to the public and private industry by L/RAs. This includes supporting scheme awareness campaigns with education and technical/ market data on local, regional and national recycling activities.

In addition to conventional communications through advertising, leafleting and road shows, there are a number of opportunities through which L/RAs can promote and develop local plastic recyclate markets:

- Develop partnerships with the Private Sector
- Promote waste exchanges and market places for plastics
- Introduce exhibitions for recycled product manufacturers
- Development of a green procurement policy: "Do-as-I-do"

Partnership with the private sector

COMMUNITY OF MUNICIPALITIES OF COURÇON

The Community of Municipalities of Courçon gathers together 14 municipalities and 9,625 inhabitants. Since 2002, the Community of Municipalities of Courçon have collected EPS through its unique container park.

The initiator is the firm ISOBOX TECHNOLOGIE, which is located at less than one kilometre of the container park and processes the EPS. ISOBOX TECHNOLOGIE proposed to the Community of Municipalities to place a container in their container park. As the citizens were asking for a specific collection of the EPS waste, the Community decided to accept it. ISOBOX TECHNOLOGIE built a wood shed in order to provide shelter for a container gift by ECO PSE.

The container park is open to the private individuals and to the small businesses. The employee of the container park checks the quality of the deposited EPS, which must be clean and white.

Each week, ISOBOX TECHNOLOGIE takes back the collected EPS to its facility. In this case, the collection cost is considered as equal to zero. The quantities weekly collected are between 4 to 6 m^3, equivalent to 14 - 24 kg (75 - 130 g/inh/y).

The collected EPS does not need additional sorting and has two destinations. It can be granulated to make new packaging; or it is compacted and sent to Holland to make seedling board.

The information about this collection scheme is spread through a municipal public display and a booklet, which explains the materials accepted at the container park and which is distributed to its visitors.

CO.RE.PLA

In Italy, an agreement with producer responsibility organisation CO.RE.PLA[51] was elaborated, in which Provinces committed to:

- promote the agreement for selective collection of waste plastics with public and private collectors
- promote the creation of a plant for recovery of heterogeneous plastic packaging waste
- foresee a financial contribution for the selective collection of the waste plastics
- promote the CO.RE.PLA campaign on the good management of plastic packaging
- promote transfer of the collected plastic packaging waste to recyclers identified by CO.RE.PLA.

In return, CO.RE.PLA agreed to:

- organise the transfer of collected plastic packaging waste to regional recyclers and guarantee monitoring of those operations
- promote information campaign meant to the producer, users and consumers for a better use and management of plastic packaging
- develop activities of formation for the personal of the public and private collection companies
- promote the collection in the private sector

There are also two awards developed. **"Ecological enterprise"** award prizes to enterprises with the best growth in the selective collection of waste plastics. There are two awards (€ 7,000) for enterprises with more than hundred workers, two (€ 5,000) for those with 15 - 100 workers, and two (€ 3,000) for those with less than 15 workers.

The **"Waste: Reduction and Recycle"** awards rewards the three best theses related to innovative marketing techniques for increasing recycling of packaging.

Promotion of waste exchanges/marketplaces

Once the plastic collected and sorted, it must be sold to processors. The market places permit to put in relation sellers and buyers. Some magazines are informing about the market trends and about potential buyers like "Recyclage et Récupération Magazine", "Recycling International", "Recycling Magazine"...

Other magazines like "Europäischer Wirtschaftsdienst" or the "Bourse Belge des Déchets" give the current price of the market and publish offers and demands advertisement for sorted products. The "Bourse Belge des Déchets" is a public initiative.

For EuPR (European Plastics Recyclers), it is necessary to put in direct contact the sellers and the buyers of sorted plastics. For the year 2003, EuPR would spread to the local authorities a list of the regional plastic recyclers. This list would help the local authorities to find outlet for the sorted plastics and will permit a direct exchange on the quality requirement for the sorted plastic.

51- CO.RE.PLA. : Consorzio Nazionale per la Raccolta, il Riciclaggio e il Recupero dei Rifiuti di Imballggio in Plastica (National Consortium for the collection, the recycling and the recuperation of the plastic waste packaging)

Usually, the national plastic (transformers) associations have a list with the plastic recyclers and the type of plastics accepted.

During the last years, the number of virtual market places is growing.

The following internet sites offer different examples:

- http://www.wastechange.com/
- http://www.recycle.de/
- http://www.eupc.org
- http://www.ccip.fr/bourse-des-dechets/
- http://www.wastexchange.co.uk/welcome.htm
- http://www.wrap.org.uk/
- http://www.reststoffenbeurs.nl
- http://www.waste2b.com/france/loc/html/home/
- http://cig.bre.co.uk/connet/mie/

Development of Green Procurement Policies

Public procurement in the EU represents around 14 per cent of GDP, that is equivalent to around € 1,000 billion per annum. The attitudes of public entities, such as L/RAs can therefore have a considerable impact on the development of the secondary product markets, especially in the case of plastics where these markets are still emerging. L/RAs have a responsibility and vested interest to integrate green recycled products into their annual purchasing budget. By adopting such policies L/RAs are able to project their environmental consciousness and demonstrate to local industry and commerce on how recycled products can be economically viable and integrated into local purchasing decisions. From this experience, L/RAs will have practical knowledge on the products and suppliers available at a local and national level and can disseminate this information to businesses. By supporting these markets, L/RAs are effectively ensuring a continuing market is available for the recyclate, of which they are and will continue to be a major provider.

There are no European legislative barriers to the purchasing decisions of public institutions, providing that the freedoms of the European Union and competition are respected.

ICLEI[52] reviewed nine countries of the EU in order to compare their attitude in relation to green procurement policies. None of the countries studied prohibited green procurement, however in only three countries (Denmark, Germany and Austria) is green purchasing legally required, whilst in only two countries (Denmark and Sweden) do environmental criteria have the same weight as other criteria in tender evaluations processes.

In five of the studied countries, the municipalities have the autonomy to decide which are the prevailing criteria for tender evaluation and have then the possibility to include green criteria.

52- " Green Purchasing Good Practice Guide " G. Plas et C. Erdmenger – ICLEI - 2000

Aspects of national legislation									
	Greener purchasing is			The environmental criteria are		Prevailing criteria for tender evaluation			
	Legally required	Advised	Allowed	A selection criteria	Part of the technical specifications	Autonomy of municipality in choice	Environmental. criteria have same weight as other	Functional need of the product	Economic efficiency of the product
Denmark	•		•			•			
Germany	•		•						•
The Netherlands		•		•					
France			•		•			•	
United Kingdom			•	•	•	•			
Sweden		•		•	•	•	•	•	•
Austria	•				•	•			
Finland			•	•		•			
Italy			•	•	•	•			

Source: ICLEI 2000

Why should L/RAs buy green?

L/RAs, which have developed green purchasing policies, have put forward the following arguments as to why these policies are a necessary element of purchasing policy:

- It aids and support the development of local sustainable development policies
- it reduces the environmental impacts of waste disposal, through landfill or incineration
- they promote the development of products and markets with reduced environmental impacts
- it promotes the environmental responsibility of L/RAs and provides a model of environmental responsibility for public and private sectors.

How to buy green?

The Catalonian EPA[53] identified five steps that the administration must follow for the implementation of a green purchasing policy.

1. Define and approve the political objectives

define a green purchasing policy
define objectives and goals
develop norms
integrate the green purchasing in a sustainable development policy

2. Analyse the initial situation

identify the circuit of purchasing
list the purchased products and services and their suppliers

3. Promote the formation, the communication and the participation between the different actors: suppliers, purchasers, users and administrators

4. Decide the environmental criteria

define clearly the environmental criteria and the decision process
elaborate a database of homologated suppliers
elaborate a database with the product and services to purchase
elaborate a database with the products and services to avoid
define the procedures of control

5. Take political actions: cooperate and establish supra-regional cooperation

Exchange the information between administrations
Favour the union between the administration in order to:

- *Have more influence on the market*
- *Promote the development of innovative markets*
- *Promote the information, the motivation and the political influence*
- *Debate and define common criteria*
- *Cooperate at national and European level in the legislative and normative aspects*

When any L/RA launches a call for tender, the "green specifications" must appear clearly in it. They must respect the principle of free market as defined in the EU treaties. The criteria address the:

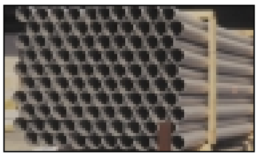
- production process
- use of specified raw materials
- use of the performances such as defined e.g. by the ecolabels (but it is not allowed to restrict public purchasing exclusively to eco-labelled products)
- requirement for higher performances than those laid down in legislation or standard

The attribution criteria may also include a green constituent as the integration of the whole life costs when those are borne by the purchaser as the costs of use, the costs of recycling or disposal.

53- " Guia de Compres Públiques Ambientalment Correctes " - Departament de Medi Ambient – Generalitat de Catalunya - 2000

For the implementation of a green procurement policy, the reading of "GRIP Purchasing – a Guide to an Environmentally Efficient Purchasing Practice"[54] is recommended.
In the USA, the federal agencies must establish affirmative procurement programmes for products with recovered content and other environmentally preferable products. In order to respect those obligations, the National Park Service, Hazardous Waste Management & Pollution Prevention Team of Washington established a list of products to purchase preferentially. This list compiles own data and a list published by EPA for the implementation of the federal green purchasing policy. Part of this list, corresponding to the goods containing recovered plastics, is reproduced below. If this list is non-exhaustive and corresponds to the American way of consumption and recycling, it gives an idea of the type of goods containing recycled plastics that can be purchased by public entities. Only the goods containing recovered plastic are presented below.

Construction products



floor tiles
shower and restroom dividers/partitions
patio blocks
non-fibreglass building insulation
acoustic ceiling tile
recovered plastic lumber
docks and piers
pipes

Transportation products

parking stops
chanelisers, delineators and flexible delineators
traffic barricades
traffic cones
speed bumps
signs

Park and recreation products

playground surfaces
lawn and garden edging
plastic snow and sand fencing
park benches and picnic tables
playground equipment and bike racks
signs and signposts

Landscaping products

garden and soaker hose
lawn and garden edging
hose reels
wheel burrows, gardening and landscaping tools

Office products

plastic envelops
office waste and recycling containers
plastic desktop accessories
remanufactured toner cartridges
binders
plastic bags
pens and pencils
erasable and cork boards

Miscellaneous Products

pallets
recycling bins and trash bins
bubble wrap and other packaging materials

54- May be ordered from: GRIP center – Oslo – Norway- Tel: +47 22 57 36 00 – Fax: +47 22 68 87 53

HOW TO FIND RECYCLED PRODUCTS?

Once a recycled products policy is established, the problem for the L/RA is to find the recycled products. This finding seems a common obstacle encountered by the L/RA. Other common obstacle is that a lot of products contain yet recycled plastics, but for commercial reasons the manufacturers do not desire mention it.

The following recommendations can be helpful to identify the right suppliers:

- ask current suppliers if they supply or can supply recycled products
- examine current purchasing specifications that prevent the use of recycled materials and modify them if possible in order to permit the use of recycled plastics
- ask for samples and test them
- look at product directories, for some specify recycled products
- ask national plastic associations (general, converters and recyclers) a list of the companies which use recycled granulates with a description of the kind of products manufactured
- look in existing catalogues [55] and databases[56] of recycled products
- participate in a network of L/RA on green purchasing
- exchange databases of suppliers with other L/RA

55- For example: "Favoriser le marché des produits du recyclage – Inventaire de catalogues européens de produits recyclés" – ACRR – June 2002
56- Examples of internet databases: http://www.cycleplast.com/en/index.php3, http://recycledproducts.plasticsresource.com/,

CHAPTER 8

The costs and tools to promote plastics recycling

The Costs of Recycling

Recycling costs money and there are four main activities through which these costs are incurred:

- selective collection and sorting
- transport
- processing, including pre-treatment
- disposal of rejects from sorting

However, recycling can also generate revenues from the sale of the collected material and savings through avoided disposal costs and it is balance between costs and revenue that determines the economic cost-benefits of a scheme.

There are factors outside the control of L/RAs that can influence this balance, such as the market price of virgin materials. Yet L/RAs can optimise economic expenditure on recycling schemes by targeting materials identified in waste characterisation studies and selecting collection, sorting and processing methods and technologies that best suit their individual local and regional characteristics.

Historically, the costs of recycling have exceeded the revenues generated by processed plastics. However, some materials and waste flows can be seen to be profitable, while many more need only some support by external sources of funding. This "financing need" corresponds to the amount of financial injections necessary to render recycling profitable from a recycler's point of view.

A TNO report, commissioned by APME, identified a number of specific plastic flows that under current practices are profitable or need only partial support. These included:

- Distribution and commercial films and crates
- PET and HDPE bottles
- EPS packaging
- PVC pipes and Windows
- Agricultural films
- Automotive bumpers

This situation however, only reflects current practice; those flows that are not seen to be profitable at the moment may well be so in the future as new sorting and processing technologies emerge.

General Trends in Collection and Processing Costs

While it is beyond the scope of this study to collate and analyse costs of all the various options of waste plastics management, it is interesting to consider the likely evolution of costs and revenues in the future.

Selective Collection Costs

The costs of selective collection systems currently ranges from between € 50/t (PVC windows) to € 800/t (EPS). Improvements in the performance of selective collection schemes will enable the costs of these systems to decrease. However, cost differences between schemes (kerbside collection, neighbourhood containers and container parks) and the containment methods will still exist.

Sorting Costs

These currently range from € 50/t (from the Lipor scheme) to around € 200/t (HDPE bottles). Similarly to collection costs, improvements in current technologies, and development in new automated technologies will decrease costs. It is estimated by the DSD for example, that the SORTEC Technology will reduce sorting cost by around 30 per cent in the coming years.

Transportation Costs

These are highly dependant on local conditions, but are quoted at around € 27 – 45/t (with the exception of EPS, however, no disaggregated data is available for this waste plastics). It is likely that transportation costs will increase in the future, although the increased use of compaction vehicles may help stabilise these costs.

Pre-treatment and recycling costs

These are very much application-dependant.

Disposal of Rejects

Currently estimated at around € 10-220/t the cost of disposing of rejects is likely to increase as landfill and incineration taxes increase. However, as collection, sorting and processing technologies become more efficient, it would be expected that the quantity of reject material decreases.

Revenues from Sorted Plastics

Revenues generated from sorted plastics is dependant on the balance between costs, the price of recycled plastics and the avoided costs of disposal. This can range from between € 150/t to – € 60/t (i.e. a loss). While the amount of revenue generated is dependant on the wastes targeted and the collection and processing methods used, it is also influenced by the market price of recycled plastic and that of virgin plastic. This varies with the oil market price, which has dramatically increased in recent years. Current market prices for recycled plastic bottles and films can be found at: http://www.letsrecycle.com/plastics/prices/pricesarc01.htm

Avoided Disposal Costs

The current costs of avoided waste disposal, which ranges between € 10–220/t, are highly dependant on the levels of national as well as European taxation. Avoided disposal costs of between € 10-220/t can be expected and these are likely to increase with progress towards landfill and incineration directive targets.

In conclusion, plastic recycling costs can range between € 100-1600/t, yet savings and revenues can reduce this by € 50–370 /t. The balance between costs and revenue is dependant on the waste streams targeted and the methods of collection and processing employed.

For some waste plastics, a shortfall of between -€270 and 1,650 per tonne can exist, meaning that extra financing is needed to support plastic recycling for these flows. This situation may not persist in the future as new technologies are employed and the pricing of recycled plastics becomes more favourable compared to virgin material. However, while plastic recycling may be profitable in some cases, in other the need for financial support will remain important.

Costing Case Studies

It is difficult to evaluate and compare the costs of recycling between countries because recycling systems need to reflect local and national circumstances and these may not be directly comparable. In addition, published data is often issued alongside a number of caveats or is accompanied with little detail on the activities encompassed by the figures. Given this, a number of case studies are presented for different waste plastics, detailing the costs involved on a local and national scale for collection, sorting and processing activities. These do not provide a guide of the costs that can be expected on a universal scale as each scheme must be developed to reflect local and regional conditions. However, they may provide an insight as to where the main costs in collecting these wastes will arise.

Plastic Bottles

PET and HDPE are the primary targeted polymers of plastic bottle collection schemes. The cost of collection associated with these materials is intrinsically linked to existing recycling schemes in place within L/RAs; kerbside collection, neighbourhood container and container parks. These show considerable variation between countries and extracting costs for plastics from other collected recyclables is often difficult from aggregated municipal waste data.

Table 21: Cost of Activities (€/tonne)

	Collection	Sorting	Processing	Transport	TOTAL
Fost-Plus (BE) HDPE bottles	186 - 190	195 - 200			
Fost-Plus (BE) PET Bottles	186 - 190	195 - 200			
RECOUP (UK)	188	135		27	
PETCORE EU Average	350	150	225		350 - 800

Collection costs remain a function of the types of schemes involved, the materials targeted and the collection frequency. Sorting costs however will decrease as new technologies emerge.

Agricultural Films

Agricultural films are a seasonal waste flow and collection systems need to reflect this seasonal supply and collection points can be temporary sites. The Plastretur system in Norway is supplemented by fees paid by the producers of agricultural films; amounting to around € 210/ tonne, which is set to reflect the balance between the costs of collection and recycling.

In the Plastretur system, the greatest costs concern the processing of collected material, reflecting the washing and residual disposal activities necessary to remove contaminants, which can be considerable.

The costs of such activities can be minimised by requesting and accepting only certain agricultural films and only those films which are brushed and dried.

Table 22: Cost of Activities (€/tonne)

	Collection	Sorting	Processing	Transport	TOTAL
BEP					142
Plastretur (NOR)	120		220		

PVC Pipes

The pipe recycling scheme organised by FKS in The Netherlands is based on a neighbourhood and container park collection system. PVC pipes are accepted along with PE and PP and therefore processing costs includes the manual sorting of the polymer and large contaminant removal.

Table 23: Cost of Activities (€/tonne)

	Collection	Sorting	Processing	Transport	TOTAL
FKS (NL)	100		500		

Processing costs are considered to be the most expensive part the recycling process, although micronisation processes (estimated at € 150/t) are included in this figure. There is considerable tonnages of PVC in applications that have yet to reach end of life and technological developments is likely to reduce the processing costs of these products. This is application-dependant. For some, collection and sorting costs can be much higher than the actual processing costs.

Distribution and Commercial Films

Commercial and distribution films are typically sourced from large retailing and industrial outlets, which provide large quantities of relatively clean, homogenous waste and therefore makes collections and sorting costs less expensive than collecting form a diffuse source, multi-polymer/product sources.

Table 24: Cost of Activities (€/tonne)

	Collection	Sorting	Processing	Transport	TOTAL
Lipor	140	50			
Netherlands	450 - 650		275 - 375		
UK	90 - 110		275 - 350		

Material cleanliness has the greatest impact on processing costs; the dirtier the material, the more washing is needed and the greater the amount of residues that are produced.

EPS

EPS has a bulk density of between 10 – 80 kg/m^3. The high volume and low weight nature of this waste has a significant impact on the overall costs of EPS recycling, through high collection and transportation costs. With a large proportion of available waste arising from large retailers and producers, sorted at source, reverse logistics, i.e. filling returning lorries with EPS waste can help reduce these costs, as can co-collecting separated waste with other industrial or trade recyclables and densification.

Table 25: Cost of Activities (€/tonne)

	Collection	Sorting	Processing	Transport	TOTAL
IMOG					330
Plastretur (NOR)	300				
Other EU	200 - 250				300 - 1,700

Only clean EPS is usually requested and simple processing techniques are used to produce a granular, EPS product; processing costs of € 100 have been reported. The cost range detailed, € 300 – 1,700 is not typical of L/RA collection systems. It also reflects private collection initiatives which may have to establish independent collection systems, however, the overall cost of the system is highly influenced by the collection method employed.

Legal and Economic Instruments to Promote Waste plastics Recycling

Some waste plastics are currently economic to recycle, however others are not, although they maybe in the future or need to be targeted now in order to meet national and European targets. For such waste plastics, support is needed to stimulate the development of recycling activities and this can be provided by the adoption and implementation of a number of economic and/or regulatory instruments.

The most important of these instruments are reviewed below. However, these instruments must be introduced with caution, because they can be counter-productive if they are not justified, explained and monitored. For example, increasing the costs of landfill disposal through taxes can stimulate illegal dumping.

A combination of the different instruments is often more effective than the introduction of one instrument alone. For example, the ban of landfilling can be coupled with the introduction of a subsidy for sorting activities.

Regulatory instruments

Regulatory instruments are strong obligatory instruments, which impose legal obligations in order to achieve a level of environmental protection/ quality. These typically concern restrictions on activities which are considered to be detrimental to the environment. For such measure to be successful, they must meet a number of criteria.

The first is that they should be accepted by the public and the actors concerned, which must be convinced that the new rules will lead to a better situation. Education and increasing awareness of the issued targeted are also necessary if this condition is to be met.

The second condition is the effectiveness of the control and monitoring of the new rules. If the controls are poor and/or the infringement of the rules rarely generates sanctions and/or the sanctions are not credible, the new rules will probably not be effective. This is also dependant on the availability of facilities which enables regulatory instruments to be monitored and enforced.

Ban of landfilling and/or incineration

The landfill and incineration directives impose controls on the amounts of waste that can be disposed through traditional measures. Some countries have however also introduced bans on waste disposal through traditional methods. By the introduction of such a ban waste generators are obliged find alternative ways to manage there waste, i.e. through reuse or recycling. However, it is difficult to apply and control such restrictions for household waste and these limitations are usually only applied for commercial and industrial wastes.

France

In France, Decree N° 94-609 forces holders of industrial and commercial packaging waste to sort and recover packaging. The only recovery options are reuse, material recovery (recycling) and energy recovery. Landfilling and incineration without energy recovery is prohibited, except for treated wastes.

The Netherlands

In The Netherlands, the production of construction and demolition waste is estimated at 15 million tonnes per annum , ie 940 kg/inh/year or the volume equivalent to a six-lane speedway of 250 km length, 20 metres wide and 2 metres thick. In order to reduce this huge amount of waste, the Dutch government introduced, in April 1997, a landfill ban on reusable or burnable C&D waste. The objective of this ban is to promote material separation and to maintain the materials into the C&D cycle. This ban includes PVC and PE films. Two factors weaken the enforcement of this ban. Firstly, residues can be landfilled if they contain less than 12 per cent of recyclable materials. Secondly, since the Provinces define the landfill charges and control the landfills, there are differences between the provinces in how the landfill ban is enforced. However, as result of this ban, alongside other measures, 90 per cent of C&D waste is recycled in the Netherlands.

Germany

Mixed construction and demolition waste may not be landfilled after 2005.

Obligatory environmental or planning measures

The waste plans are obligatory in all the EU countries. They permit the integration of legal obligations but they can also includes their own objectives, such as the implementation of specific collection schemes for certain type of waste plastics, recycling goals, prevention policies for defined sectors etc.

France: The Waste Plan of the Department of Aveyron

The "Departmental Plan of Household and Assimilated Waste Elimination" from the Department of Aveyron in 2001 established several objectives concerning the collection of the waste plastics. For household waste, a target for the collection of 5 kg of plastics/inh/year has been set, from which 4.3 kg/inh/year must be recovered. The preferential way of recovery must be recycling.

For bulky waste, the Plan recommends reuse, repair or recovery. Containers parks will be equipped with specific containers for the collection of the agricultural films. They can also be collected through existing collection schemes.

Germany: Ordinance on the Management of Municipal Wastes of Commercial Origin and Certain Construction and Demolition Waste (19/6/02)[57]

This is piece of national legislation that has a direct influence on waste plastics. The Ordinance applies to producers and holders of municipal wastes of commercial origin and of certain construction and demolition waste, and to operators of pre-treatment facilities in which those wastes are treated.

Commercial waste

As with household waste, certain materials from municipal wastes of commercial origin (paper and cardboard, glass, plastics, metals, biodegradable wastes from kitchens, canteens, parks, gardens and markets) should be consigned to a recovery operation after separate collection. It is permissible to collect these fractions together, as long as subsequent sorting permits the separation into different fractions with a quality equivalent to that yielded by source separation. Where separation as described is not technically possible or economically reasonable, the mixed municipal waste can be consigned to a recovery operation.

Construction and demolition (C&D) waste

Where they are produced separately, certain C&D wastes (glass, plastics, metals, concrete, bricks, tiles and ceramics) must be consigned to a recovery operation as separate fractions. Again, separation can be undertaken in a sorting plant provided that the quality is the same as for source separation. Derogation is possible for those wastes which cannot be separated for technical or economical reasons.

A pre-treatment facility is defined as an installation in which mixed wastes undergo pre-treatment before further material or energy recovery. It must achieve a recovery quota of at least 85 per cent from 2005. There are no specific targets set for individual materials.

Strengthening environmental controls

Legislation is only effective if the system is policed and enforcement correctly controlled. For example, in Germany and The Netherlands similar legislation on the landfilling of C&D waste exists, where only the fraction of waste that can not be reused or recycled can be landfilled, However, the different control measures imposed by each country has resulted in different recycling rates. Only the fraction that cannot be re-used or recycled can be landfilled. In Germany, which represents 55 per cent of the PVC roofing market in Western Europe and where there are strict landfill controls, the Edelweiss programme is underway. ESWA (EuPC sectoral association for roofing membranes) started a study in 2002 on the Collection and Recycling of end-of-life PVC roofing. This study looked into projecting theoretical waste streams through 2015. This made it possible to evaluate the conditions for further development of recycling operations at the premises of AfDR during the transition years 2003 and 2004. (AfDR, or Arbeitsgemeinschaft für PVCDachbahnen- Recycling, is a mechanical cryogenic recycling unit located in Germany. It is owned and operated by ESWA members since 1994).

The present recycling capacity will not be sufficient to implement the industry's Voluntary Commitment after 2005. ESWA is currently examining three possible routes for boosting capacity: an investment into added AfDR capacity, or agreement with partners on two different solvent-based recycling units by 2005.

57- From "Background paper – Environmentally sound recovery of municipal wastes of commercial origin and Certain Construction and Demolition Wastes" - German EPA http://www.bmu.de/english/download/waste/files/gewerbeabfallv_hintergrund_engl.pdf

In contrast, Dutch pipe recyclers could increase pipe recycling if associated landfill controls were improved.

Economic instruments

Economic instruments are financial tools which are softer in their application than legislative instruments, although they can be very effective in changing behaviour. Essentially, they provide an economic incentive to change current management practices. This maybe either through increasing the costs of traditional disposal methods or financing collection and recycling activities and thereby making plastic collection and processing more economically attractive.

Landfilling or incineration costs or tax

In an open economy, the cost of the different ways of disposal have a considerable impact on the decision to recycle those wastes for which the sale of the sorted materials does not cover the cost of collection and sorting. The costs of landfilling and incineration have increased in recent years as new obligations have been introduced, i.e. the adoption of the landfill and incineration Directives.

Belgium: The example of Recyhoc for C&D wastes

Recyhoc SA is responsible for the C&D waste in the Walloon Region. It applies differential tax rates according to the composition of the waste, see below.

The non-inert fraction include wood, plastics, paper, cardboard, gypsum, non-ferrous metals, carpets, mattresses, window frames, tyres and insulating materials.

Table 26: Recyhoc landfill taxes (€/T at April 2002, excluding VAT 21 per cent)

Mixed inert	Non-reinforced concrete	Reinforced concrete	Asphalt	Mixed inert with<20 percent noninert	Mixed inert with<40 percent noninert	Mixed inert with<60 percent noninert
7.45	3.00	6.20	5.00	25.00	42.00	62.00

Subsidies for collection (and sorting)

Subsidies are a controversial instrument. Its supporters claim that they are necessary in order for recycling schemes to achieve an economic balance, whilst its detractors argue that they favour uneconomic recycling schemes. The use of subsides should only be considered where economic activities which are capable of producing positive 'externalities' require addition support, otherwise they may distort pricing mechanisms and lead to the uneconomic allocation of resources.

France: The example of the Department of Aveyron

Since 1999, the Department of Aveyron has had in place a collection scheme for the agricultural plastic films.

The General Council of the Aveyron initiate a partnership between the different actors: SOPAVE and the Local Agricultural Syndicate.

The Syndicate has the responsibility for coordinating thecollection of plastics, whilst SOPAVE undertakes to receive and recycle the collected films. The scheme was initially planned to last three years, but as of 2002, the scheme was still in operation. A renegotiation will occur next year. Collection is organized twice a year, in April and October during two or three weeks. The collection point can be a public or a private place (e.g. a farm yard). The plastic films are unloaded onto a platform where they are then loaded into a container with compactor to reduce the volume for transportation.

As the collection scheme is not economically self-sufficient, the General Council gives a grant of € 38/t collected films to support it. This grant must cover transport costs, but it covers only two-thirds of them. It is paid directly to the SOPAVE, which organises transportation, on the basis of collected quantities.

Tax credits for recycling stakeholders

The city of San Jose (California, USA) requires contractors to pay a construction waste fee as part of the building permit process. The fee is returned to contractors that can demonstrate on-site reuse of materials or provide receipts for materials from recycling facilities.

Producer responsibility

> "Extended producer responsibility is an environmental protection principle to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product. The extended producer responsibility is implemented through administrative, economic and informative instruments. The composition of these instruments determines the precise form of the extended producer responsibility."[58]

Producer responsibility is widespread for municipal packaging wastes, but is also applied to other waste streams.

Belgium: Wallonia decree on takeback

A governmental decree of the Belgian Walloon Region (25/04/2002) on the take-back obligation for certain wastes illustrates a local and regional approach to the management of these wastes.

This decree gives a sense of responsibility to the person who puts on the market, products including agricultural plastics, vehicles and E&EE. Those responsible should either organise the collection themselves or finance it through a certified organisation. They may also conclude a convention or agreement with the Region.

The decree fixes the following objectives:

- for plastics from E&EE, reuse and recycling rates must reach 20 per cent.
- for agricultural plastics, recycling must reach 20 per cent by 2003 and 50 per cent by 2005
- for ELVs, there are no specific goals for plastics, but there is an overall reuse and recycling rate target of 80 per cent by 2006[59]

58- Thomas Lindhqvist - Swedish Ministry of the Environment in 1990
59- Those goals are the same than those defined by the EU Directive on ELV (Directive 2000/53/CE)

Spain: Decree 104/2000 of the Government of Andalusia

Andalusia is a region of Spain where plastics are used intensively for agriculture. Inappropriate management of agricultural film plastics (for example open burning or dumping) can damage surface and ground waters and impairs the natural beauty of the landscape. The Andalusian decree aims to avoid these problems.

The decree obliges manufacturers, wholesalers and retailers of agricultural plastics to participate in Management Groups, which guarantee the correct recovery and elimination of agricultural plastics wastes. The groups must finance of these activities and must also ensure correct identification of plastics used in agriculture. Holders of any waste plastics which are not supervised by a Management Group must fulfil the same obligations. The decree does not specify any recycling, reuse or recovery objectives.

Norway: Plastretur

In Norway, the **Plastretur** system covers packaging and agricultural films. The Plastretur system is an initiative of the plastic industry, the packers and fillers and the retail trade sector. This initiative is born from a project of the Norwegian Government to introduce an eco-tax to the packaging. In view of this legislation and its associated costs, the business and the industrial community decided to work on the basis of a voluntary agreement. The agreement with the government fixed a recovery rate of 80 per cent and a recycling rate of minimum 30 per cent for the year 2001. If Plastretur does not fulfil the agreement, the government maintains the possibility to legislate. At the end 2000, the recovery rate was 78 per cent (19 per cent recycled and 59 per cent energy recovered). The covenant was renegotiated during the year 2002.

Plastretur ensures that plastic packaging, agricultural films and construction films are collected and recovered. The scheme is funded by a licence of €210/t for all the plastics included in the framework of the agreement. The Plastics are collected by the municipalities, professional collectors, local farmers. Collectors are paid €175/t by the recyclers, which receive the contribution from Plastretur. The contribution to the collectors is € 202/t for films, € 240/t for PP bags, and € 54/t for the fraction which is energetically recovered.

Voluntary agreements

A voluntary agreement or commitment is a voluntary action developed by socio-economic groups to face certain problems. The voluntary agreement can be a spontaneous action from a sector without any form of pressure or a spontaneous action under the public opinion or legislative pressure.

The voluntary agreement can be controlled or by the concerned sector itself, or by an independent audit or by the public authority. If the goals of the voluntary agreement are not reached, the penalties scheme goes from any sanction to restrictive legislative measures.

Denmark: Voluntary agreements to planning measures

In 1991, an agreement was concluded between the Danish Ministry of Environment and various private associations to reduce the amounts of PVC waste reaching incineration plants by cutting the use of PVC in packaging and other products, and by increasing recycling of plastics in construction. The objective of the PVC agreement was to reduce the amount of PVC in packaging by 85 per cent of the amount consumed in 1987 by 2000. To encourage this shift, a tax on PVC films (ACT 91) was introduced to provide a financial incentive to change to alternative materials.

Additional targets were placed on the consumption of other PVC products, however these did not take into consideration the growth of new PVC goods.

A PVC tax was introduced in Denmark in 2000, charged at a rate of DKr2 (€ 0.27) per kg on hard PVC and about DKr7.50 per kg for phthalate-softened PVC (precise rates depend on the amount of phthalates contained).

In November 2003, the Danish Ministry of Taxation introduced draft legislation to lift taxation on all rigid PVC products. Among rigid PVC products only pipes, windows and doors are presently exempted from this environmental tax.

The changes are proposed because collection and mechanical recycling of a number of rigid PVC products (including gutters, roofing, venetian blinds and cable trays) is now a possibility; the original aim of the tax on these products is no longer relevant.

The Netherlands: FKS, a voluntary agreement for pipes collection and recycling

The Danish case described above shows limitations of the voluntary agreement, whilst FKS shows how a voluntary agreement can be effective.

Since 1991, FKS has organised a national collection scheme for plastic pipes in the Netherlands. FKS is the association of the Dutch plastic pipes industry, which has existed since 1973. The objective of the industry was to offer a complete environmental friendly service for pipes users, from the factory to the grave, through a voluntary commitment.

In 2001, FKS collected 3,500 tonnes of which 5 per cent was refuse; this compares to 2000, where 3,000 tonnes was collected of which, 2,500 tonnes (~83 per cent) were PVC pipes. FKS does not make the differentiation between PP and PE pipes and all collected pipe waste is post-consumer waste. It is difficult to compare PVC waste arisings to consumption in The Netherlands (~110,000 tonnes) because plastic pipes, and especially PVC pipes have a long application life, with a life potential of up to 100 years.

The objective of FKS is to collect 50 per cent of collectable pipes by the year 2005 into the framework of the voluntary agreement of the European Plastics Pipe and Fitting Association (TEPPFA).

There are two collection schemes offered by FKS. For the small quantities, a network of containers is available. The containers are located in 57 pipes selling places, which cover all the Netherlands. The deposit of plastic pipes is free.

For large quantities from C&D works, FKS offers a service of container renting and used plastic pipes purchase. The 30m containers are directly solicited at the FKS Secretariat. The fees are € 124.79 for the transportation costs of the container and € 2.25 by day for the renting of it. In return, the tenant of the container receive € 0.0454/kilo of clean pipes. The average quantities by container is 2 tons, for which € 90 are paid. This system permits to avoid high disposal costs. In comparison, the average incineration costs are about € 100/t in the Netherlands.

Vinyl 2010

Vinyl 2010 – The Voluntary Commitment of the PVC industry is a ten year voluntary commitment. It includes a strict implementation monitoring process through certified annual reports.

A formal legal entity called Vinyl 2010 was created, gathering the whole PVC industry chain and open to a partnership with all interested parties. The PVC industry will provide a financial support scheme, in particular for new technologies and recycling schemes, allowing up to 250 million euro of financial contribution over the 10 year programme.

Vinyl 2010 includes the following key actions and commitments:

- compliance to ECVM Charters regarding PVC production emission standards
- a plan for full replacement of lead stabilisers by 2015, in addition to the replacement of cadmium stabilisers (achieved in March 2001)
- the recycling in 2010 of 200,000 tons of post-consumer PVC waste
- the recycling of 50 per cent of the collectable available PVC waste for windows profiles, pipes, fittings and roofing membranes in 2005, and flooring in 2008
- a research and development programme on new recycling and recovery technologies, including feedstock recycling and solvent-based technology
- the implementation of a social charter signed with the European Mine, Chemical and Energy Worker's Federation (EMCEF) to develop social dialogue, training, health, safety and environmental standards, including transfer to EU accession countries
- a partnership with local authorities within the ACRR for the promotion of best-practices and pilot recycling schemes at local level.

For more information, see Vinyl2010's website at: www.vinyl2010.org

ANNEX 1

A review of life cycle analysis (LCA) studies on plastic recycling

The different studies on the LCA of waste plastics show a range of diverging results. However, from an environmental point of view, most of the studies conclude that the mechanical recycling of waste plastics is often the best solution, providing that certain conditions are met in order to achieve environmental sound recycling. This includes aspects such as the quality of goods that can be manufactured from the recyclate. Under other conditions, the ecological advantage of mechanical recycling is not as clear when compared, for example, with incineration with energy recovery. Many LCA studies on plastics are oriented towards plastic packaging because of the introduction of the Packaging and Packaging Waste Directive (94/62/EC) and also PVC, due to the attention this polymer has commanded by the European Commission.

According to Europen[60]:

"LCA is a decision supporting tool not a decision making tool. It should be used in conjunction with other tools to assist in identifying areas of potential ecological improvement".

The LCA studies a particular case under particular conditions and its conclusion cannot be generalised. A case-by-case approach is necessary because the:

"regional or local conditions to a large extent determine which of the options (reuse, recycling, or recovery) is preferable from the point of view of a high level of environmental protection".

LCAs do not determine usually clearly *"winners and losers".*

General LCA on waste plastics treatment

The Öko-Institut[61] reviewed ten of the most important LCA studies on plastic recycling, the references to which are given at the end of this annex. This study confirmed, that for the waste plastics, the same waste hierarchy exists as that established for the waste management at the EU level:

- 1. Mechanical and monomer recycling
- 2. Feedstock recycling
- 3. Incineration with energy recovery
- 4. Landfill

A number of factors can produce a change in this hierarchy, including the production of low quality goods by some mechanical recycling processes and where incineration (with energy recovery) systems replace existing heavily polluting energy sources, such as coal. The study also notes that, usually:

"LCA does not cover local environmental impacts and those caused by toxic substances".

60- "Use of Life Cycle Assessment (LCA) as a Policy Tool in the Field of Sustainable Packaging Waste Management" – A EUROPEN Discussion Paper September 1999. For general information on LCA, see also the Internet site: http://ewindows.eu.org/ManagementConcepts/LCA
61- "Assessment of Plastic Recovery Options" - Öko-Institut e.V. – Dr. Ing. Volrad Wollny – March 2000

Within the studies analysed by Öko-Institut, the Peer Reviewed study by TNO[62] for APME offers a framework for eco-efficient recycling. Based on a set of six recovery scenarios, an assessment of the effects of different recycling targets on economic and environmental indicators were analysed. Recovery options included:

- Landfill
- Mechanical recycling, where recyclate substitutes primary plastic
- Mechanical recycling where recyclate substitutes woods, concrete and other 'thick' applications
- Feedstock recycling
- High efficiency energy recovery

Recovery scenarios included current practice and 100 per cent landfill alongside recovery targets of 15-35 per cent for mechanical recycling, 10-15 per cent for feedstock recycling and 50-85 per cent for energy recovery. The eco-efficiency of these recovery options, within the various scenario conditions, involved the comparison of the economic and environmental advantages and disadvantages of products and processes. Results from this study, based on its underlying assumptions, suggests that the optimum rate for the mechanical recycling of plastics, when combined with municipal waste incineration with energy recovery, is indicated to be in the range of 15-20 per cent.

Another study mentioned by Öko Institut, the FhG-ISI study[63], believes that the future potential to reduce the costs of the plastic recycling is considerable.

The Dutch Government commissioned **PRé Consultants**[64] to develop the Eco-indicator 99. This indicator integrates the damage to resources, ecosystems and human health but does not include the transportation factor. It gives a hierarchy, by kg, of material used. (Note: *comparing materials by the kg is not recommended as it is the functional unit which is important and not the unit itself*).

For HDPE, LDPE, PET, PP, PS and EPS it confirms the conclusions from Öko-Institut: the most environmental friendly option is the recycling followed by incineration and the landfilling takes the third place. For the PVC, the recycling is the best environmental option followed by the landfilling. The incineration is considered for this case as the worst option.

A **TNO**[65] paper compares four options for the treatment of waste plastics: municipal solid waste incineration (MSWI), energy recovery, feedstock recycling and mechanical recycling. The main conclusions of this paper are:

- From an **energetic point of view:**

  Mechanical recycling is in theory the best option if: "one is able to use technologies that lead to high-quality secondary material. Otherwise due to more complicated collection and upgrading, the low effective replacement of primary by secondary material and the low fraction that is eventually is used as secondary plastic" do not make the energetic benefits of this option significantly better than feed stock or energy recovery options. Mechanical recycling, theoretically, enables the calorific value of the plastic to be recovered (+/- 40 MJ/kg) as well as the energy necessary to produce the plastic (between 40 and 50 MJ/kg), i.e. a total energy recovery between 80 and 90MJ/kg is achieved. However, the energetic expenses to selectively collect or sort and pre-treat and reprocess the waste plastics were not considered.

62- "Assessing the eco-efficiency of plastic packaging waste recovery" TNO – 2000
63- "C-Ströme: Abschätzung der Material-, Energie- und CO2- Ströme für Modellsysteme im Zusammenhang mit dem nichtenergetischen Verbrauch, orientiert am Lebensweg – Stand und Szenarienbetrachtung" (C-Streams: Estimation of material, energy use, from a life cycle perspective – Status and Scenarios) - Frauenhofer Institute for Systems and Innovation Research – 1999 – [FhG-ISI 1999] – Local focus: Germany
64- http://www.pre.nl
65- " Comparing feedstock recycling of plastics waste to mechanical recycling methods " - Dr A. Tukker – TNO - 2002

Municipal solid waste incineration (MSWI) was considered the worst option because:

> *"energy recovery is relatively low due to technical limitations in comparison to normal power plants"*[66].
>
> The maximum bonus of the energy recovery and feedstock recycling is *"limited by the caloric value of the plastic waste (40 MJ/kg) plus the energy needed to produce the replaced energy carrier (often just few MJ/kg)".*

- **From a cost point of view:**

  Landfilling will always dominate unless recycling targets or taxes are implemented. Energy recovery or feedstock recycling in blast furnaces could almost be competitive with MSWI. Other feedstock recycling (to alcohols) does not seem to be competitive with energy recovery or blast furnaces, because of the costs associated with higher capital investment; mechanical recycling seems to be the more expensive option.
- **From an environmental point of view:**

  Landfill is the worst option as essentially there is no energy recovered, followed by MSWI due to its low energy recovery efficiency. Energy recovery (coal substitution) scores almost equally with feed stock recycling (e.g. cement kilns). However feedstock recycling, theoretically, has far better potential than energy recovery, although this has not been realised in practice. Mechanical recycling is in theory the best option, but again is not always the case in practice; operating conditions need to achieve low losses during the process and, via advanced separation and upgrading technologies, reach high quality secondary resins that permit a high quality recycling.

LCA on packaging waste

In their LCA on packaging waste, **Coopers & Lybrand**[67] uses a range of values for the description of the different situations met in the Member States rather than using fixed values, valid for all of them. Their conclusions showed a conditional preference for the recycling of plastic packaging because of the positive impacts on energy resources, the greenhouse effect and on waste production. One of the conditions mentioned by Coopers & Lybrand concerned the rate at which recycled polymers are incorporated into the production of new goods; this should reach 50 per cent.

A Taylor Nelson Sofres[68]Consulting study for the EU Commission compared the costs-efficiency of different packaging recovery systems in four countries (France Germany, The Netherlands and the United Kingdom.) This study concludes that for the plastics the:

"recycling results in relatively high costs per unit of energy saved. There is, however a strong variability depending on the composition of the material and the outlet chosen. Energy savings are highest for mechanical recycling of clean, source separated plastics, which substitute virgin plastic resins in the same proportion. Mechanical recycling of plastics fractions which substitute less virgin plastic resins or other materials (wood, concrete) as well as feedstock recycling (in the case of blast furnace process) results in lower energy savings. If compared to incineration with energy recovery, the energy balances of both material and feedstock recycling depend on the energy use efficiency of the alternative incineration process. In the case of highly efficient use of electricity and heat, the balances are still favourable to material recycling of PE, but not significant for other resins (PET, PVC) and may be unfavourable to feedstock recycling of mixed plastics. In the case of low energy efficiency of incineration, the balances are favourable to both material and feedstock recycling."

When household and non-household plastic recycling was compared, household recycling appeared to be "relatively expensive per energy unit saved" yet remained comparable with other recovered materials.

66- See also below the conclusions of the German study on packaging for which incineration of small plastic packaging can be a good option if the thermal efficiency reaches 70 per cent
67- "Eco-balances for policy-making in the domain of packaging and packaging waste" - RDC and Coopers and Lybrand - 1997
„ Costs-Efficiency of Packaging Recovery Systems – The Case of France, Germany, The Netherlands and The United Kingdom" Taylor Nelson – Sofres
68- Consulting for the Commission of the European Communities – DG III – January 2000 – http://europa.eu.int/comm/entreprise/index_en.htm

Non-household plastic however, whilst reporting lower plastic packaging waste arisings than from household sources, appeared to be considerably cheaper, largely due to the concentrations of large, clean volumes of waste from a comparatively small number of locations. In many cases, non-household plastic recycling is profitable.

Three governments, **Germany, Austria and Denmark,** have questioned the selective collection and recycling of plastic (packaging).

The study for the **German EPA**[69] shows that the incineration of small plastic packaging (cups, foils etc.) and plastic composites does not have any clear ecological disadvantages if the energy recovery facility has a minimum thermal efficiency of 70 per cent. However, the study also shows that optimising sorting technologies can result in recycling that is ecologically superior to other recovery options, even in the case of small plastic items. Where state-of-the-art sorting technologies can be introduced, the exclusion of small packaging waste is less of an issue in scheme design. However, the eco-efficiency of the system, incorporating economic costs as well as environmental factors needs to be considered.

Following a study for the **Danish EPA**[70], the incineration of the plastic bottle waste, with energy and heat recovery, was seen as the best option for this waste from an economical point of view. An important factor in reaching this conclusion is that energy and heat recovery efficiency in Denmark can reach 80 per cent; most European incinerators, (which do not recover heat but only generate electricity) only reach about 30 per cent or less.

From the **Austrian EPA** study[71] the selective collection of plastic materials from households clearly has a negative cost-benefits balance. For commercial waste plastics, the cost-benefit balance of collection and recycling is currently slightly positive. The study notes that, within specified parameters, the cost-benefits result for a defined option of treatment can be positive or negative.

69- " Bases for an ecologically and economically reasonable recycling of sales packaging " - J. Christiani et al. July 2001
70- "Samfundsøkonomisk analyse af bortskaffelse af plastflaske- og dunkeaffald fra husholdninger" Miljøprojekt nr. 695, 2002 - Danish EPA - http://www.mst.dk/
71- "Cost-Benefit Analysis - Recycling/Treatment of Different Packaging Materials" Angst G et al. - Wien, 2001 http://www.ubavie.gv.at

ANNEX 2

Thermo-plastics: identification of polymers and their applications

Table 27: Identification Codes and Abbreviations	
1 PET	2 HDPE
3 PVC	4 LDPE
5 PP	6 PS
07-19 OTHERS	

Polyethylene Terephthalate (PET)

PET is a linear thermoplastic polyester with a molecular structure which allows it to crystallise, governing its properties and applications. PET has excellent chemical resistance and barrier properties and is largely used to package carbonated liquids, because of its gas barrier characteristics. This material can be recycled using virtually all techniques from mechanical to chemical recycling, and by pyrolysis to yield activated carbon. However, there can be problems when recycling PET. Label adhesives may cause discoloration and a loss of clarity, whilst residual moisture during reprocessing can induce yellowing and alter the mechanical properties of the recyclate.

In the USA there are more than 1,400 products made from recycled plastics. Quality standards have generally improved, with recyclers able to supply consistent, reliable resins within defined performance specifications. These resins often sell for 20-25 per cent less than virgin resins.

Markets for recycled PET fibre include clothing, carpets, non-woven textiles and fibre-fill. The largest manufacturers of this fibre is Wellman in Shrewsbury, New Jersey (they also have a plant in Spijk, The Netherlands). They produce Fortrel Ecospun from 100 per cent recycled PET bottles. Sales increased from 3 million pounds in 1993 to 30 million pounds in 1997. Dyerberg uses Fortrel Ecospun to make Eco-fleece fabric, first used by Patagonia as the post-consumer resin Synchilla fleece.

Low and high density polyethylene (LDPE & HDPE)

Polyethylene (PE) is a thermoplastic polymer belonging to the olefin family. Its properties are influenced by the degree of chain branching within the molecules. LDPE is produced by polymerising ethylene under high pressure and temperature. HDPE is produced using catalysts, and the resulting polymer is more linear and crystalline than LDPE. PE has a wide range of uses because of its low cost, processability and high resistance to impact, chemicals and electricity. HDPE is usually recycled by granulation, producing flakes. Contaminants are removed by washing and the flake is separated from other plastics by flotation techniques. LDPE is not so extensively recycled; the main recyclable product is stretch wrap film.

Recovery of LDPE and HDPE products is generally limited to transport packaging (shrink and stretch films). These are recycled into products such as builders' film (damp proofing), rubbish bags and agricultural films. Shrink film is the most common form of LDPE collected for recycling. Stretch film has been recycled successfully by several companies in the USA, usually blending a small percentage (10-20 per cent) with other films, to minimise processing difficulties.

Markets for recycled HDPE include packaging, plastic wood, bins, crates, pipes, furniture and film. The US Plastic Lumber Corporation has six plants manufacturing structural and non-structural plastic lumber, and making products from the lumber. The company estimates the US market at US$10 billion pa.

Visy Recycling in Melbourne, Australia works with pipe manufacturers to make a modified dairy HDPE pipe for operating at low pressure. Post-consumer HDPE has been blended successfully with LDPE or LLDPE to make film for shopping and rubbish bags.

Polyvinyl chloride (PVC)

PVC is the most widely used of all vinyl polymers. The purest PVC is produced by bulk polymerisation in an inert atmosphere. PVC is generally less stable chemically, thermally and on exposure to light. It has a tendency to become embrittled at low temperatures and to degrade at high temperatures. Like PET, the properties of PVC are determined by the degree of molecular branching. The main use for rigid PVC is for pipes, fittings and window or door frames. This material is often referred to as unplasticised PVC, or U-PVC. PVC has good insulation properties and can be rendered flexible. As such, it is used for wire.Other applications include clothing, thermal insulation (PVC foam), automotive parts, flooring, adhesives and coatings. Recycling of PVC is not as widespread as for other polymers, partly because most of its applications are long-term. PVC can be recycled by grinding, or by chemical recycling to recover chlorine (that can then be used in monomer production).

Post-consumer PVC is recovered from electrical wire and cables, building products and packaging. Applications for the recycled resin include outdoor furniture, pipes, flooring, window profiles, hose core, mud flaps, clothing and matting. PVC bottles are recovered through recycling centres and bottle banks throughout Europe.

Collection programmes in France, including kerbside and drop-off systems have been organised by an industry-funded group GECOM. The material has been used to make pipes, shoe soles and garden furniture.

In Australia, PVC bottles and cable cover are finely ground using a cryogenic technique, and the recycled resin is used to make pipe fittings.

A plant was set up in Germany in 1990 to recycle used PVC floor coverings back into new floor coverings. This is a joint venture between European PVC producers and flooring manufacturers.

A new technology, called Vinyloop®, has been developed by the Belgian firm Solvay. It is based on the selective dissolution of PVC and allows to separate and recover PVC compound from plastic waste containing a significant proportion of other polymers. The first commercial plant, a 10 kt/a to treat electrical cable waste, was started up end 2001 in Ferrara (Italy).

PVC bottles were recycled into clothing through a programme developed by Rhovyl, a French clothing manufacturer and Elf Atochem. Jumpers, scarves and socks from 30 per cent wool and 70 per cent mineral water bottles were produced.

NV Ekol in Belgium uses recycled PVC with other plastics to make a range of products including noise reduction barriers, fencing and stakes, mobile traffic islands, flower tubs and garden furniture.

In Denmark, waste management company RGS90 is building a feedstock recycling facility for PVC waste. It will treat mixed PVC waste products, mainly from the B&C sector, with a capacity of 40 kt.

ARCOA in America makes recycled PVC into artificial reefs which can be placed in coastal waters to create a habitat for fish.

Polypropylene (PP)

PP is the second most common thermoplastic of the olefin family. PP has a lower impact strength then PE, but a superior working temperature (enabling containers to be 'hot-filled') and tensile strength. PP has excellent insulation properties, but is most widely used as fibres and filaments produced by extrusion. The fibres are used in some products as carpets, wall coverings and upholstery for furniture and vehicles. PP is also used for wire insulation, piping and sheeting. Injection moulded products are another significant product group, especially for use as medical supplies which need sterilisation through heating or irradiation. Most recycled PP comes from vehicles, including battery cases and car bumpers (fenders). The main recycled process is through re-granulation.

Applications include boxes, crates, lumber and office products.

Polystyrene (PS)

PS is a relatively cheap, hard plastic, usually produced by polymerising styrene monomers. High molecular weight PS is used for coatings, while lower molecular weight PS grades are used for injection moulding. The main weaknesses of PS are that it is brittle, instable when exposed to ultra-violet (UV) light and flammable.

Other forms of PS include expanded Polystyrene (EPS), which is produced by using inert volatil solvents as blowing agents, and high impact PS (HIPS) which is made by incorporating small particles of butadiene rubber. EPS is used mainly as an insulating material in the construction sector, as an insulator for disposable food containers and protective packaging. The major application for HIPS is fast food packaging. PS can be recycled using moist techniques. The most abundant form is EPS, although this presents some challenges, mainly due to the fact that the material needs to be densified for transportation, and additives introduced during blowing can be difficult to remove.

PS recycling tends to be more limited than other commodity resins, because of challenges with collection and processing. Attempts to recycle PS packaging from companies such as McDonalds have not been a commercial success. Amoco Foam Products used recycled PS (including McDonalds clamshells) in extruded insulation panels, however these cost more to make than the virgin equivalent.

Swiss company Rastra AG uses recycled EPS and concrete in insulating concrete building panels.

ANNEX 3

National, regional and local waste stocks

National

Consumption and waste stocks

The table below details the amounts of plastic consumed and available for collection in Western European countries, including the means through which this is waste is disposed of.

Table 28: Total Plastics in Western Europe 2000 (x 1,000 tonnes)

	Consumption	Collectable	Recycling	Recovered	Landfill/ Incineration
Austria*	749	381	74	83	224
Belgium	1368	535	87	144	304
Denmark	604	345	25	260	60
Finland	443	159	22	31	106
France	4564	3024	248	977	1799
Germany*	10825	3111	915	821	1375
Greece	437	303	6	57	240
Ireland	220	199	13	0	186
Italy	6738	3306	367	301	2638
The Netherlands	1393	1085	162	636	288
Portugal	584	438	12	106	320
Spain	3235	1970	268	146	1556
Sweden	648	370	35	160	175
United Kingdom	4077	3610	242	231	3137
TOTAL EU	35884	18836	2468	3956	12413
Norway	295	179	26	77	76
Switzerland	590	526	36	383	107
Western Europe	36769	19540	2540	4416	12584

*In Austria and Germany, recycling includes feedstock recycling
Source: APME, 2002[72]

72- " An Analysis of Plastic Consumption and Recovery in Western Europe 2000. APME, Spring, 2002

Consumption by polymers and applications

Switzerland

In 1999[73], the Swiss consumption of plastics was about 800,000 tonnes, or 110 kg/inh/y. In the same year, waste plastics production was estimated to 570,000 tonnes (78 kg/inh/y), i.e. 71 per cent of consumption. The plastic stocked in the anthroposphere is estimated to 12 Mt , i.e. equivalent to the production during 15 years, or 1.65 t/inh.

Table 29: Waste plastics management in Switzerland (1999)

Type of waste plastic	Kg/inh/y	per cent
Packaging	3.4	47
PET bottles	3.1	43
Crates	0.3	5
Caps and PE bottles	0.1	2
Films from agriculture and construction	0.1	1
PVC flooring	0.1	1
EPS thermal insulator	< 0.1	< 1
Pipes	< 0.1	<1
Total	**7.3**	**100**

Source: OFEFP (2001)[74]

United Kingdom

Plastics consumption in the UK was about 4.5 Mt in 2000. The table below gives the proportions by market sector[75] :

Table 30 : UK consumption of plastics by sector (2000)

Sector	per cent
Packaging	37
Building & construction	23
Electrical & electronic	8
Automotive & transport	8
Furniture & housewares	8
Agriculture & horticulture	7
Leisure, toys & sport	3
Medical	2
Mechanical Engineering	2
Footwear	1
Other	1
Total	**100**

73- "Recyclage des matières plastiques en Suisse – Exposé de la position de l'OFEFP" Office Fédéral de l'Environnement, des Forêts et du Paysage – Berne 7/2001
74-"Recyclage des matières plastiques en Suisse – Exposé de la position de l'OFEFP" Office Fédéral de l'Environnement, des Forêts et du Paysage – Berne 7/2001
75- Waste Watch (2003) Plastics in the UK economy by Recoup for Waste Watch

The UK Government's Department for Environment, Food and Rural Affairs (DEFRA)[76] estimated in 1999 the municipal waste stock in England and Wales to 480 kg/inh/y, from which 29 kg (6 per cent) were made of dense plastics and 24 kg (5 per cent) of plastic films. DEFRA reported that only 3 per cent of the total waste plastics was recycled in the UK in 1998.

Burstall[77] estimates that the plastic films waste in the UK is estimated to 1,000,000 t/year or 17 kg/inh/year, from which 150,000 t/year (2.5 kg/inh/year) is recycled. Sixty percent (i.e. 10.2 kg) of those films waste have a domestic origin. The waste plastics from ELV is estimated to 240,000 t/year (4 kg/inh/year) and those from E&EE waste to 220,000 t/year (3.7 kg/inh/year).

Norway: Plastic Packaging

Data estimates for the amount of waste plastic packaging discarded in Norway for 2002 exclude special waste packaging, drinks containers and refuse sacks.

Table 31 : Plastic Packaging Waste Generation in Norway (tonnes)

	Household	Trade & Industry	Agriculture	Fish rearing industry	TOTAL
Plastic Film	39,400	25,000	7,000	1,500	72,900
Rigid Disp. Pack.	20,700	4,500	500		25,700
PP bags	100	1,700	800	1,600	4,200
Reusable Packaging		4,100			4,200
TOTAL	**60,200**	**35,400**	**8,300**	**3,100**	**107,000**

Denmark: PVC in the C&D sector

The Danish EPA estimated in 1997 that, from a total of 34,000 tpa (6.5 kg/inh/y) PVC waste, the recoverable potential of PVC construction and demolition waste is around 10,000 tpa (1.9 kg/inh/y), from which 4,100 tpa is hard PVC (window frames, pipes). PVC flooring wastes are estimated to 3,600 tpa and PVC waste cables to 1,000 tpa. The supply of PVC goods for the entire sector is estimated at 45 – 50,000 tpa (8.6–9.5 kg/inh/y).

Belgium: Household Packaging Flows[78]

In Belgium, the plastic packaging waste fraction from households is made up of:

Table 32: Composition of household plastic packaging in Belgium

	Kt	Kg/inh/y	per cent
PET bottles	43.7	4.37	34
HDPE bottles	15.7	1.57	12
Total bottles	**59.4**	**5.94**	**46**
Other plastic packaging	69.6	6.96	54
Total	**129**	**12.9**	**100**

76- "Waste Strategy 2000 – England and Wales" – Department of the Environment, Transport and Regions" - 2000
77- Mark Burstall – Vice Chairman – BPF Recycling Council Ltd
78 "Extension de la fraction plastique collectée par FOST Plus - Analyse des conséquences d'une éventuelle extension du scénario de collecte, tri et recyclage" – FOST Plus – Mars 2001

The non-bottle household plastic packaging comes from 180 different groups of products. The origins of this fraction are:

Table 33 : Sources of household plastic packaging in Belgium			
	Kt	Kg/inh/y	per cent
Food-related goods	40.1	4.0	58
Services packaging	8.0	0.8	11
Body care	4.9	0.5	7
Cleaning and maintenance	3.6	0.4	5
Others (<3kt/category) – 19 categories	13.0	1.3	19
Total	**69.6**	**7.0**	**100**

This classification illustrates the broad variety of plastic packaging. The packaging can also be classified by type. The plastic non-bottle packaging can also classified into hard and soft packaging. The proportion of soft packaging is estimated at 30 – 50 per cent. The proportions of the different films are:

- LDPE films 61 per cent
- PP films 24 per cent
- HDPE films 24 per cent

Table 34 : Sources of household plastic packaging in Belgium			
Packaging type	**Kt**	**Kg/inh/y**	**per cent**
Bottles	59.4	5.9	46.1
Crates	9.2	0.9	7.1
Bags	8.7	0.9	6.8
Jars & small dishes	6.5	0.7	5.0
Presentation containers (small dishes, terrines, trays, tubs,)	5.9	0.6	4.6
Multipacks	5.8	0.6	4.5
Films, covers,	5.0	0.5	3.9
Others (<5 kt/category) – 14 categories	28.5	2.8	22.1
Total non-bottle	69.6	7.0	53.9
Total	**129.0**	**12.9**	**100**

Regional and Local Waste Flows

Belgium (Wallonia)

Table 35 : Waste plastics management in Wallonia (1994)	
Wallonia	
Year of reference	1994
Household	34.7 kg/inh/year
Commercial and industrial sector	9.0
Construction & Demolition	6.0
ELV	3.0
Agriculture	3.0
E&EW	2.4
Total	**58.1**

Region Nord-Pas de Calais (France)

In 1993 ADEME and the Région Nord-Pas de Calais undertook surveyed the waste plastics in the Région Nord-Pas de Calais. This region in Northern France has about four million residents (at a population density of 323 inh/km^2). The theoretical waste stock was estimated about 270,100 tonnes or 67.4 kg/inh for the year 1993:

Table 36 : Waste plastics management in Nord-Pas de Calais, France (1993)

	Quantities (kg/inh/y)	Proportion (per cent)
Household	46.1	68.5
Plastic industry	8.2	12.1
Industry, trade & artisan	7.0	10.4
ELV	2.5	3.7
E&EE	1.5	2.2
C&D	1.1	1.6
Agriculture	1.0	1.5
TOTAL	**67.4**	**100**

The composition of the French household waste plastics was determined by ADEME with the MODECOM methodology in 1993:

Table 37: Waste plastics management in France (1993)		
Type of waste plastic	**Kg/inh/y**	**per cent**
PE and PP films	24.1	52.2
PS packaging	4.6	10.0
PVC bottles	4.6	10.0
Other Polyolefin's	2.9	6.3
PE and PP bottles	2.8	6.1
PET packaging	1.9	4.1
Other Plastics	1.9	4.1
PVC packaging	1.3	2.8
Other PS	1.1	2.4
Other PVS	1.0	2.2
Total	**46.2**	**100.0**

Table Source: CNR

Agricultural plastics in Andalusia[79]

In Andalusia, the importance of the plastics in the agricultural activities grew dramatically in recent years. Land used for cultivation under plastic reached 70,000 ha in 1999. Sixty per cent of agricultural HDPE films sold in Spain were used in this region (>30 000 tpa, or 430 kg/ha).

79- Consejeria de Medio Ambiente – Junta de Andalucia

The Region of Brussels (Belgium)

In Brussels, waste analyses during 1999 focused, in part, on plastic packaging and films. Other plastics were not considered during that particular waste analysis campaign. There are systems in place for the selective collection of the plastic bottles, but these do not include plastic films and bags.

Table 38 : Household waste plastics from kerbside collection in Brussels, Belgium (1999, kg/inh/y)

Fraction	Mixed waste	Packaging waste	Papers & card	Total
PVC bottles	0	0		0
PET transparent bottles	1.9	1.1		3
PET coloured bottles	1.0	0.5		1.5
PE	1.3	0.5		1.8
Other packaging	3.6	0.4		4.1
Total packaging	**7.8**	**2.5**		**10.3**
Garbage bag	2.9	0.3	0.2	3.4
Retail bag	3.3	0.1	0.0	3.4
Plastic film	3.4	0.3	0.1	3.8
Other plastic	6.4	0.1	0.0	6.5
Total non packaging	**16.1**	**0.8**	**0.2**	**17.1**
Total Plastics	**23.9**	**3.3**	**0.2**	**27.4**

Garbage bags present in the kerbside selective collection of papers and cardboards come mainly from the bags used for this collection.

For the same year, the output of the sorting plant was:

Table 39 : Household waste plastic bottles – output from sorting plant in Brussels, Belgium (1999, kg/inh/y)

HDPE bottles	Blue LDPE bottles	White PET bottles	Coloured PET bottles	PVC bottles	Total
0.38	0.24	1.02	0.10	0.00	1.74

ANNEX 4

Plastretur

Norway offers a number of interesting examples of producer responsibility schemes which work to recover and recycle waste plastics.

Plastretur AS is a private non-profit company established in 1995, with shareholders comprising:

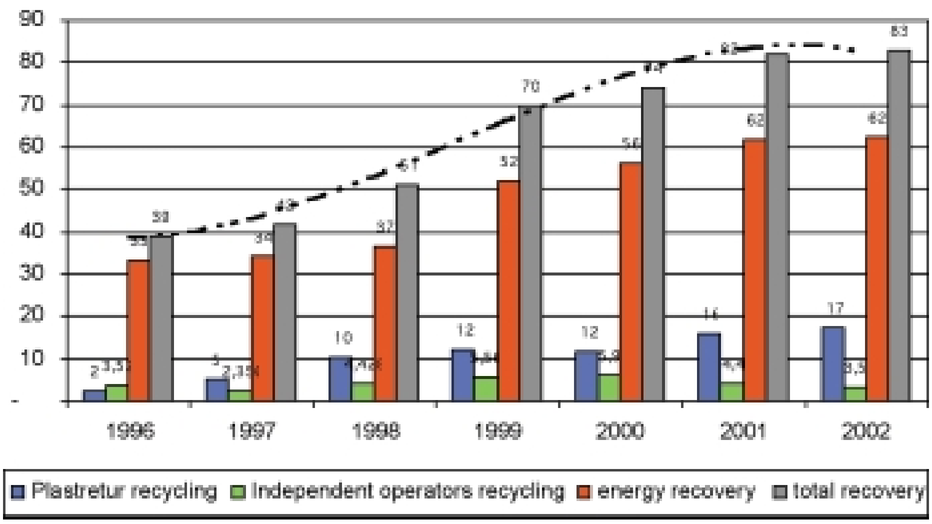
- plastic producers
- retail trade
- users of plastic packaging

Plastretur is developing, organising and executing plastic packaging recovery schemes, both from private households, agriculture, fish farming and trade and industries.

In the case of agricultural films, farmers can deliver the waste materials free of charge. Plastretur pays collectors €175/t for all films delivered by collection agents to recyclers. Silage film is mainly recycled (into carrier bags) in Norway, while mulching films and the large polypropylene bags are exported.

Table 40: Plastretur targets – 2008	
Option	**Per cent**
recycling	30
energy recovery	50
total	**80**
Targets include agriculture film. EPS not included EPS targets: Recycling 50 per cent, energy recovery 10 per cent Packaging from hazardous waste not included	

Figure 11: Waste plastics recovery in Norway (1996 – 2002)



Independent operators : Mostly recycling of reused packaging

EPS-recycling 2002 : 1,400 tons (29 per cent,vs target 50 per cent)

Characteristics of Plastretur

Signed contracts: 162 out of 430 municipalities
Population served: 2.0 million people out of 4.5 million (44 per cent)
Collection carried out by: Municipalities (or collectors on behalf of municipalities)
Collection cost paid by: Plastretur/Municipalities
Average collection contribution (including baling) by Plastretur: €135/t
Transport carried out by: Independent contractors; organized by sorters
Transport cost paid by: Plastretur
Door-to-door collection share:50 per cent (of collected material) (mostly single stream)
Drop-off system share: 50 per cent (plastics only)
Household sorting centres: Four
Household sorting carried out by: Public owned sorting facilities
Sorted materials: Film, Rigid plastics, Energy

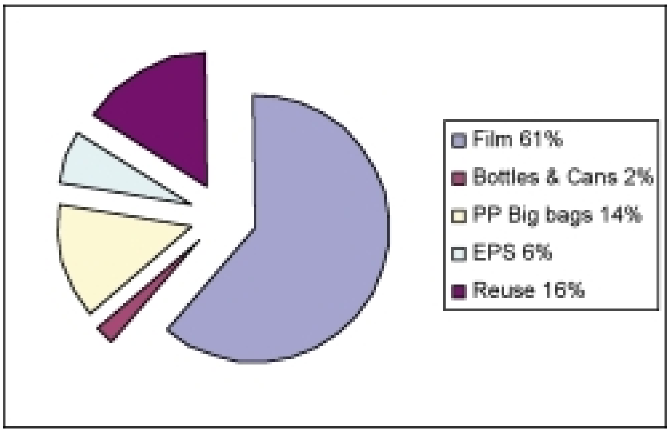
T&I collection and sorting carried out by 115 Private and Municipal Enterprises with agreements with Plastretur
Sorted materials: Film, Rigid plastics, PP-bags, EPS, Energy

- Covenant with official Norwegian environment policy
- Reports to Norwegian Pollution Control Authority
- Responsible for developing, organizing and executing plastic packaging recovery schemes, both from private households, agriculture, fish farming and trade and industries
- Plastretur AS functions as a catalyst towards all parties of the recovery chain, but does not physically handle the plastic packaging in any way
- Follows up and ensures the quality of plastic between the sorting centres and the recyclers, including the training of sorting staff
- Promotes plastic packaging recycling through information and communication tools for trade and industries, agriculture, municipalities and fish farming industry
- Works with the packaging industry towards solutions likely to facilitate recycling

2002 recycling levels

Material	**Tonnes Recycled**
Rigid plastics	500
Film	13,800
PP-big bags	3,100
EPS	1,400
Mixed fraction (granulates and products)	0
Feedstock recycling:	0
Independent operators recycling	3,500
Total recycled	**22,300**

Figure 12: Outlets of Plastic Recycling 2002



Sectors not Covered by Plastretur

Beverage: Packaging with high environmental taxes.

Taxes are reduced according to recovery rates in the collecting systems. Collection is organised through deposit schemes on PET bottles (both refillable, 80-90 per cent and non-refillable 10-20 per cent). The system for PET refillables is operated by the breweries (since 1991) and non-refillable system operated by Norsk Resirk AS -retail and breweries- (since 1999/2000).

Refillable PET bottles are material recycled after 12-16 trips; approx 2000 MT yearly. Non-refillable PET bottles; approx 1200MT yearly.

Both refillables and non-refillables are mainly recycled in Denmark, going into applications of blister packaging, cookie trays and high performance polyester strapping.

Hazardous waste: Plastic packaging containing oil,
gasoline etc. (included in new ovenant – but not included in targets)

Systems will be developed by Plastretur in 2003 and 2004 for empty packaging.

Waste of electrical and electronic equipment (WEEE):

The Norwegian regulation for WEEE came into force from the 1st of July 1999. The regulation is placing specific obligations on manufactures and importers for collecting, recycling and disposal of hazardous waste from WEEE. In 1998, the Ministry of the Environment and national suppliers' organisations entered into a sector agreement, with the aim of preventing and reducing environmental caused by WEEE.

The organisations have established three management enterprises

- Hvitevareretur AS
- Elektronikkretur AS
- RENAS AS

Hvitevareretur and Elektronikkretur, which principally deal with customer WEEE, chosed to work together on the establishment of collective system for logistics, recycling and profiling. The joint waste management system consisting of Hvitevareretur and Elektronikkretur is called El-retur.

Elektronikkretur is the waste management who is sorting out a relative large amount of plastic, especially from IT- and TV-equipments. In 2002 the amount was nearly 1,400 tons. About 60 per cent of this is disposed by incineration (energy recovery), 15 per cent by material recycling and 15 per cent by landfill.

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Editor : Jean-Pierre Hannequart - ACRR 2004