APPRICOD

Assessing the Potential of Plastics Recycling in the Construction and Demolition Activities

GUIDE

Towards Sustainable Plastic Construction and Demolition Waste Management in Europe

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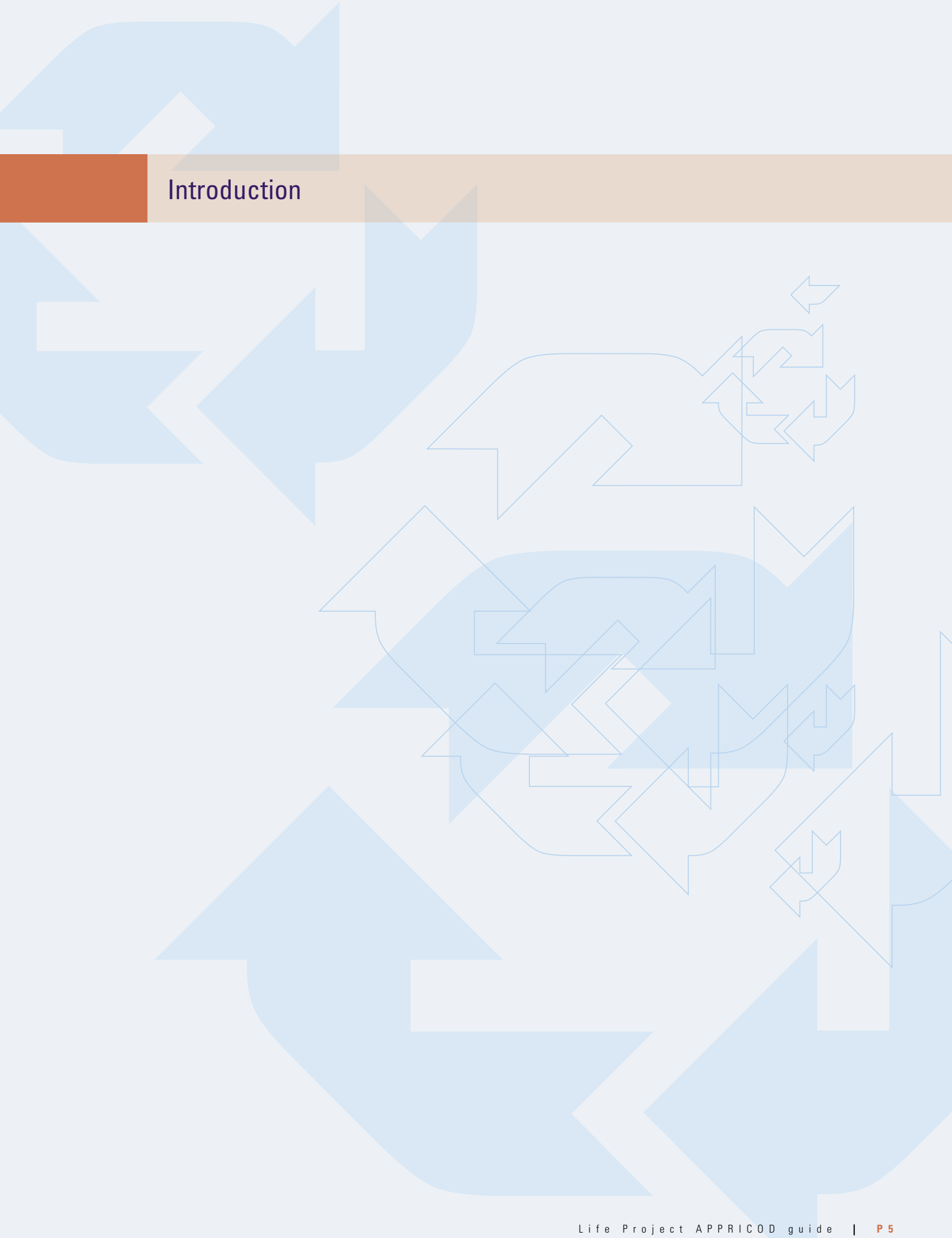
Introduction



Construction and demolition (C&D) waste represents one of the European Union's largest waste streams, in quantitative terms. It is estimated to account for 180 million tonnes of waste per year, i.e. 480 kg/inh/year. Some EU countries have attained high recycling rates for the inert fraction, which is the main fraction of C&D waste. But recycling rates for the other C&D waste fractions and in particular for plastic waste remain poor.

Established techniques for recycling the inert fraction exist and where they are applied high recycling rates are reached. The steel fraction is also well recycled. Conversely, however, plastics are poorly collected and recycled. As a result, they are usually landfilled or incinerated but not recycled.

> The origin of the Life Project "APPRICOD"

The project is based on the following diagnostic.

A growing body of experience of management of waste from construction and demolition (C&D) activities has been gained. Plastics are usually considered as a whole, which is recyclable, but no specific recommendations are made to bring this about: how to collect them, what the different plastics are and how to recognise them, what the requirements for plastics recycling are, which plastic fractions can be collected together, where the various types of plastics can be sold, etc.

Little experience exists of selective collection schemes for plastic packaging from construction works. There are, however, some selective collection schemes for rigid plastics from construction, renovation and demolition, which are geographically limited and specific to certain types of plastics waste (e.g. pipes and/or window frames).
Electrical cables are collected more for the value of the copper than for the value of the plastics.
But all these experiences are scattered and there is no global vision of the optimum management of plastics from C&D waste.

One of the reasons is the lack of information about techniques for the selective sorting and collection of plastic waste, and the lack of cooperation between the various actors:

- For the C&D sector this separation is considered too heavy a burden.
- Plastics producers diffuse little information on the types of plastic used and it is sometimes difficult to identify adequate recycling opportunities.
- Local or regional authorities (LRAs) are poorly informed, if at all, of the possibility of collecting plastics from C&D waste in order to recycle them. These aspects are rarely integrated in waste management strategies.
- Plastics recyclers have difficulties in finding regular quantities of "secondary raw material", or plastics to recycle of satisfactory quality and quantity.

Another main reason is obviously the economic cost of recycling plastic C&D waste.

> The objectives of the Life Project "APPRICOD"

Funded by the Life Environment Programme of the European Commission, the APPRICOD project brings together 3 main groups of stakeholders concerned with plastic C&D waste management:

- The C&D sector (Belgian Building Research Institute - BBRI, Brussels Confederation of Construction - CCB-C/CBB-H, European Demolition Association - EDA).
- Local and regional authorities (Agència de Residus de Catalunya - ARC, Brussels Institute for the Management of the Environment - IBGE-BIM, Provincia di Ancona, Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto - LIPOR, Association of Cities and Regions for Recycling and sustainable Resource management - ACR+).
- The European plastics industry and recyclers: Association of Plastics Manufacturers in Europe - APME, now PlasticsEurope (producers of raw materials), European Council of Vinyl Manufacturers - ECVM (PVC resin producers), European Plastics Converters - EuPC (plastics converters), European Plastics Recyclers - EuPR (European plastics recyclers).

The partnership developed by the project has a unique character because it brings together a variety of actors, each representing an important element of the recycling chain. Each of them is a partner in the chain for the proper management of plastic C&D waste.

The main objectives of this project were:

- to optimise the selective collection of plastic waste from construction and demolition (C&D) sites.
- to evaluate the costs associated with the selective collection of plastic C&D waste.
- to disseminate examples of sustainable management of plastic C&D waste at European level.

As a first step, the project included a benchmarking exercise on C&D plastics waste in the European Union. The European context for C&D waste management was analysed and particularly in four frontrunner countries: Germany, Austria, Denmark and the Netherlands. The most innovative sorting and/or recycling schemes for C&D plastics waste in Europe were also presented for different types of plastic products. Secondly, pilot projects were established by the four local or regional authorities (Provincia di Ancona, Brussels-Capital Region, Catalonia and Greater Porto). This approach encourages collaboration at local level with the C&D sector, the plastics industries and these authorities. The sorting and collection methods were identified before implementing the pilot projects. It was then followed by the evaluation of its results.

Finally, conclusions and recommendations aimed at local and regional authorities and at the C&D sector were established. In order to disseminate this information, four local workshops were organised by the local and regional authorities as well as a European Workshop. The creation of a website, the publication of a leaflet presenting the project and its results, the elaboration of a toolbox for the C&D sector and this guide are contributions to this task.

The objectives of this guide are:

- to provide information on the technical, environmental and economic aspects of plastic C&D waste management (Part 1);
- to give an insight into current leading experiences for plastic C&D waste sorting and recycling based on the European and specific national legal and financial frameworks (Part 2);
- to learn from the experience of the pilot projects carried out at local and regional level as part of the Life Project "APPRICOD". These pilot projects aimed to implement a variety of scenarios for sorting and selectively collecting plastic C&D waste (Part 3); and
- to draft practical recommendations for public authorities, esp. local and regional authorities, and good practices for the C&D sector with the common objective of promoting plastic C&D waste sorting and recycling (Part 4).

BBRI

EDA

Confederatie Bouw Brussel-Hoofdstad
Confédération Construction Bruxelles-Capitale

Agència de Residus de Catalunya

BRUXELLES ENVIRONNEMENT
LEEFMILIEU BRUSSEL
-IBGE-BIM-

ACR+

PlasticsEurope
Association of Plastics Manufacturers

ECVM

ECPC

EuPR
European Plastics Recyclers

PART 1 Plastic waste in C&D waste - General context

Within the framework of European and national environmental and waste legislation (including the European legislation transposition), more and more local, regional or national public authorities are paying special attention to the reuse and recycling of construction and demolition waste (C&D).

The reasons for this are, among others, that:
- C&D waste represents one of the largest proportions of all waste produced (the commonly accepted European average is 30%).
- A very large proportion of C&D waste is easily re-usable or recyclable (the stony and sandy fraction, known as "debris" which can represent up to 90-95% of C&DW).
- Reusing or recycling this fraction helps to save natural resources and energy.
- Recycled C&D waste can be cheaper than using raw materials.

The plastic fraction of C&D waste, although only a small percentage, can be important in terms of the impact that plastic waste management has on the environment.

This chapter aims to describe the general context of plastic C&D waste management in terms of its technical, environmental and economic aspects.

It begins with a presentation of the subject from a waste-product-resource perspective (point 1):
- by recalling the main characteristics of C&D waste in Europe, with a final focus on plastic waste generated by the C&D activities;
- by situating the plastic products used in the C&D sector with a focus on their applications and technical characteristics; and
- by presenting the opportunities for recycling plastic secondary raw materials into new products.

Point 2 aims will set out the environmental aspects of plastic C&D waste recycling.

Point 3 aims to describe the recycling technologies for plastics

Finally, point 4 will give a picture of the key players in the plastic C&D waste recycling chain:
- the construction sector,
- the plastics producers industry, and
- plastics recyclers.

1 Quantitative and qualitative aspects of plastic waste in C&D waste

> 1.1. What is C&D waste?

The 'umbrella' term C&D waste can cover a very wide range of materials. The most obvious categories are:
- waste arising from the total or partial demolition of buildings and/or civil infrastructure;
- waste arising from the construction of buildings and/or civil infrastructure; and
- soil, rocks and vegetation arising from land levelling, civil works and/or general foundations.

The impact of C&D waste over the lifetime of a building can be assessed by adding together three factors:
- the C&D waste generated during initial construction;
- the C&D waste generated by subsequent renovations; and
- the C&D waste from final demolition.

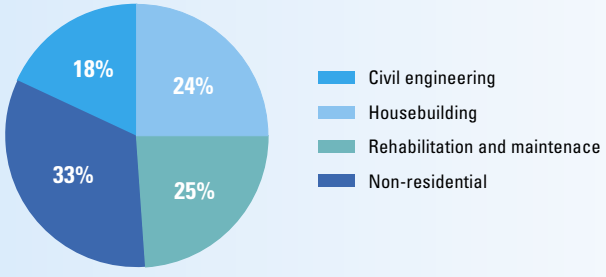
The nature of today's demolition waste is directly influenced by the building techniques and materials that were in vogue when the buildings, civil engineering structures and associated infrastructure being demolished today were built.

The nature and volume of demolition waste arising also reflect the solidity and flexibility (and therefore the life expectancy) of the structures and materials of previous years.

The nature and volume of today's construction waste, by contrast, reflects today's building materials and activity levels.

The breakdown of production in Europe by type of building activity is presented in *Figure 1*. Rehabilitation and maintenance are poorly covered by statistics, even though in many cases they are among the main components of construction activity.

Figure 1 : Breakdown of production in C&D sector in Europe by activity[1]



(1) FIEC, European Construction Industry Federation : http://www.fiec.org

> 1.2. C&D waste produced and recycled in Europe

Although C&D waste and its environmental impacts account for a relatively small portion of total costs and impacts over a building's lifetime, at the end of a building's life they may be substantial. In the EU-15, total production of waste is about 3.5 tonnes per person per year. Waste arising from construction and demolition (C&DW) alone amounts to around 180 million tonnes each year. This is over 480kg per person per year, and only about 28% across the EU-15 is re-used or recycled. Landfilling the other 72% (some 130 million tonnes a year) at a density of 1.0 requires the equivalent of a brand new landfill 10m deep and roughly 13 square km in surface area every year. To illustrate this, 13 square km is a circle with a diameter of just over 4km. Adding construction waste, road planning and excavated soil and rock to this figure more than doubles the total weight and volume of material to be managed.

Five Member States (Germany, the United Kingdom, France, Italy and Spain) account for around 80% of the total of C&DW, which is broadly consistent with the share of the overall construction market accounted for by these same countries.

A high proportion of conventional demolition waste, and particularly the fraction derived from concrete, bricks and tiles, is well suited to being crushed and recycled as a substitute for newly quarried (primary) aggregates in certain lower grade applications, most notably engineering fill and road sub-base. This practice has been common (though not necessarily widespread) in several Member States for many years. The use of such C&DW-derived aggregates in new concrete is much less common, and technically much more demanding.

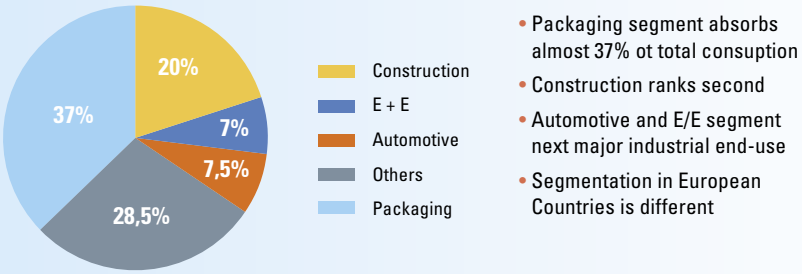
These materials therefore have the potential to divert equivalent volumes of primary aggregates, thus preserving non-renewable resources, with minimal need for landfill space. Reducing pressure on increasingly scarce landfill space is widely seen as one of the key benefits of C&DW recycling. In some Member States the volume of C&DW going to landfill exceeds that of household waste.

> 1.3. How significant is the use of plastics in the building and construction sector?

Total plastics consumption, including virgin polymers and recycled granulate, continues to increase. In 2004, the consumption of virgin polymers for plastics applications in Western Europe was 43.5 million tonnes. This followed a 2.8 per cent increase from 2003. The consumption of plastic materials in Western Europe was approximately 100 kilograms per person of virgin plastics in 2004[2].

If the total consumption is spread over the various industrial sectors, it can clearly be noted that the packaging sector is the major consumer of plastics with 37 per cent of all plastics consumed. 'Building and Construction' accounts for 20% or 8.7 million tonnes of plastics in 2004. The construction industry is the third largest user after household and domestic uses and the packaging sector *(see Figure 2)*.

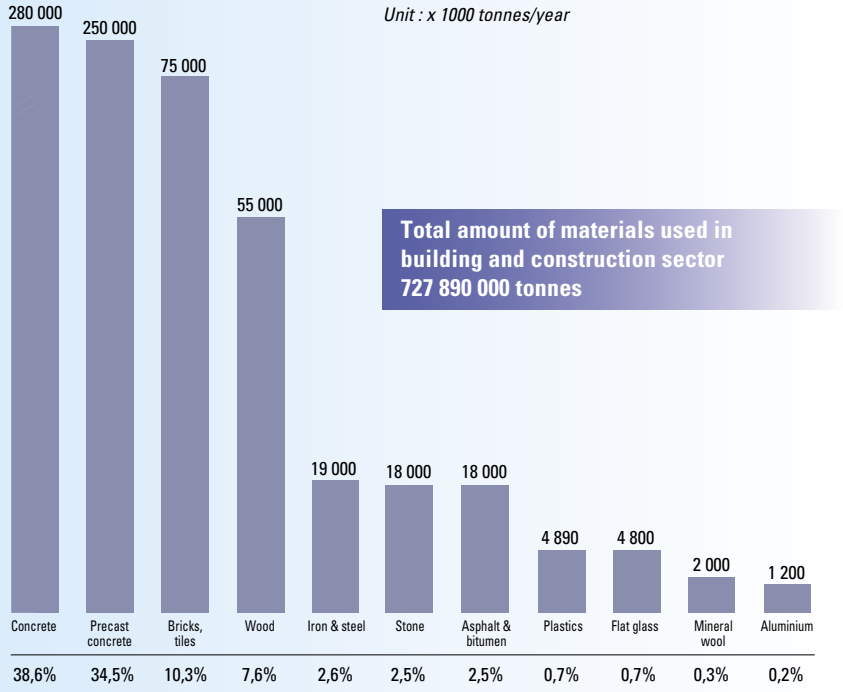
Figure 2 : Total consumption and consumption by industry sector[3]



(2) PlasticsEurope: http://www.plasticseurope.org
(3) APME, Plastics, An analysis of plastics consumption and recovery in Western Europe, 2000, Published Spring 2002

As we can see in *Figure 3*, plastics materials represent less than 1% of total materials used in the building and construction sector in Western Europe.

Figure 3 : Percentage of plastics materials in construction, Western Europe, 1995[4]



> 1.4. What types of plastic are used in the construction sector, and in which applications?

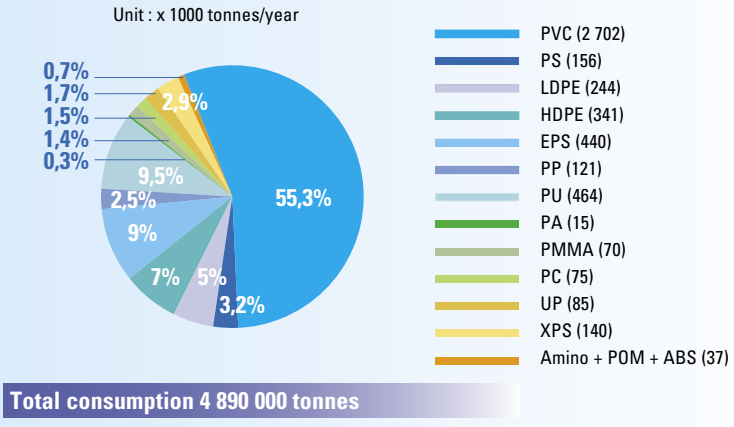
1.4.1. Polymers

Plastics consumption in the construction sector accounts for 8.7 million tonnes in 2004.

The dominant substance is PVC (polyvinyl chloride), which makes up 47 per cent by weight of total plastics used (2002 data). PVC is used in pipes and ducts, floor and wall coverings, window frames, profiles and linings. Accounting for about 25 per cent of PVC resin demand in Europe, PVC pipes and ducts can be used above or below ground for the transport of many substances including drinking water, waste water and gas.

The insulation market with EPS (expanded polystyrene), XPS (extruded polystyrene) and PU (polyurethane) accounts for an important 18 per cent with 1044 million tonnes in 2002. A third large group consists of HDPE (high density polyethylene) and LDPE (low density polyethylene), which make up 18 per cent of which a large part is used in pipes and ducts.

Figure 4 : Plastics consumption by resin in the construction sector, Western Europe 1995[5]



(4) (5) APME, Plastics, A material of choice in building and construction, Plastics consumption and recovery in Western Europe, 1995

1.4.2. Products used in the construction sector

One of the major uses of rigid PVC in construction is in profiles for windows and doors. Some 40% of all European window profiles are made from PVC using about 600.000 tonnes, which is more than 10% of Western Europe PVC production.

Other PVC applications consist of wiring and cable insulation (where PVC has 60% of the market share), cladding and roofing membranes and (vinyl) flooring[6].
Plastic foams are used widely for thermal insulation of house walls, floors, roofing, pipes and many other applications.

Table 1 : The applications of the plastics in the C&D sector[7]

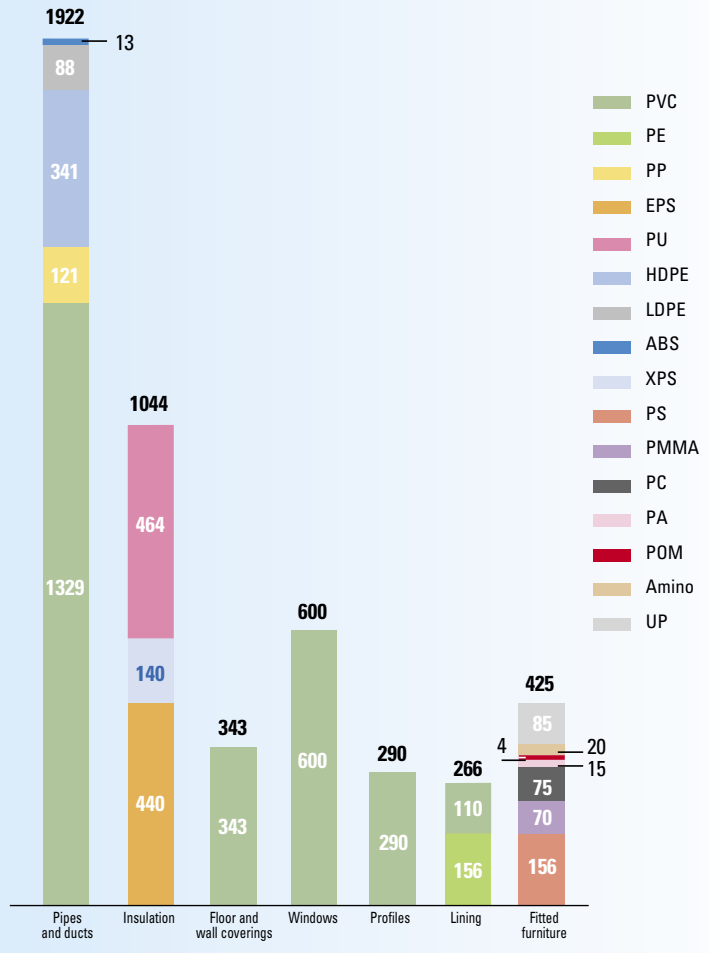
Plastic	Properties	Applications
HDPE (High density polyethylene)	Chemical inertia, resistance stress cracking	Pipes
PVC (Polyvinyl chloride)	Stable physical properties, inertia, resistance stress cracking	Lining, flooring, window frames, shutters, pipes, cables
LDPE (Low density polyethylene)	Transparency, flexible, toughness	Lining, wires and cables, pipes
PP (Polypropylene)	Resistance stress cracking, rigid	Pipes
PS (Polystyrene)	Good thermal insulation	Insulation
PU (Polyurethane)	Good thermal insulation	Insulation

The third-largest application area for plastics is in window frames, which are made almost exclusively out of PVC. This is an application that has developed relatively recently (since only 1965) but, over 35 years, it has secured more than a 50% share of window systems in the major industrialised countries of Europe. The lifecycle calculation for window frames indicates an average life of 40 years.

After pipe, insulation and window profiles, the fourth major application area is for wall covering and flooring. Plastic floorings, in particular those made of PVC, have been in use for 55 years, and have proved their worth in domestic areas such as kitchens, bathrooms, corridors and children's rooms. They have also made a very valuable contribution in public areas, such as hospitals, sickrooms, operating theatres, schools, municipal buildings, offices and sports centres.

Profiles for interior fittings (which have been in existence since 1955) have also secured an important role, accounting for 8% of the total plastics consumption in the construction industry. They are used in doors, flooring trim, skirting boards, pipes, and guide rails, covering and decoration.

Figure 5 : Plastics consumption by product and resin in building and construction sector, Western Europe, 1995[8]



(6) ECVM, PVC in building and construction, no date
(7) (8) APME, Plastics, A material of choice in building and construction, Plastics consumption and recovery in Western Europe, 1995

The average working life of all plastics applications in construction is 35 years but, depending on the specific application, this has a wide variation between 5 years (such as wallpaper) and 100 years (such as pipes). These are only cautious assumptions, because there is not yet any practical long-term experience with a technically defined end to their working life.

> The specific case of plastic packaging in the C&D sector

The packaging sector is the major consumer of plastics. Plastic packaging in the industry sector accounts for about 40% of transformed plastics in Europe. The use of plastic packaging is increasing and European consumption of plastics grew to almost 16 million tonnes in 2004[9].

The most important fractions by volume in the packaging of construction materials are timber pallets (26%), cardboards (29%) and polyethylene films (12%)[10].

On average about 25% by volume of construction site packaging waste is made up of plastic. That is to say about 9% by volume of all the C&D waste is plastic packaging[11].

> 1.5. Plastics waste arising in C&D sector

Of all C&D waste, the fraction of plastic waste is only a small 1%. A large proportion of plastics used in the construction industry have an intended life of many decades. Over the past 25 years there has been a trend towards increased use of plastics in the building industry and in Western Europe it is predicted that plastics use will increase to almost 8 million tonnes by 2010[12].

Compared to other materials the total volume of plastics used is small, but they make a significant contribution to a huge variety of applications.

The lifespan of plastic pipes and ducts is estimated up to 100 years and plastics windows a lifespan of up to 50 years. This often means that for such products, the technical lifespan is longer than the effective lifespan and will be equal to the lifespan of the building.

APME (PlasticsEurope) has developed a theoretical model used to calculate quantities of plastics waste arising in the building and construction sector, which gives an estimate of 1 975 000 tonnes of plastic waste in 2010.

Table 2 : Plastic consumption and plastic waste in B&C in Western Europe[13]

Plastics in the European Building and Construction sector

Year 2002	Unit: x 1000 tonnes/year	Unit: x 1000 tonnes/year
Country	**Plastic consumption**	**Plastic waste**
Austria	190	25
Belgium	240	30
Denmark	130	17
Finland	120	15
France	1250	175
Germany	2300	260
Greece	60	10
Ireland	80	11
Italy	740	130
Netherlands	350	50
Portugal	80	12
Spain	550	100
Sweden	160	23
United Kingdom	800	135
Total EU	7050	993
Norway	70	10
Switzerland	150	18
Western Europe	7270	1021

(9) PlasticsEurope: http://www.plasticseurope.org
(10) BRE, WRAP, Establish tonnages, and cost effectiveness of collection, of construction site packaging waste, April 2005
(11) SBR: Stichting Bouwresearch, Praktijkboek Bouw- en sloopafval
(12) APME, Plastics, A material of choice in building and construction, Plastics consumption and recovery in Western Europe, 1995
(13) ECVM, 2002: http://www.ecvm.org/

Some plastic components such as pipes are buried below ground. In the normal course of events, they are unlikely to be removed for disposal, as the cost of this would far outweigh any perceived benefit. According to a study by Waste Watch on plastics in the UK, the quantity of potentially recoverable plastics in building and construction sector is estimated at some 70%[15].

This figure means that within a reasonable time – before it is necessary to demolish today's new buildings – some 70% of the plastics used in buildings each year or 4,700,000 tonnes (70% of 6,700,000 tonnes) of plastic waste is potentially recoverable.

Table 3 : Forecast of plastics waste from building and construction (in thousand tonnes/year), Western Europe 1995[14]

	1995	2000	2010
Floor & Wall Coverings	274	285	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**

2 Plastic C&D waste: what is the environmental challenge? What are the difficulties?

Selectively collecting and recycling plastic C&D waste can be helpful in making local, regional, national and global environmental improvements by avoiding wastage of resources, reducing the need for new waste disposal facilities, limiting greenhouse gas emissions, implementing integrated selective collection including various materials from C&D activity (synergies) and contributing to a greener C&D sector.

Separation of plastics will increase the quality of the easiest fraction to recycle: the inert fraction. This will permit a reduction in the landfilled volume of C&D waste by diverting not only plastics but also the inert fraction. The reduction of landfilled volume will have as economic consequence a diminution of the costs associated with landfilling, which have tended to increase since the introduction of the landfill directive. Constraining factors in landfilling plastics (apart from issues of longevity) also include the volume of space that plastics occupy in relation to their weight.

Plastics manufacturing, which largely uses crude oil as the raw material, is estimated by industry to account for four per cent of global crude oil consumption. For every kilogram of plastic that is produced, roughly two kilograms of oil are needed. However, the resulting product (because of its low weight and its 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.

However, the main benefit of plastics recycling lies in the savings associated with primary energy consumption. Polymer production accounts for the largest proportion of resource use in plastic product manufacture, ranging from between 72 and 91 per cent of total energy consumption, depending on the polymer[16]. This compares with process energy usage of between 6 and 20 per cent, depending on the product being manufactured (i.e. bottles, pipes or films).

But there is a series of obstacles to the recycling of plastics from C&D waste:

- Cost, time and space needed for dismantling and separation (especially in urban areas).
- A lack of synergy between local/regional authorities and the private sector.
- The low cost and/or poor control of landfilling.
- A lack of sorting/crushing plants.
- Cross-contamination and general mixing of materials.

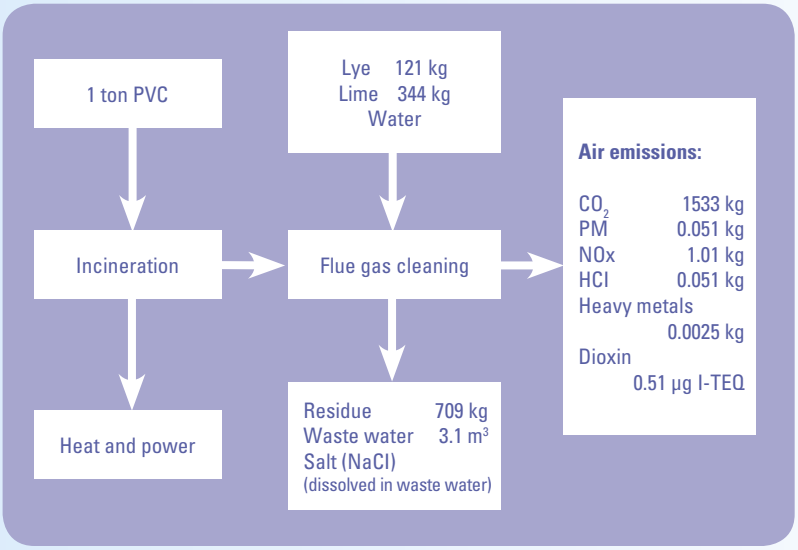
The main objective of this guide is to identify these blocking factors and to propose recommendations in order to improve recycling performance for plastic C&D waste.

(14) APME, Plastics, A material of choice in building and construction, Plastics consumption and recovery in Western Europe, 1995

(15) BRE, WRAP, Establish tonnages, and cost effectiveness of collection, of construction site packaging waste, April 2005

(16) "Eco-Profiles of Plastics and Related Intermediates - Methodology", I. Boustead, Brussels 1999, and Association of Plastics Manufacturers in Europe, LCA/Eco Profile fact sheets, http://www.apme.org , and "Assessing the environmental potential of clean material technologies", EC/IPTS, Sevilla, 2002

Figure 6 : Incineration of 1 tonne typical PVC waste[17]



Environmentally sustainable management of PVC waste is still being developed. The Danish waste strategy 2005-2008 proposes various measures:

- Introduction of legislation that ensures PVC containing lead and cadmium is separated for landfilling or alternative forms of treatment.
- Promotion of new technologies for PVC waste treatment by exempting new plants from the waste tax.
- Substitute building materials made of soft PVC with environmentally acceptable alternatives.
- Carry out a cost/benefit analysis of mechanical recycling and chemical treatment compared to landfilling.

3 What is plastics recycling?

> 3.1. Post-producer vs. post-consumer recycling

The infrastructure for recycling plastics **post-producer** consists of four major components:

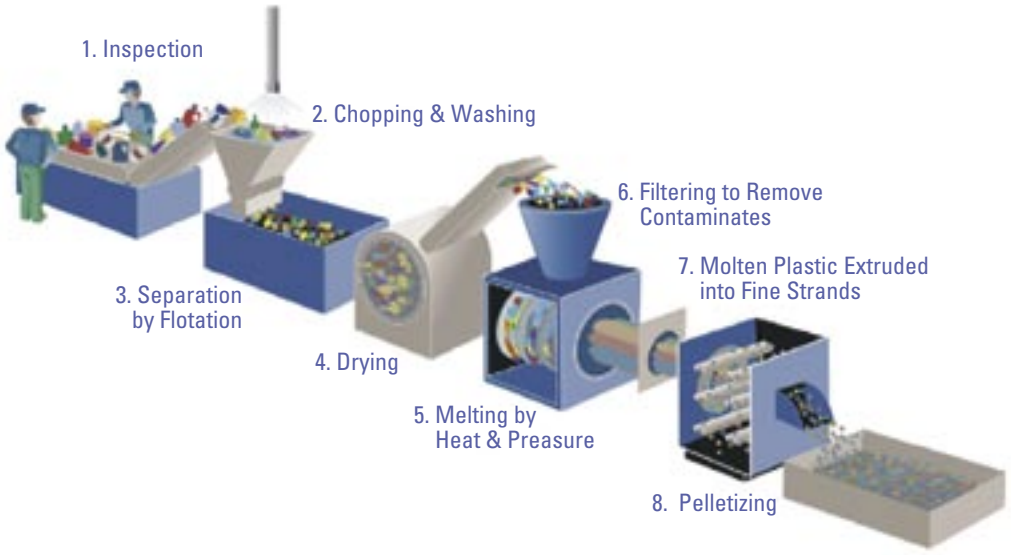
- Collection: different scenarios can be used to collect post-consumer plastics in order to favour recycling instead of landfilling.
- Sorting: the collected plastics need to be sorted to increase their quality and reduce the costs of evacuation.
- Reclamation: the sorted plastics are cleaned and processed directly into end products or into pellets of a quality acceptable to manufacturers.
- End-use: the pellets or end products are marketed to manufacturers.

The recycling of plastics **post-consumer** is more complex because of unknown residual contaminants. The steps for recycling these plastics post-consumer may vary from operation to operation *(see Figure 8)*:

- Inspection: incoming plastics are inspected for contaminants.
- Pre-sorting.
- Granulating: post-consumer plastics are ground and washed.
- Flotation tank: if the different kinds of plastics are not sorted, they are separated in a flotation tank (density of the different plastics).
- Drying: clean plastic pellets must be dry because dampness decreases the quality of the end product.
- Melting: heat and pressure melt the plastic in an extruder (each type of plastic has a different melting point).
- Filtering: the molten plastic is forced through a fine screen to remove any contaminants that may have eluded the washing cycle.
- Pelletizing: the strands are cooled and chopped into pellets to be sold.

(17) Kristensen, N. B., PVC waste in Denmark- costs and benefits of alternative treatments

Figure 7 : An example of the different steps in plastics recycling[18]



> 3.2. Methods for recycling

There are two methods for recycling plastics waste:

> **Mechanical recycling**
is the material reprocessing of waste plastics by physical means into new plastics products. This kind of recycling is used for post-production waste as well as consumer waste. It is feasible when sufficient quantities are available and the quality is sufficient.

> **Feedstock recycling** or **chemical recycling**
is material reprocessing which breaks down the plastics into their chemical constituents usually by heat and pressure (depolymerisation). This recycling method is suited for large amounts of mixed plastics like household packaging. The recovery process is unique to plastics. Post-user plastics waste treated by feedstock recycling produces basic chemical substances of defined specifications and high quality. Feedstock recycling reduces the consumption of oil resources used for production but this option needs a high-performing and expensive installation.

If recycling is not feasible, energy recovery is the next best option for recovery of plastics waste. Mixed plastics can be used to generate heat and/or power, as with the use of plastics waste in cement kilns because of its high calorie content. Energy recovery can also allow the recovery of a substantial proportion of the energy used for the production of plastics products.

Recycling or recovery techniques may vary according to the type of waste.

For instance, if the plastics are hard (window frames and pipes) and quite clean, then traditional mechanical recycling techniques are used: shredding, sorting (glass and metal particles are removed), regranulation, extrusion and production of recycled products (as much as possible for window frames).
For softer (roofing and cables) and less clean PVC, the VINYLOOP® process (see box) can be used in addition to conventional mechanical recycling. This process works in a mechanical process in closed cycle in which a selective solvent dissolves the PVC resin matrix, releasing the additives and secondary materials. When the secondary materials are separated, the dissolved PVC resin and additives are recovered and precipitated, which results in a regenerated PVC compound.

(18) Environment and Plastics Industry Council: http://www.plastics.ca/epic/

VINYLOOP FERRARA, Italy

The Vinyloop® process is a recycling process in which a selective solvent dissolves the PVC resin matrix, releasing the additives of the PVC compound and the secondary materials. Then the PVC resin and the additives are covered by precipitation - and this constitutes the originality of the process - to yield a regenerated PVC compound.

> Collection scheme

Type of plastics considered: The main sources of raw material for the recycling unit will be waste from used wires and cables (more than 70%). The current version of the process is well suited for post-consumer waste from floor coatings, waterproofing membranes and post-industrial PVC-EP blister wastes.

Quantities: The nominal capacity of Vinyloop Ferrara S.p.A. is 10,000 tonnes of raw material per year, with a weight rate of 85% of extractable PVC compound, which represents 8,500 tonnes of regenerated PVC compound.

> Recycled PVC from C&D sector

- Cable waste

Cable waste from the recovery of metals is presented in the form of 3 to 5 mm granules. It contains 50 to 85% PVC compound depending on whether the cables are sorted.

- Floor coverings

Floor coverings waste comes from production, cut-out and use. It generally contains more than 85% PVC compound, which can be re-used in the same applications as bottom or intermediate layers of floor coverings.

- Tarpaulin waste

Tarpaulin waste comes from end-of-life products used in different applications (stretched tarpaulins for building applications, truck tarpaulins, tents, etc.) It contains 60 to 70% PVC compound.

- Other waste

For waste from window frames, pipes and corrugated sheets, an effective recycling process other than Vinyloop® already exists. But in some case, Vinyloop® can provide a more profitable and more economical solution for these products.

For waste from semi-rigid packaging for the food and pharmaceutical industries, reinforced flexible pipes and other flexible applications (roofing membranes, geotextiles, flexible pipes, etc.) Vinyloop® can provide a recycling solution. In this case, the waste must be reduced and sometimes needs to be sorted or to undergo some other specific treatment.

> Sorting and recycling phases *(see Figure 8)*

During *pretreatment*, waste is transformed into raw material suitable for introduction into the Vinyloop®.

Dissolution: in a closed reactor, the waste is combined with a selective solvent which releases the PVC compound matrix. All additives and foreign materials are either dissolved or in suspension in the liquid.

Separation: the solution is filtered. The undissolved fraction is separated.

Precipitation: the addition of steam converts the organic phase into the aqueous phase. The PVC resin precipitates and fixes the components of the compound in the form of microgranules.

Drying: water is extracted from the slurry (sludges).

Recovery of the solvent: the solvent is reused in a closed loop.

> Quality of recycled products

- Regenerated PVC compound with qualities comparable to virgin materials. It can be used alone or with virgin material.
- The Vinyloop® PVC compound is well suited for transformation by: extrusion, calendering, injection, rotomoulding, dispersion in plastisols, etc.

Outlets:

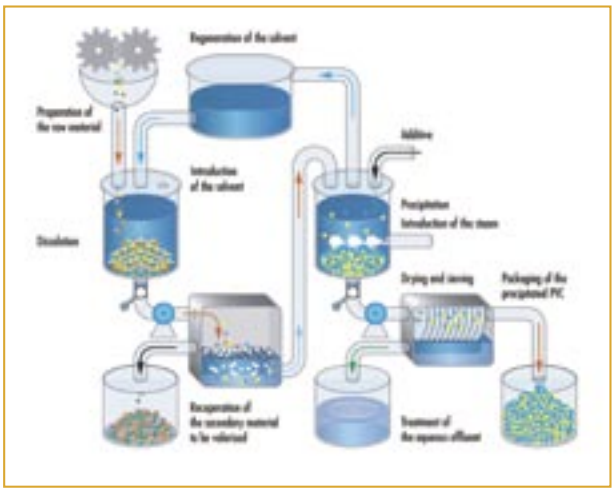
- Insulation and sheathing for cables that respect the specifications of the harmonised European standards for cables of classes TM1, TM2, TI1 and TI2.
- Waterproofing membranes for tunnels, anti-water barriers in foundations, as under-layer in roofing membranes, etc.
- Under-layer in flexible pipes
- Automobile accessories
- Floor coverings

> Costs

Considering its qualities, the regenerated PVC compound could be sold at a price several percent lower than that of the equivalent virgin PVC compound. The precipitated PVC compound has comparable properties to the initial compounds, except for the colour, which depends on the raw material.

http://www.vinyloop.com/

Figure 8 : Vinyloop® PVC recycling process[19]



(19) http://www.roofcollect.com/recycling/vinyloop_prozess.cfm/hn_ld/9/sub_ld/60

4 Description of the sectors: C&D sector, plastic industry, recycling sector

> 4.1. The construction sector in Europe

In 2004, construction activity in the European Union (EU-15) amounted to EUR 1000 billion or around 10% of Europe's GNP and it gave employment to more than 14 million persons (in 2.4 million enterprises, of which 97% are SMEs with fewer than 20 operatives), thus accounting for around 7% of total employment. The building industry is the largest employer in Europe. This figure does not take account of the number of jobs (12 million) generated indirectly by construction activity in other upstream and downstream sectors[20].

In 2002, Germany accounted for nearly 24% of construction activity as a whole while the 5 'big' countries (Germany, United Kingdom, France, Italy and Spain) accounted for around 75% of the total.

> 4.2. The plastics industry in Europe

The European plastics industry, including plastics converters and machinery manufacturers, employs well over one and a half million people and is a major contributor to Europe's economic strength. Manufacture of polymer resins is an important part of Europe's second largest industry, chemical manufacture. The wider plastics industry in Europe accounts for a turnover of EUR 160,000 million.

> 4.3. The recycling sector in Europe

Around 3,000 companies in Europe are active in the mechanical plastics recycling industry, meaning that they actually have machines installed to either shred, grind, wash, regenerate and/or compound.

About 80% of the total volumes that are mechanically recycled are, however, processed by less than 100 companies, so the market still is quite fragmented. A lot of companies in the recycling market are still family-owned businesses, and certainly not only the small ones, but even the larger recyclers are still SMEs. Others, meanwhile, have links with either plastic converter groups or waste collection companies.

Most companies specialise in recycling part of the plastics waste stream, doing for example only PVC waste and others doing only PET bottles.

(20) FIEC, Construction activity in Europe in 2002

PART 2 Management of plastic waste in C&D waste in Europe

The final report of the "Mechanical Recycling of PVC Wastes" Study for DG XI of the European Commission (January 2000) states that: "There is no European regulation for C&D waste, which is the most important waste stream for PVC. Only in a few member States do related measures exist. For example in the Netherlands, Sweden and Denmark there are national programmes to increase recycling and recovery of these wastes, in Austria an ordinance requires the separation of plastics and other fractions at the construction sites and in Germany there exist similar regulations on a regional level, being accompanied by local/regional landfill surcharges for mixed construction and demolition wastes."

Most EU member states in Western Europe have national systems to collect, recycle and recover some types of plastic C&D waste. They vary from one country to another depending on the policy philosophy, e.g. voluntary agreements, command-and-control policies, regulatory approach.

At a regional or local level, there is a poor knowledge of local plastics recycling: which plastics can be recycled, the collection methods and the sorting systems available, the quality requirements of recyclers, prices, technologies, etc. There is also a lack of knowledge of the recycling market operators and in general, weak cooperation between the main actors, i.e. the public authorities, the C&D sector and the plastics recyclers.

The objectives of this chapter are:
- to give an insight on the European framework regarding plastic C&D waste (point 1);
- to analyse national contexts in countries which have put in place leading C&D waste management systems and to gain a better knowledge of the technical challenge of plastic recycling and illustrate the case of plastic C&D waste recycling by a selection of interesting case studies from contemporary Europe (point 2).



1 Legal and political framework at European level

> 1.1. European legislation and policy

The principal directive controlling waste management throughout the European Union is the **Framework Directive on waste** 75/442/EEC amended by Council Directive 91/156/EEC. It recognises that Member States must "take measures to restrict the production of waste particularly by promoting clean technologies and products which can be recycled and re-used; to encourage the recycling of waste and re-use of waste as raw materials; to adopt specific rules for re-usable waste".

On 21 December 2005, the European Commission proposed a new strategy on the prevention and recycling of waste. As a first step, the Commission proposes revising the 1975 Waste Framework Directive to set recycling standards and to include an obligation for Member States to develop national waste prevention programmes. This revision will also merge, streamline and clarify legislation, contributing to better regulation. The strategy comes as a package. It includes a legislative proposal to modernise the 1975 Waste Framework Directive.

The main elements of the proposed revision of the Waste Framework Directive are:
- focussing waste policy on improving the way we use resources;
- mandatory national waste prevention programmes, which take account of the variety of national, regional and local conditions, to be finalised three years after the entry into force of the directive;
- improving the recycling market by setting environmental standards that specify under which conditions certain recycled wastes are no longer considered waste; and
- simplifying waste legislation by clarifying definitions, streamlining provisions and integrating the directives on hazardous waste (91/689/EEC) and on waste oils (75/439/EEC), the latter with a focus on collection rather than on regeneration that is no longer justified from an environmental point of view.

Further measures are programmed for the next five years to promote recycling and create a better regulatory environment for recycling activities.

Daughter directives to the framework Directive on waste are the incineration and landfill Directives. They aim to harmonise regulation between Member States in order to avoid the dumping of waste in countries where national legislation is less restrictive and therefore less costly.

> 1.2. Waste treatment policies

> Incineration

Directive 2000/76/EC of the European Parliament and of the Council on the incineration of waste has as its objective the prevention or reduction, as far as possible of air, water and soil pollution caused by the incineration or co-incineration of waste. The Directive is intended to fill the gaps existing in the Community's waste incineration system which was covered by Directives 89/369/EEC, 89/429/EEC and 94/67/EC. The Directive applies both to facilities intended for waste incineration and to co-incineration plants. Existing plants and new plants have to comply from December 2005 and 2002 respectively.

> Landfill

The Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste is intended to prevent the harmful effects of the landfill of waste which remains the prevailing option for many Member States, especially for municipal waste. It banned the co-disposal of hazardous and non-hazardous wastes. This Directive does not address plastics in particular, although it introduces a staged reduction of biodegradable municipal waste admitted to landfill of 25%, 50% and 65% below 1995 levels by 2006, 2009, and 2016 respectively. The dates can be extended by 4 years each for Member States that landfill over 80% of their municipal waste.

Through it is more costly than traditional final disposal, recycling in general will become increasingly attractive from an economical point of view. The strict requirements for waste and landfills will prevent and reduce the negative effects of landfill on the environment.

> 1.3. Product-related policies

A number of product-oriented Directives have been adopted in the last 10 years, resulting from a new integrated approach. The growth of interest in Integrated Product Policy (IPP) marks an important new stage in the evolution of environmental policies. The action has first concentrated on oils, packaging, end-of-life vehicles, and waste from electrical and electronic equipment and batteries.

> The first of these directives to be adopted was Council Directive 94/62/EC of 15 December 1994 on **Packaging and Packaging Waste** that was to be implemented by Member States by 30 June 1996. Directive 2004/12/EC (amending Directive 94/62/EC) provides that Member States shall take measures to prevent the formation of packaging waste, which may include national programmes and may encourage the reuse of packaging. Member States must introduce systems for the return and/or collection of used packaging to attain the following targets:

- no later than 31 December 2008 a minimum of 60% by weight of packaging waste will be recovered or incinerated at waste incineration plants with energy recovery;
- no later than 31 December 2008 between 55 and 80% by weight of packaging waste will be recycled; and
- no later than 31 December 2008 the following recycling targets for materials contained in packaging waste must be attained: 60% by weight for glass, 60% by weight for paper and board, 50% by weight for metals, 22.5% by weight for plastics and 15% by weight for wood.

> Construction and demolition (C&D) waste were the subject of a priority waste stream report in 1995. Since then, the Commission has put forward proposals for a Recommendation on the management of C&D waste, which could be made by the European Council and Parliament. In *Environmental Signals 2002*[21], the European Environment Agency reported that overall at European level "C&D waste quantities are increasing and are closely correlated with economic growth". At European level, there is no legislation directly relating to the recycling or removal of plastics from the building and construction sector. But the Packaging and Packaging Waste Directive (94/62/EC) and the Landfill Directive (99/31/EC) apply also to plastic waste from the C&D sector.

> Green paper "Environmental issues of PVC" (COM(2000) 469 final): this green paper on the environmental issues surrounding PVC was presented by the European Commission. There were several divergent scientific, technical and economic opinions about PVC and its effects on human health and the environment. Some Member States had recommended or adopted measures about specific aspects of the PVC life cycle. These measures were not identical and an integrated approach was therefore considered necessary. The first main objective of this paper was to assess on a scientific basis the various environmental issues including related human health aspects (use of certain additives in PVC, etc.) that occurred during the life cycle of PVC. The second main objective was to consider, in view of sustainable development, a number of options to reduce those impacts that needed to be addressed because PVC waste was expected to increase by about 80% over the next twenty years. The European Parliament considered that it was necessary to continue to develop technological research to reduce the costs of the process and improve its effectiveness to increasing the percentage of PVC waste recycled and to reduce the percentage of waste incinerated or landfilled. It also asked for an examination of the possibility of providing incentives for the use of recycled material, giving priority to PVC (pipes, tubes, window frames, roofing membranes, etc.).

(21) European Environment Agency - Reports, http://reports.eea.eu.int/environmental_assessment_report_2002_9/en

> 1.4. Voluntary commitment on PVC waste: Vinyl 2010

The European PVC industry has embarked on a 10-year plan to enhance its sustainability profile by relentlessly improving production processes and products, investing in technology, minimising emissions and waste and boosting collection and recycling.

Vinyl 2010 is the instrument to deliver the industry's commitments. It brings together European vinyl resin manufacturers, plastic converters and producers of stabilisers and plasticisers.

Specifically, for waste management, it aims to actively support an integrated waste management approach. The goal is to use raw materials as efficiently as possible and utilise the most sustainable end-of-life options. Vinyl 2010 and its members will work with stakeholders to research, develop and implement the necessary recycling technologies to achieve this target. Thanks to the development of additional mechanical and feedstock recycling technologies, total PVC post-consumer waste recycling is expected to reach 200,000 tonnes per year in Europe in 2010 (in addition to quantities already recycled today and coming from EU legislation on packaging, end-of-life vehicles and waste electrical and electronic equipment).

A Brussels-based international non-profit association Vinyl 2010 brings together the entire European PVC industry to implement the Voluntary Commitment.

To encourage a steady supply of PVC waste for recycling, Vinyl 2010 launched two new pan-European collection projects in 2004:

- Roofcollect, a collection and recycling initiative for end-of-life roofing membranes; and
- Recovinyl, a scheme to provide financial incentives to support the collection of end-of-life PVC products such as pipes, window profiles and shutters.

2 Strategies and practical experiences in Europe

In this section, we will describe the experience of 4 frontrunner countries (Germany, Austria, Denmark, The Netherlands) that have put in place legal, financial and/or technical frameworks with the objective of managing C&D waste.

We will see how these specific contexts have favoured the emergence of initiatives for the selective collection and recycling of plastic C&D waste.

For each country, we will describe the legislative instruments and the financial instruments implemented by the authorities. Then we will focus on the eventual voluntary agreements concluded between private sector and public authorities, and other remarkable technical aspects. Finally, the specific initiatives for plastic C&D waste collection and recycling will be examined.

> 2.1. Germany

High disposal cost
Landfill ban
Legal instruments
Voluntary agreements and commitments

The total C&D waste produced in 2002 amounted to 240.8 million tonnes. Only a fraction of 34.3 million tonnes is landfilled and 86% is recovered (206.1 million tonnes), which is in accordance with the objectives of the voluntary agreement.
The achievement of this recycling quota is closely linked to the high disposal costs in Germany as well as specific German legal and voluntary instruments that promote better C&D waste management:

- the Closed Substance Cycle and Waste Management Act[22]: aiming to promote a circular economy;
- the Ordinance on the management of commercial and some C&D waste, which requires that waste is sorted at source and kept sorted until recovery/disposal;
- the Landfilling Ordinance (24/07/2002) and the Ordinance on Waste Disposal aiming to develop mono-landfilling for inert waste, and in so doing to promote waste selective collection and sorting;
- the voluntary agreement with the construction sector (of 1996) to reduce the landfilling of C&DW by 50% by 2005; and
- collection and recycling schemes for the specific case of PVC C&D waste established by national associations in the 1990s, significantly prior to the Vinyl 2010 European Voluntary Commitment, which make it easier for Germany to fulfil the objectives of this Voluntary Commitment;
- the Ordinance on waste disposal, which states that from 01/06/2005 no untreated waste may be landfilled, is also an incentive for the sorting and recovery of waste.

(22) Kreislaufwirtschaft- und Abfallgesetz (KrW-/AbfG), 1996

2.1.1. Legal instruments in Germany

> Producer responsibility

The key to waste management policy in Germany is producer responsibility. Through this the conditions for effective and environmentally sound waste avoidance and recovery will already be have been created in the production stage. Producers and distributors must design their products in such a way as to reduce waste occurrence and allow for environmentally sound recovery and disposal of the residual substances. The 1996 Closed Substance Cycle and Waste Management Act puts this policy into practice.
In particular, construction and demolition waste management falls under the contractor's responsibility. C&D waste should be treated as follows:

- soil and stones should be reused as much as possible;
- mineral C&DW (concrete, bricks) should be separated and recovered, if technically feasible and economically reasonable;
- mixed C&D waste is allowed only if it is separated for recovery; and
- packaging waste must be collected separately so that a take-back system (ex. Interseroh) can deal with it appropriately; ideally multi-use packaging should be used.

For construction projects, sustainable products, which minimise the amount of polluting waste or which are made from recycled materials, should be used.
The Federal Ministry for Transport, Building and Urban Development published a guide on implementing these concepts in public works[23].
A guide on the ecological impact of construction works was created ARGEBAU[24].

> C&DW landfilling restrictions

The landfilling Ordinance and the Ordinance on waste disposal are the legal basis for the landfilling of waste. The general objective pursued is to allow landfilling only for inert waste, which makes waste sorting mandatory. This particularly applies to mixed C&DW.
The landfilling Ordinance established a new landfill category: category 0 for inert waste in which only concrete, bricks, ceramics and other mineral waste (with very little hazardous content) may be landfilled.
The Ordinance on waste disposal states that untreated waste will be banned from landfills from 1/6/2005. However, some exceptions will be granted allowing untreated waste to be landfilled until 15/7/2009.

> Ordinance commercial and C&D waste management

The Ordinance on the management of non-household municipal waste and some construction and demolition waste of 7/11/2001 has an important impact on selective collection of C&D waste as it requires that the producer and holder of C&DW collect, store and keep waste separately in order to favour recovery; the fractions which must be kept separated are: glass, plastics, metals, concrete, bricks and ceramics as long as they do not contain hazardous materials. This is a useful tool for stimulating selective demolition.

At Länder level

In some Länder, C&DW recycling reached 80 or even 90%, for instance, in Hamburg and Mecklenburg-Vorpommern.

The 90% recycling rate was achieved in Hamburg thanks to the regional C&D waste plan whose main aim was to secure the sorting of mixed C&D waste in the Region.
In addition, a cooperation agreement was signed on 18/02/2000 in north Germany between the environment ministers of the Länder Hamburg, Meckenburg-Vorpommern and Schleswig Holstein and 8 waste management associations. The aims pursued are

- resource saving,
- selective collection of waste,
- waste management in accordance with the proximity principle
- transparency of waste flows
- unification of the regulatory framework.

The following instruments were put in place to reach these objectives:

> Material flow chart

The C&D waste flow chart shows the amounts of input (construction materials), output (C&D waste), the link between both and what is done with them (reuse, recovery, contruction).

This chart shows that 2,5 million tonnes of C&D waste produced in the Hamburg region (total = 5,7 million tonnes) were recovered in the construction industry, i.e. 40%, which is higher than the national average of 25%.

> Local high-level waste management facilities

Waste management facilities are the key to recycling because they fulfil a waste treatment function and also because they allow the use of recycled C&D waste which saves natural resources.
Since the 1980s Hamburg has had a well organised waste management structure with qualified companies in the fields of collection, transport, treatment, recovery and disposal of C&D waste.
As a consequence, more than 80% of mixed C&D waste is treated in these facilities and the remaining 20% is treated around the Region, in accordance with the proximity principle.

> Waste control and waste transport control

C&D waste inspection structures "Bauabfall Nord e.V." and waste transport inspection structures "Bauabfall- transport e.V." have been in operation since the end of the 1980s, and have established a quality standard for waste management facilities.

(23) Bundesminister für Verkehr, Bau und Stadtentwicklung: http://www.bmvbs.de/
(24) ARGEBAU is a conference of the ministers of the 16 Länder in Germany responsible for city planning, construction and housing, http://www.is-argebau.de/

2.1.2. Financial instruments in Germany

There are no landfill taxes but rising landfill tariffs encourage sorting and recycling. There are no subsidies for C&DW recycling or re-use. In addition to the recovery obligation (cf. the voluntary agreement of the building industry), the high cost of landfill and its variation according to waste composition are incentives for sorting.
Indeed, between 1990 and 1996, landfill costs for mixed C&D waste increased from 38 to 138 EUR/tonne (and even reached 408 EUR/tonne in some cases) while prices for the mineral fraction remained constant (around 7.70 to 10.20 EUR/tonne)[25].

Recycling costs are not known in detail but it is understood that recyclers accept plastic C&D waste for free as long as it is sorted and delivered in large quantities; even if the material provided is mixed (ex. glass and metals are still attached to the PVC window frame).

Table 4 : Example - Tariffs for PVC disposal[26]

Type of treatment	EUR/tonne
Landfill	31-230
Incineration	128-306
Locally reduced incineration prices	From 102

2.1.3. Other measures

The German system is completed by the following measures:

- Recycled materials standards and norms.
- Demolition works standards and norms.
- Waste exchanges: Regional and national waste exchanges are organised on the internet for uncontaminated C&D waste materials, including plastics. Such auctions are organised by various companies, such as Clickwaste AG Deutschland[27].

2.1.4. Voluntary agreements in Germany

A voluntary agreement (VA) (Kreislaufwirtschaftsträger Bau - KWTB)[28] was concluded in 1996 between the Federal Ministry of the Environment, Nature Protection and Regional Planning (BMU)[29] and the building industry with the aim of stimulating on a voluntary basis the recycling in C&D works. The KWTB e.V. association was created to represent the parties to the VA: most C&D contractors, architects, engineers, construction materials manufacturers, etc.

The general objectives of the VA are

- to avoid C&D waste as much as possible,
- to reuse or recover unavoidable waste, and
- to eliminate non-recoverable waste in an environmentally friendly way.

The landfilled but recoverable waste fraction must be reduced by half between 1995 and 2005, i.e. by 23 million tonnes.
Other targets were developed in this VA, such as: waste management planning[30], R&D on avoidance of C&D waste production, quality assurance for recycled materials and promotion of applications for recycled materials.

At Länder level

Voluntary agreements also exist at regional level. For example, the VA agreed between the environmental authorities of Berlin and Brandenburg and their respective industrial and recycling organization contains the following objectives:

- Only re-use and recycling of C&DW is authorised (landfilling only for non-recyclable fractions).
- Adequate separation of the hazardous fraction.
- Quality standards of the recycled materials comparable to raw materials.
- As selective demolition becomes an attractive option for the C&D sector, on-site sorting is developing for the same reasons. The typical fractions to be separated are the mineral fraction, wood, roofing and packaging, i.e. materials which are relatively easy to keep separated and which have not been contaminated to a great extent by other waste types.

Selective demolition

Some local selective demolition projects also exist, such as in
Erfurt (former East Germany) where "plattenbauten", a kind of panel, were used in high-rise housing buildings (11 to 25 floors) in former East Germany. They are reused for the construction of lower-rise housing buildings (around 4 floors), to adapt to the changing demand of the housing market. The construction materials are re-used and part of the land where the buildings were located is used for new housing, in accordance with a general German objective to reduce the use of land.
Everything that can be taken out of the building before demolition is taken out, such as: window frames, floorings, roofing, pipes, doors, cables, etc.
What cannot be easily taken out, such as pipes or cables built in the concrete walls, is demolished with the main building and sorted mechanically or manually.
For demolition works where little space is available, a system of small containers is used for keeping the fractions separate from each other. If selective demolition is performed, then plastics are part of it.

(25) Gallenkamper B et al, «Vertärkte Erschließung des Verwertungspotentials von Baustellenabfällen durch organisatorische und technische Maßnahmen», Umweltbundesamt 1997.
(26) Arbeitsgemeinschaft PVC und Umwelt e.V.
(27) Clickwaste AG Deutschland: http://www.clickwaste.de/
(28) Kreislaufwirtschaftsträger Bau - KWTB: http://www.arge-kwtb.de/
(29) Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU): http://www.bmu.de/allgemein/aktuell/160.php
(30) Transposing the planning obligations contained in the EU framework waste directive.

2.1.5. Initiatives for plastic C&D waste collection in Germany

Preliminary remark:
In Germany the concept of "plastic recycling" may comprise material recycling as well as feedstock recycling, i.e. the conversion of plastic waste into valuable chemicals useful as fuels or raw materials.
For some plastic waste flows it is commonly accepted in Germany to include feedstock recycling in the recycling statistics.
However, for the very specific case of windows, only material recycling is accepted.

The recycling rate of C&D plastics waste in Germany is high compared to other European countries. For the windows, for instance, 40% of collectable and available waste was recycled in 2004, which is relatively high.

This is due to the fact that C&D plastics collection and recycling have for more than 10 years been organised in Germany via specific initiatives for each waste flow (windows, pipes, flooring and roofing). Overall, Germany contributes 36% of post-consumer PVC recycling in Europe[31].

> PVC waste management in Germany

In 2003, 1.9 million tonnes of PVC were produced in Germany and 1.6 million tonnes were consumed by the German conversion industry, of which 72% were used by the construction industry[32] .
Recycling systems for PVC window frames, pipes, floor coverings and other items have existed in Germany since 1991.

2.1.6. Collection and recycling systems for specific flows

Case 1: Collection system for windows

> REWINDO

Active since 2002, Rewindo is the largest German clearing house for post-consumer PVC window recycling. Rewindo cooperates with recycling companies. They make equipment, technology and logistics available for the collection side, and handle the reprocessing of fuel and the delivery of recycled PVC.

> Collection scheme

Collection takes place in 6 stages:

1. Establishment of contact with a qualified recycling company.
2. Communication of the approximate quantity of the windows, doors, shutters and their fittings (with or without glazing).
3. Submission of an offer by the recycling company. Selection of the offer by the waste owner.
4. The recycling company provides the coordinates of a pick-up point as close as possible to the waste owner and/or agrees on a date for the collection of containers supplied in advance.
5. Coordination of the collection logistics and delivery of the PVC waste to the recycling centres by the recycling company's transporters.
6. Recycling of the material, i.e. separation of the constituent elements, the high-quality PVC recyclate obtained is provided to the transformer of the "industry" treating the plastic material. The recyclate is reintroduced into the production of new PVC construction profiles.

Quantities:
The partners in Rewindo represent around 80% of the German plastic windows market. In 2004, the gross potential of used windows was 20,700 tonnes. The recovered part was 13,000 tonnes. The recycled quantity was 8,200 tonnes, i.e. a recycling rate of 40%.

> Conclusions

Rewindo organises the collection of post-consumer PVC windows and profiles via its partners throughout Germany. Joint collection allows the quantity of waste to be increased and, therefore, the development of bigger recycling plants.

http://www.rewindo.de

(31) EuPC, Total of audited PVC post-consumer waste recycling in the EU 15 in 2003
(32) Arbeitsgemeinschaft PVC und Umwelt e.V., PVC-Recycling, December 2001, p.4

Case 2: Collection system for roofing membranes

> ROOFCOLLECT

The Roofcollect system (recycling system for thermoplastic membranes) was introduced in 2003 by the roofing membranes sector represented by ESWA. The objective was to collect end-of-life roofing and waterproofing membranes and to recycle at least 50% of the available and collectable quantities of post-consumer material by 2005.

> Collection scheme

- The membranes are collected in big bags. Interseroh Entsorgungsdienstleistungs GmbH handles the collection of end-of-life PVC roofing membranes.
- Transportation from construction site to the recycling plant is now fully organised in Germany and the system is to be extended to the rest of Europe.
- The following conditions have to be met on the construction site:
  - Pre-cleaning of the membrane, as they should not contain residual particles of glue or bitumen.
  - Removal of the fastening elements of mechanically fastened roofing membranes, measuring and cutting the membrane into metre-wide strips
  - The old roofing membrane must be rolled up and fixed.
  - Stacking in big bags.

915 tonnes were collected in 2005 (of which 889 tonnes were PVC) and 812 tonnes of post consumer PVC were recycled from these applications. Although achieving substantial progress on the previous year with increases of 57% in collection and 48% in recycling, ESWA nevertheless fell short of its target of recycling at least 50% of the available and collectable quantities of post-consumer material by 2005, because this corresponded to 1,200 tonnes. Germany remains by a substantial margin the largest market for PVC roofing membranes. In July 2005 a ban on the sending to landfill of most types of material came into effect. This had a significant and rapid effect with major increase in the volume of waste collected as from August.

Given the results obtained by the DUD/ESWA system with Interseroh, an expansion to Belgium, the Netherlands, Austria and France is envisaged. Other European countries are also being examined as possible members of the collection system.

> Recycling

ESWA has partnerships with several recycling plant operators. Vinyloop®, a process owned and operated by Solvay and based on selective dissolution by a solvent (see below), was selected by ESWA in 2004 as the prime long term solution to deliver tailor made recyclates. In 2005 an agreement was made to recycle 100 tonnes of PVC roofing waste in 2005 and 250 tonnes in 2006. An initial difficulty was encountered with certain types of fibres but rapidly solved by diluting these with cable waste. Roofcollect also contracted KVS Herbolzheim in Germany to shred certain types of waste for delivery to Vinyloop® while it evaluates whether to install its own shredding facilities. ESWA now closely cooperates with Jutta Hoser in Kodersdorf, Germany, in recycling PVC roofing and waterproofing waste material. This company has an innovative application for the recyclate as drainage sheets for riding halls, tournament stadia and stables.
Market: Weatherproofing membranes, drainage sheets.

> Costs

Information on costs for transport and recycling as well as registration forms are available on the ROOFCOLLECT website and can be printed or downloaded.

> Conclusion

With the organisation Roofcollect, which will be spreading all over Europe, the recycling of PVC or PVC-containing roofing membranes becomes an attractive alternative to landfill or incineration.

http://www.roofcollect.com/

Case 3: Collection system for flooring

> AgPR - Association for PVC floor covering recycling

End of 1993, producers of PVC and PVC floor coverings joined together and established the AgPR (Association for PVC floor covering Recycling).

> Collection scheme

A network of collection centres takes back floor coverings meeting the list of acceptance criteria. If the acceptance criteria are respected, collection is free of charge. The coatings are sorted beforehand on the building site.

Type of plastics considered:

- Homogeneous coverings (one-layered, patterned)
- Heterogeneous coverings (PVC surface on a PVC underlay)
- System flooring (thicker PVC surface layer on PVC foam underlay)
- Cushion Vinyl floor (thinner PVC surface on PVC foam underlay)
- PVC Wall coverings (PVC surface on PVC foam)

Acceptance conditions:

1. Only sorted post-use PVC floor coverings and PVC off cuts – which conform to the AgPR recycling list – can be accepted and utilised at the AgPR collection centres.
2. The material should not have been compacted.
3. Cement or glue residues adhering to the PVC do not present a problem provided their weight is markedly less than that of the PVC floor covering.
4. PVC floor coverings that are contaminated by oil, solvents or other dangerous substances are not acceptable.
5. The costs of disposing of delivered material that cannot be utilised in the recycling process will be charged to the supplier of that material.
6. If the amount of unusable material in one single delivery exceeds 5%, the AgPR will be compelled to refuse acceptance of the delivery or to charge the supplier for the sorting and return or disposal of non-recyclable material.
7. It is recommended that an appointment be made with the appropriate collection centre before delivery. The address of the nearest collection centre can be obtained from the AgPR.

Quantities: Recycling capacity of approximately 6000 tonnes, but in real terms AgPR recycled 4000 or 5000 tonnes per year.

> Recycling

Recycling technique: Mechanical recycling.
Quality of recycled products: AgPR produces a finely ground black/grey powder (particle size smaller than 400 µm). The product contains PVC, plasticisers and fillers.
Market: This powder is well suited for use in the production of new floor coverings.

> Costs

The necessary financial means are provided by the AgPR's members.
Collection centres take back floor coverings for free.

> Conclusions

- This project is interesting for its network of collection centres. It gives the advantage that big quantities are not needed to deliver to the collection centres.
- The PVC floor coverings have to be separated from other floor coverings like linoleum, textile coverings, rubber flooring, bitumen covering, etc., but can be contaminated by cement or glue residues, which is frequent on building sites.
- The members of AgPR finance the cost.
- The recycling plant is situated in Germany but collection also takes place in neighbouring countries.

http://www.agpr.de/

Case 4: Collection system for pipes

> KRV

In 1994 the German association of plastic pipes manufacturers Kunststoffrohrverband (KRV)[33] and the Gütegemeinschaft Kunststoffrohre (GKR)[34] established a plastic pipes collection and recovery system which is free for sellers and customers. In order to do so, KRV set up collection and recycling systems for their products. These are set apart by the fact that they decided to collect and recycle all plastic pipe system waste, whether they are made of PVC or other plastics, such as polyethylene, polypropylene and other thermoplastics. The sales value of the secondary raw material is approximately 70% (best quality) of the price of corresponding new plastics.

http://www.krv.de/

(33) Fachverband der Kunststoffrohr-Industrie: http://www.krv.de/. KRV is an association representing the pipes and fitting manufacturers in Germany
(34) Gütegemeinschaft Kunststoffrohre (GKR): http://www.krv.de/gkr.htm

Case 5: Collection system for coated fabrics

> EPCOAT

The EPCOAT[35] project is an initiative of the European PVC coated fabrics sector covering applications such as tarpaulins, tents, marquees, advertising panels, artificial leather, etc. to contribute to the recycling targets of Vinyl 2010.
In respect of collection schemes a contract was signed in early 2004 between IVK (Industrieverband Kunststoffbahnen), the German Plastics Foils Association, and the German Waste Management company RWE Umwelt. Subsequent to the contract RWE was taken over and the new owner expressed no interest in continuing the contract in 2005/2006. Currently, Interseroh undertakes most of the collection and transport, with a smaller contribution by IVR and KMW. Transport costs remain an obstacle, even though the system of 'big bags' facilitates collection up to a maximum 1.1 tonnes of waste each.

On recycling, in 2004, German company Friedola received some of the collected waste from the IVK collection scheme. During 2005 Friedola invested, with financial support from Vinyl 2010, in technical improvements in the mixing silos, conveying and cooling material, exchange motors and control system. The firm has little use itself for the recyclates of coated fabrics and tests are ongoing to develop new markets for several end products (e.g. basic tarpaulins and reinforcement fabrics).
The company Hoser, in Kodersdorf, also successfully started recycling coated fabrics for its line of drainage sheets (see also section on flooring above) and treated the bulk of the volume in 2005.

http://www.eupc.org/epcoat

Case 6: Collection system for cables

An important fraction of cable waste is prepared by cable separators who recover copper and aluminium by shredding and separation (sieving and pneumatic separation). The recyclates, such as PVC, Polyethylene and rubber can be used for various products. According to the Arbeitsgemeinschaft PVC und Umwelt[36], of the 47,500 tonnes of PVC cable insulation materials waste produced in 2004 in Germany, 14,600 tonnes were recycled in Germany into products such as industrial floorings and road safety products. About 8,000 tonnes are exported yearly for recycling outside Germany. In addition, 11,000 tonnes of such waste are used for energy recovery.

2.1.7. Conclusion

The success of plastics waste recycling in Germany is also influenced by the general context, which is characterised by a combination of instruments promoting recycling:
- high disposal costs;
- the changes in landfill management, such as the landfill ban for untreated waste; and
- a general policy to promote recycling.

In the future, a significant increase in plastics waste and in plastics recycling quantities and capacities (up to 30%) is expected as well as an improvement in recycling techniques.
As a consequence, more selective collection and recovery techniques and facilities will be needed and will have to be effective to treat the increasing quantities of materials.

RECOVINYL, Europe

> Description

The main problem with post-consumer PVC waste is that of ensuring a steady supply of secondary raw materials to recyclers in order to justify their investments. In order to ensure a steady supply, recyclers and the PVC sector, vinyl producers and converters agreed to establish an association, RECOVINYL, to foster the collection and recycling of post-consumer PVC waste across Europe through a network of certified recyclers (http://www.recovinyl.com). RECOVINYL aims to recycle 75,000 tonnes of post consumer PVC in Europe by 2010, focusing on mixed streams for hard PVC mainly in the C&D activities.

> Collection scheme

Type of plastics considered: window frames, shutters, profiles, cladding, cable ducts, and pipes.

> Costs

Incentive paid to collectors, registered on our website, per tonne of post-consumer PVC collected and delivered to a certified recycler.

http://www.recovinyl.com/

(35) EPCOAT - EuPC PVC Coated Fabrics Sector Group - http://www.eupc.org/epcoat
(36) Arbeitsgemeinschaft PVC und Umwelt e.V: PVC-Recycling, December 2001, p.16

> 2.2. Austria

Landfill ban
Legislative instruments
Voluntary agreements

Austria is a frontrunner in C&D waste recycling thanks to the voluntary agreement signed in 1990 between the Ministry for Economics and the Construction Industry Federation. The objective pursued is to increase C&D waste recovery rates in order to reduce landfilling and so preserve natural resources, in accordance with the aims pursued by the Waste Management Act (Abfallwirtschaftsgesetz).

The Generation of construction and demolition waste (excluding 22 million tonnes excavated soil) in Austria was 2004 total 6,72 million tonnes[37].
3,8 million tonnes of the Austrian CDW are recycled of the members of the Austrian building material recycling association (Österreichischer Baustoff Recycling Verband - ÖBRV). The Recycle-Quota of "Demolition waste (excl. construction waste)", "Road-construction waste" and "Waste concrete" is about 76 %.

The Austrian legislative framework is characterised by tools that lead to recycling promotion in general, such as the implementation of the Landfill Ordinance according to which only pretreated waste may be landfilled as of 01/01/2004.
On C&D waste in general, the Ordinance on C&D waste separation requires that the various different flows (including plastics) be collected separately and recovered.

2.2.1. Legal instruments in Austria

> Landfilling Ordinance of 1996

From 01/01/2004, only pre-treated waste that threatens no harm to health and the environment may be landfilled. The Ordinance contains a specific obligation to pre-treat high calorific power waste before landfilling.

> Ordinance on C&D waste Separation

The "Baurestenmassetrennungsverordnung BGBl 259/1991" is applicable since 1/1/1993 and obliges the contractor to sort C&D waste into different material flows and to recover it if minimum quantities arise, such as: 20 tonnes of excavated soil, 20 tonnes of concrete, 5 tonnes of asphalt, 5 tonnes of wood, 2 tonnes of metal, 2 tonnes of plastics, 40 tonnes of mineral C&DW or 10 tonnes of mixed C&D site waste. The contractor must register the sorted and treated waste materials in the appropriate form (Baurestmassennachweisformular[38]).
Waste must be sorted either on site or at specialised centres and in such a way that recovery is possible.
This sorting and recovery obligation applies only if there is a treatment centre at a distance of at most 50 km from the waste production site and where recovery costs do not exceed 125% of traditional disposal costs.

2.2.2. Financial instruments in Austria

There are no landfill taxes but there are fixed "remediation rates"[39] aiming to discourage landfilling. The funds collected are to be used exclusively for the remediation of contaminated industrial sites and old landfills.
There are no direct subsidies for C&DW recycling or re-use.

2.2.3. Voluntary agreements in Austria

A voluntary agreement was signed in 1990 between the Ministry of the Economy and the Construction Industry Federation; the objective pursued is to increase C&D waste recovery rates in order to reduce landfilling and so preserve natural resources.
This voluntary agreement led to the Ordinance on Separation of C&D Waste.
In 1990, 14 enterprises founded a voluntary association of recycling companies, the "Österreichische Baustoff Recycling Verband"[40], now comprising 60 members. The members recycle up to 80% of C&D waste at 100 fixed and mobile recycling facilities.
Various issues mentioned in the VA have been implemented, such as quality standards for recycled materials and a waste exchange scheme.

(37) Austrian Federal Waste Management Plan 2006 http://www.bundesabfallwirtschaftsplan.at/
(38) Baurestenmassetrennungsverordnung BGBl 259/1991, http://www.wk.or.at/fvbi/nachw.htm
(39) According to the amended law of 7/6/1989 to finance the remediation of contaminated sites
(40) Österreichischer Baustoff-Recycling Verband: http://www.brv.at

2.2.4. Initiatives for plastic C&D waste recycling in Austria

The recycling techniques applied to Austrian waste are the "classical" ones: mechanical recycling (and feedstock recycling) some being processed in Austria, others in Germany. According to the Austrian Federal Waste Management Plan 2006[41], 59 million tonnes of waste are produced yearly in Austria from which 0.96 million tonnes are hazardous.

22 million tonnes (37,2%) are excavated soil and 6.72 million tonnes (11.4%) are C&D waste, their sum, 28.7 million tonnes, accounts for 48.6% of the total waste produced. A general estimation of 450.000 tonnes of plastic waste is proposed by the Austrian Chemical Industry Federation FCIO[42], which would represent 1.1% of the total waste produced of 37 million tonnes waste produced (excavated soil is excluded).

Austria, as Germany's neighbour, benefits from the facilities and techniques used for PVC C&D waste and is influenced by the general recycling trends in Germany. However, the recycling of PVC C&D waste is still marginal except for pipes where the Austrian pipes manufacturers have created a nationwide voluntary association for the collection and recycling of old pipes. For floorings, an organised collection and recycling scheme is operational in Upper Austria, and for windows and roofing initiatives and results are still marginal.

Case 1: Collection system for pipes

> ABCO

In response to the proposal of the Austrian Parliament to recover PVC construction materials, the Austrian pipes manufacturers created, on a voluntary basis, the association "Österreichischen Arbeitskreis Kunststofrohr Recycling-ÖAKR"[43]. The association comprises pipes and fittings manufacturers and importers.
A nationwide network for the collection, sorting and recovery of plastic pipes is in place and is managed by "ABCO Abfall Consulting GmbH"[44] and its regional partners.

Different kinds of plastic pipes are collected via the ÖAKR network: PVC, Polypropylene, Polyethylene, Polybutene.
Three options are offered to the waste holder:

- bringing his waste free of charge to one of the 54 collection sites for used pipes and fittings,
- bringing his waste directly to the waste treatment centre free of charge, or
- renting a container for which he must pay a price.

After sorting and cleaning, the waste is transformed into secondary raw material (granulate), which is brought back into the production cycle.
Only pipes without strongly attached impurities such as: concrete, bitumen, etc. are available for mechanical recycling (usually into other products than new pipes, for technical reasons). More seriously contaminated waste is treated in another way, such as by thermal recovery.

According to the ÖAKR, of the 5,000 tonnes collected waste, 4,000 tonnes were recycled into cable protection pipes, plates and pallets.

http://www.abco.at/

Case 2: Collection system for flooring

> LAVU A.G.

PVC flooring is collected in Austria and in particular in Upper Austria since 1990. The Oberösterreichische Landes-Abfallverwertungunternehmen, LAVU A.G.[45] organises collection and recycling.

Collection is organised via a network of 180 collection centres where households and businesses can bring their waste.
Used floorings are taken back in strips; they are brought from the collection point to the central collection centre and then transported to Germany for recycling.

According to API PVC- und Umweltberatung, 109.6 tonnes of used PVC flooring were recovered in 2001[46]. PVC floorings are generally recovered into the production of new floorings.

http://www.lavu.at

(41) Austrian Federal Waste Management Plan 2006, http://www.bundesabfallwirtschaftsplan.at/
(42) Fachverband der chemischen Industrie Österreich FCIO, http://www.kunststoffe.fcio.at/publikationen/abfaelle1.htm
(43) Österreichischen Arbeitskreis Kunststoffrohr Recycling: http://www.oeakr.at
(44) Abfall Consulting GmbH (ABCO) http://www.abco.at/
(45) Oberösterreichische Landes-Abfallverwertungunternehmen (LAVU) http://www.lavu.at
(46) API PVC- und Umweltberatung, http://www.pvc.at/d/themen_recycling_print_0301_2.htm

> 2.3. Denmark

Polluter Pays Principle
Landfill tax
Voluntary agreements

Danish waste management policy at national and local level primarily focuses on the "Polluter Pays Principle". The high cost of sending waste to landfill or incineration encourages waste producers to maximise their recycling efforts, while the tax on raw materials encourage industries, particularly building and construction, to use reclaimed and recycled materials (which are not subject to taxation). In addition to this, waste producers must finance the management of their waste, whilst its movement, from production to disposal, is monitored at every step by the local authority.

According to the Danish Environmental Protection Agency (EPA)[47], construction and demolition activities generated approximately 4 million tonnes of waste per year. In 1999, Denmark's waste management plan, Waste 21, set a target to maintain the 90% recycling for C&D waste in 2004. This was first reached in 1997 and has been maintained at this level ever since. The remaining waste is incinerated or sent to landfill.

Demolition waste comprises 70 to 75% of C&D waste, whilst 20 to 25% comes from renovation and a further 5 to 10% from new building developments.

The focus is currently on ways to increase recycling levels of PVC waste produced by the C&D sector, which produces more PVC waste than any other sector. Since the introduction of regulations for the management of PVC waste in April 2001 recycling of PVC waste has become obligatory.

Denmark's high recycling rate for C&D waste is maintained by using a combination of legislative and financial instruments to divert recyclable and reusable materials away from landfill. Furthermore, a wide range of players within the building and construction industry are encouraged to participate in the waste management process through voluntary agreements and government-sponsored R&D projects.

2.3.1. Legal instruments in Denmark

There are several key elements to Danish waste management policy in relation to C&D waste: prevention, source separation and recycling. Prevention is achieved by the promotion of cradle-to-grave product design that integrates waste management into the product lifecycle. In the building and construction sector, recyclable materials such as stone, bricks, soil, asphalt, plastic and wood, etc. are separated.

The Danish Environmental Protection Agency is responsible for formulating and implementing action plans which are regularly monitored and updated. These are supported by economic, administrative and technical tools to ensure that the recycling rate remains high. They include the following:

- A tax on waste that is incinerated or sent to landfill.
- A ban on landfilling waste that could be incinerated was introduced by the Danish government in 1997.
- Statutory Order (no. 655 of June 27 2000) on Recycling of Residual Products and Soil in Building and Construction Work that sets out the rules for recycling residual products and soils in building and construction work.
- A tax on the extraction and use of raw materials.
- Action plans at national level to encourage recycling.
- Voluntary agreements with producers of C&D waste.

2.3.2. Financial instruments in Denmark

> Landfill tax on construction and demolition waste

Since its introduction in 1987, the Landfill Tax has been the main factor in helping to maintain high recycling rates. In the case of C&D waste its impact has been significant, mainly because the tax is weight-based and waste producers have directly incurred the costs. Landfill is a costly option compared to the recycling of materials, especially concrete, bricks and asphalt.

> Treatment costs in Denmark

The cost of sending waste to landfill is one of the main contributing factors to the high recycling rate. When the Danish Waste Tax on the landfilling of waste was introduced in 1987, the charge was approximately 5 EUR per tonne. By 2001 it had increased to 50 EUR per tonne. The tax has given an incentive to enterprises to recycle waste instead of sending it to landfill, creating savings of 40-47 EUR per tonne (EEA).

TABLE 5 : PLASTIC (TONNES) COLLECTED FOR RECYCLING 1998-2002, BY SOURCE[48]

Type	Source	1998	1999	2000	2001	2002
Packaging waste	Households	0	0	0	64	1682
	Service	0	0	0	621	2764
	Industry	0	0	0	1590	1342
	Building and construction	0	0	0	7	26
	Other	0	0	0	3583	0
Subtotal		*0*	*0*	*0*	*5865*	*5814*
Other waste types	Households	1233	1459	1585	1473	3165
	Service	4021	5865	7411	8737	10126
	Industry	27517	30535	31150	29646	30713
	Building and construction	67	285	117	352	719
	Treatment plants	0	0	0	0	6
	Other	129	0	0	85	81
Subtotal		*32966*	*38144*	*40263*	*40293*	*44809*
Total		**32966**	**38144**	**40263**	**46158**	**50623**

(47) Miljøstyrelsen, Miljøministeriet: http://www.mst.dk/homepage/
(48) Danish Environmental Protection Agency Waste Statistics 2002

2.3.3. Voluntary agreements and initiatives in Denmark on C&D waste

> "Cleaner Products Programme"

The "Cleaner Products Programme" was established by the Danish EPA with the aim of minimising the environmental impact of products during their life cycle. On this basis a number of product panels were established, including the Danish Product Panel for Building and Construction. This is an independent body of representatives from the Danish Building and Construction industry which includes contractors, developers, planners, manufacturers, research institutes, etc.
The panel published a plan of action that considers various aspects of environmentally friendly building design, including the management of C&D waste before construction begins.

One area of consideration is the consumption of materials and waste prevention, for which the panel sets targets to minimise consumption of non-renewable raw materials and limit consumption of renewable materials to sustainable levels, as well as to reduce the amount of waste generated and promote the recycling of raw materials.

> Voluntary agreement on demolition NMK 96[49]

Nedbrydningsbranchens Miljøkontrolordning (NMK 96) is an agreement that was made between the Danish Demolition Association and the Ministry of Energy and the Environment in 1996 that sets the standard for good practice and environmental management systems. It obliges contractors to undertake demolition activities in an environmentally friendly manner to enhance waste prevention and recycling of C&D waste. Selective demolition of modern buildings is planned alongside construction and is, in effect, a reversal of the building process whereby structures are disassembled into separate material fractions. According to the Waste Centre Denmark, this process can allow recycling rates of up to 90%.

2.3.4. Plastic waste management in the C&D sector in Denmark

According to the Danish Environmental Protection Agency, approximately 34,000 tonnes of PVC waste were generated in 2002, around one third (33%) of PVC waste in Denmark is generated by the building and construction sector (making it the largest single industrial and commercial producer of PVC waste). Currently, only 10 to 15% of PVC waste is recycled and the remainder is incinerated. Since the introduction of regulations for the management of PVC waste in April 2001, separation of recyclable PVC has become obligatory.
The Danish waste strategy aims to phase out the incineration of PVC, since it provides little environmental benefit over landfilling. According to Kristensen[50], the costs per tonne of incinerating PVC are estimated to be in the regions of 190 EUR per tonne. Greater use of flue gas cleaning (lime and lye), disposal of residues, and increased production of wastewater contribute to the high costs compared to incineration of conventional municipal solid waste.

> The PVC Agreement

An Action Plan to reduce the use of PVC was presented by the Minister of the Environment in October 1988. Following this, negotiations took place between the Minister of the Environment, the Danish Employers' Confederation, the Industrial Council and the Danish Plastics Federation as well as several retailers, and thus the 'Agreement Regarding the Use of PVC' entered into force in 1991.

The agreement states that the establishment and running of recycling schemes for C&D waste containing PVC is the responsibility of the waste producer.

(49) Nedbrydningsbranchens Miljøkontrolordning (NMK 96): http://www.nmk96.dk/
(50) Kristensen, N. B., PVC waste in Denmark- costs and benefits of alternative treatments. OECD, 2004

The WUPPI Plan, Denmark

> The WUPPI Plan[51]

The recycling company WUPPI was established in 1998 by five of Denmark's largest manufacturers of PVC building products to enable the building and construction industry to fulfil the objectives of the PVC agreement. Its main purpose is to provide schemes for the collection and recycling of rigid PVC in C&D waste with the aim of receiving up to 80% of this waste fraction once the schemes have been fully established. Currently, around 50% of PVC waste is captured for recycling.

The WUPPI operates a five-stage closed loop system:

- Rigid PVC products
- Collection
- Handling
- Regeneration
- Recycling

WUPPI containers are provided at municipal bring points, and are available for companies and householders to deposit their PVC waste. Once the containers are full they are collected and transported to one of six collection stations where the PVC waste is checked and approved before being sent on to sorting and treatment plants in Sweden and Germany. Here it is separated and mechanically processed into 8-17 mm size granulate, which is washed to separate out the impurities and unwanted polyolefins.

According to Peter Bay, Administrative Director of WUPPI, approximately 90% of the processed PVC granulate is sent back to WUPPI to be sold to manufacturers of products such as electrical conduits and sewage pipes, while the non-recyclable fraction is incinerated. Products collected and treated include:

- Roof plates
- Gutters, drainpipes
- Pipes, chambers, fittings
- Windows, doors
- Profiles, strips
- Other livestock building equipment

WUPPI supplies wire mesh containers that are available in 4m^3 and 16m^3 sizes. Waste producers are charged per container (with the exception of those located at municipal bring points: these are free of charge to householders and small companies, and the costs are incurred by the local authority): DKK 100 deposit and DKK 300 for collection. If other materials are mixed in with the PVC, the waste producer can expect to pay an additional DKK 1,200 (EUR 161) for emptying, sorting and separation, therefore, waste producers are actively encouraged to separate materials correctly before disposal.

Currently, 75% of municipalities are members of the scheme and over 1,100 WUPPI containers are located at bring points throughout Denmark. Approximately 140 tonnes PVC waste from householders and small companies are collected nationwide every month.

http://www.wuppi.dk

VAL-I-PAC, Belgium

> Description

VAL-I-PAC organises a collection system by selling bags of 400 litres at 1 EUR/bag to contractors via their construction materials merchants.
The contractors use the bags to collect their plastic packaging waste on their construction sites.
Once the bags are filled, they can be put in specific containers at the dealer's place. A waste collector empties the containers.
All the bags are numbered in order to guarantee quality and to identify any user placing impurities in their bags.
The collected plastics are checked and sorted by the waste collectors and transported to recycling centres where they are melted into secondary raw materials which are used to produce recycled plastics.
The quality of the secondary raw materials and of the recycled plastic is quite good, thanks to the quality of the plastic packaging used in the construction and the relatively high purity of the collected waste, and because it has been sorted a second time.

> Collection scheme

Type of plastics considered: plastics packaging films from construction sites.
Quantities: approx. 400 contractors; 28 merchants (45 sites); 5 waste collectors (info 2006) and more than 100 tonnes of plastic packaging films were collected (2005 information).

> Recycling

Quality of sorted plastics: very good, only 5% impurities on average.
Recycling technique: mechanical recycling.
Quality of recycled products: very high quality thanks to the low percentage of impurities, the type of plastic used to pack the construction materials and the fact that the waste is sorted a second time.
Outlets: plastic packaging is recycled in packaging or other plastic products.

> Costs

1 EUR/bag for the contractor. VAL-I-PAC: stimulating selective collection of plastic film in the construction sector, Belgium.

http://www.valipac.be/

(51) WUPPI A/S: http://www.wuppi.dk

> 2.4. The Netherlands

Integrated approach based on recycling market flows
Producer responsibility
Landfill tax and ban

The Dutch have developed the concept of «sustainable development within the building industry». The basic premise of the sustainability concept is that if material cycles could be closed (use, reuse, re-reuse, etc.), less disposal and less consumption of non-renewable natural materials would occur.

A number of legislative initiatives have contributed to the framework for sustainable construction. Examples are the National Environmental Policy Plan, the Waste Materials Policy, the Soil Protection Policy, the Surface Minerals Policy, and the Construction Industry Policy Declaration.

The Dutch adopted a "market" philosophy: recycled materials are considered as «products» and not as «waste». This means that the waste will exhibit a typical product life cycle in the marketplace. Governmental and private-sector informational campaigns and policies support this market.

In the Netherlands, the government provides clear and unequivocal engineering and environmental standards for all recycled materials.

Furthermore, public or industrial working groups (including contractors) work together to achieve these standards. Recycled materials producers treat their materials like a «product,» using certified quality-assurance/quality-control programs so that the materials can compete against virgin materials.

Government and other public sector organisations run their own research and development programs in the field of prevention, re-use and recycling of construction and demolition wastes and in providing financial and management support for feasibility studies or research projects.

A number of materials are recycled at rates higher than 90 percent: construction and demolition aggregates, steel slag, blast furnace slag, phosphorus slag, coal fly ash, municipal solid waste incineration bottom ash, and RAP (reclaimed asphalt pavement).

2.4.1. Legal instruments in The Netherlands

> Producer responsibility[52]
The producer is wholly or partially responsible for the management of his products in the waste phase, and for the costs of the waste management. These costs are included in the price of the product, in line with the "polluter pays" principle. Another consequence is that greater account is taken in the design, production and use of the product and of the problems which may arise in the waste phase. All producers contribute financially to a foundation, usually in relation to the amount of products they put on the market (a small amount for each product put on the national market) and the foundation spends these funds on collecting and recycling the products when they become waste. Where 80% of the producers/importers on the Dutch market want to join a collective system of producer responsibility, they can ask the ministry (VROM) to declare the system universally binding. This means that the other 20% are also obliged to contribute to the system and cannot benefit from it for free. Each producer/importer must contribute to the system for the collection and recycling of its products. Opportunities to recycle materials or products can then be exploited more effectively. Producers are likely to know best what the possibilities are for recycling their product, and are in a position to feed the secondary generated back into the production process.

> Waste Substances Decree[53]
This Decree is also known as "Prohibition of Landfill". Since 1 January 1997, there is a total national ban on the disposal of reusable C&DW and as a result only certified C&D crushers and sorters are allowed to dispose of non-reusable C&DW (contaminated rubble and coal tar).

> National waste management policy and markets development
The national waste management policy aims to increase the influence of market forces in waste management. This will constitute a further step in the direction of an efficient and financially healthy economic sector that would work within the environmental conditions to be set by government. One crucial element in the management of construction and demolition waste is the market for secondary materials produced from waste.

> At local level
An agreement on cooperation between central government, the provinces and local authorities has been concluded (Waste Management Council). Provincial ordinances contain rules governing the disposal of commercial and industrial waste and hazardous waste (rules for collection, bans on the export for certain types of waste to other provinces, rules on reporting the transfer or receipt of commercial/industrial hazardous waste). The local authorities have several instruments to stimulate the use of secondary raw materials. For instance, they can include specific regulations into development plans or attach conditions to building permits when they are issued.

> Recycled materials standards and norms
The environmental standards to be met by secondary building materials are laid down in the Building Materials Decree. Certification of the final product gives customers certainty that the product meets all the engineering and environmental specifications.
Standard performance specifications (RAW 1995) are available for recycled and mixed aggregates when used as a sub-base material.

(52) Ministry of Housing, Spatial Planning and the Environment: producer responsibility, http://www.vrom.nl
(53) Ministry of Housing, Spatial Planning and the Environment: general policy on waste, http://www.vrom.nl

2.4.2. Financial instruments in The Netherlands

> Taxes[54]

In 1995 the Environmental Tax Act introduced a tax on waste going to landfill in order to discourage landfilling[55]. For C&D waste this tax is 83 EUR/tonne.

Between 1996 and 2001/2002 the amount of landfilled waste decreased by approximately 30%, while the amount of waste incinerated increased by 30% and the recycling rate increased by 16%. There is no tax on natural aggregates at the moment.

> Subsidies

The Dutch Government offers contractors the opportunity to earn bonuses if they use secondary (C&DW–derived) aggregates instead of natural gravel in public works.

2.4.3. Positive C&D waste planning measures[56]

In order to reach its target of 90% reuse of C&DW, the Dutch Government has taken several actions to discourage the generation of C&DW and to promote its re-use. Some basic measures, including requirements or recommendations that certain C&DW streams be separated, and that crushed rubble must be used as a secondary raw material, can be applied to all building projects, whereas others measures could only be applied to a more limited group of projects.

In order to assist national, regional and local government organizations, the Ministry of Environmental Planning has published a handbook which provides a number of practical measures and instruments on the use of secondary raw material, such as the design of long-range plans, policy developments, advisory services, creation of incentives, building specifications, selection of participants with experience and knowledge (building contractors, architects, developers, etc.).

2.4.4. Voluntary agreements in The Netherlands

In 1995, the Dutch Government and 20 [57] industry organisations, including BABEX (the demolition waste contractor's organisation), agreed on measures to prevent and re-use C&DW. In 1996, an agreement between the demolition waste contractors and the supplier of aluminium building materials was made to promote closed life cycle for aluminium building products. The same year, another agreement was made between demolition waste contractors and a glass recycling company for the separate collection of glass on demolition sites. Producer responsibility has been introduced on a voluntary basis for PVC exterior building material (windows and shutters) and PVC piping (with no minimum target recycling rate).

2.4.5. Plastic C&D waste in the Netherlands

Concerning the mechanical recycling of PVC waste, there are two recycling plants with a total capacity of about 10,000 tonnes per year. The majority of PVC waste that is not recovered or recycled is sent to incineration. The cost [58] of landfilling PVC ranges between 42 and 96 €/t plus a 14 € tax/t.

Table 6 : Summary on quantity of recycled PVC in pipes, cable and floorings in the Netherlands

	Quantity *(tonnes)*	Quantity recycled	Pre-consumer waste (production waste) *(tonnes)*	Pre-consumer waste recycled	Post-consumer waste collected *(tonnes)*	Post-consumer waste recycled
Pipes	11,200	9,900	7,200	7,200	4,000	2,700 (70%)
Cables	16,000	3,800	1,000	800 (80%)	15,000	3,000 (20%)
Floorings	8,700		2,800	1,800 (65%)	5,900	

(54) Symonds Group Ltd, Final report, February 1999
(55) European Topic Centre on Waste and Material Flows Topic Centre of the European Environment Agency, http://waste.eionet.eu.int/wastebase/prevention/details_html?pk=NL1
(56) Symonds Group Ltd, Final report, February 1999
(57) Babex, de brancheorganisatie voor sloopaannemers: http://www.babex.nl
(58) PVC waste arisings, PVC waste being landfilled, and costs for landfilling of PVC, p. 8, http://europa.eu.int/comm/environment/waste/studies/pvc/landfill_annexes.pdf

Case 1: Collection system for pipes

> BUREAULEIDING – Association of plastic pipe system manufacturers

Founded in 1991, BureauLeiding (formerly FKS) attempts through BIS (the Dutch plastic pipes collection scheme), to optimise the production, processing, installation, utilisation, replacement and recycling of plastic pipes.

> Collection scheme

Type of plastics considered: pipes in PVC, PP and PE.

A dedicated collection system is organised, and from the collection point the pipes are transported to the recycling plants. The waste owner is paid at the collection points, as a compensation for having collected and stored the PVC waste separately from other waste on the demolition site (application of the producer responsibility principle).

Occasionally or if the quantity is small, the old pipes can be deposited free of charge in almost 60 collection points recognised by BureauLeiding. These depots have containers for this purpose. For the larger quantities, containers (30m3) are provided by BureauLeiding subject to payment. These containers are provided at low cost thanks to the compensation for each kilogramme of plastic pipe waste that complies with the acceptance conditions.

Conditions for acceptance of wastes:

- The waste is constituted solely of thermoplastic pipes and accessories (PVC, PE and PP).
- The waste must be free of all chemical pollution.
- The waste must be delivered in clean condition.
- Under no circumstances are the following accepted: polyester, plastic sheets, watering hoses, sand, iron, cable sheaths, mortar, garbage bags, coffee cups, seals, coils, cables, WC tanks, corrugated sheets, etc.
- The pipes must not be cracked or packed into recovery containers.

Tariffs for 2005:

- Transport, delivery and collection of a container: EUR 135.00
- Hire of a closed container (30 m^3 , 6 x 2.45 x 2.45m) by day: EUR 2.25
- Compensation per kg PVC, PP or PE: EUR 0.045

Table 7 : Quantities, scale of case study - Results of the collection of plastic pipes[59]

Year	Tonnes
1991	0
1996	2500
1999	3000
2000	3600
Objective to be reached	
2010	5000
2020	10500

> Recycling

Involved recyclers: partners and other manufacturers of plastic products .
Quality of recycled products: The new pipe is composed of three layers: an inner layer and an outer layer in new PVC and a middle layer in recycled PVC.
Market: PVC recycled products.

> Costs

FKS organises the complete recycling and assumes the deficit of 110 EUR/tonne collected. BureauLeiding's objective is to be able to self-finance all recycling without deficit.
The gross recycling cost is around 560 EUR/t: 120 EUR/t for collection and logistics, plus 440 EUR/t for treatment costs
The waste owner bears the cost of collection and transportation to the collection points, or the cost of container rental and transportation.

> Conclusions

The disposers and the producing industry have to provide financial support for collection and recycling activities. However, the quality of the recyclate is good and demand for the recyclate far exceeds the quantity available.

http://www.bureauleiding.nl/

(59) BureauLeiding, formerly FKS: http://www.bureauleiding.nl

Case 2: Collection system for windows

> SRVKG – Stichting Recycling Vereniging Kunststof Gevelelementenindustrie

> Description

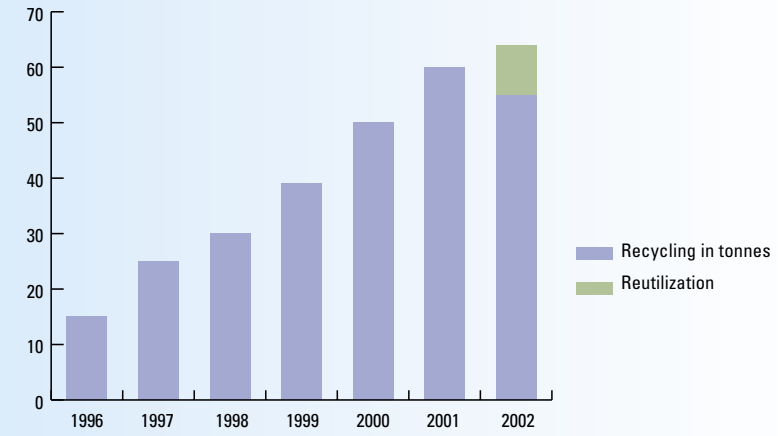
The recycling association VKG began in 1996, in association with the facade elements industry. SRVKG manages the PVC frames cycle in the Netherlands. The collection system is similar to the German system. The dismantled windows are collected in containers, which are transported to sorting or deposit installations around the country and then delivered to 5 recycling plants. Until 2005, the system was financed by a fee on imported PVC window frames (there is no domestic production of windows frames in the Netherlands), and by a disposal fee paid by the waste owners[60].

The fee on imported window frames was 2.25 EUR per standard 3.6 m2 window, i.e. 170 EUR per tonne of window frame. This 170 EUR per tonne of window frame corresponds to 58 EUR per tonne of PVC polymer, assuming that recycling of the 25% metals part can be financed from the metals revenue.
The recycling fee for the waste owner of PVC window frames was then 45 EUR per tonne, which is much lower than the cost of alternative means of disposal. A new funding system is currently being investigated. It is expected that recycling companies would now be prepared to pay a higher proportion of the costs in view of the rising price of PVC.

> Collection scheme

Type of plastics considered: PVC window frames.
Contractors and private individuals deposit old frames at a depository. Collection is conducted via the depositories, which function as an intermediate collection point for recyclers.

Figure 9 : Quantity of frames returned via a depository (tonnes/year)[61]



Quantities:
Reuse of frames began in 2002 and introduced a reduction in the waste quantity to be recycled. The collected volumes of recycled window frames were 154 tonnes in 2003, 273 tonnes in 2004 and 228 tonnes in 2005. The reduction of volume in 2005 is expected to be caused by re-use and export of assembled windows to countries in East Europe.

> Recycling

- Recycling technique: mechanical recycling.
- Phases of sorting and recycling.
- Quality of recycled products: suitable as raw material for new profiles.

> Costs

Originally, the collection was financed with support of the production sector. In exchange for a contribution per window, the SRVKG organised the whole recycling system (with a contribution of around 2.5 EUR).
The costs of transporting, sorting and recycling were borne by the companies of the sector. Either the supplier or the manufacturer provided this contribution for their retailers, but in most cases it is the contractors who make their removal contribution to the association. For each new frame placed on the market, the sector pays a removal contribution and receives a certificate of payment. The depositories are also compensated for their work. The obligatory contribution of the window frame industry was terminated per August 15, 2005. The SRVKG have accrued funds for future collection enabling them to continue their activities. The collection system needs additional contribution from the industry to continue the system. In general, the transport costs are to high to overcome without contribution.
SRVKG has reduced their operational cost by deleting the promotion budget and reducing the gate fee of recycling plants. Increased PVC recyclate prices will give SRVKG additional funds, but a break even point on recycling without subsidy is not yet to be estimated.

> Conclusions

The system is only able to operate thanks to the mandatory contribution from the manufacturers of each window frame placed on the market.

http://www.srvkg.nl

(60) Mechanical recycling for PVC wastes – Study for DG XI of the European Commission, January 2000, p.54
http://europa.eu.int/comm/environment/waste/studies/pvc/mech_recylce.pdf
(61) SRVKG – Stichting Recycling Vereniging Kunststof Gevelelementenindustrie, http://www.srvkg.nl

Case 3: Collection system for insulation materials

> STYBENEX

> Description

Stybenex is an association of Dutch manufacturers of products in EPS. The sector manages the collective interests of its members, with its primary objective being to stimulate the use of EPS insulating materials for construction in the Netherlands.

Stybenex works in collaboration with other sectors, union organisations and authorities such as the Rubber and Plastics Industry Federations (NRK), the Union of Dutch Construction Subcontractors (NVTB) and the Dutch Insulation Industry (NII) and participates in the subcontractors (suppliers) coordination organisation NVTB (Nederlands Verbond Toelevering Bouw). Foreign collaboration is formalised via the association EUMEPS (the European manufacturers of EPS).

> Collection scheme

Type of plastics considered: EPS products.
As a response to logistical-economic complexity, EPS-producers developed a collection and recycling system: big bags and containers are available at building sites for cut offs and waste. Recycling free of charge for clean EPS. Afterwards the waste is recycled.
Quantities, scale of case study: In 1997, the total volume, in the Netherlands, of construction and demolition waste amounted to 14,500,000 tonnes. The quantity of waste coming from the construction products in EPS is currently evaluated at around 660 tonnes/year, less than 0.005%.

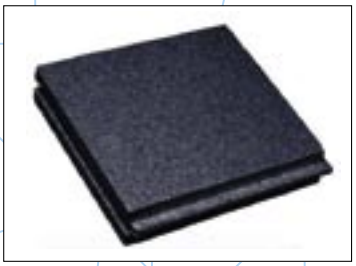
> Recycling

Recycled plastics: EPS.
Involved recyclers: the producers of EPS-products.
Recycling technique: mechanical regrinding and some times extrusion.
Quality of recycled products: scrap of EPS beads or granulates of hard polystyrene.
Market: EPS-products, blocks (e.g. Poroton: isolating brick), insulating panels (e.g. Styromul), granulates for light concretes, EPS packaging, chemical production, energy production.

> Conclusions

This experience highlights a problem with the separate collection of small quantities of waste plastics. Collection points/the manufacturers are an advantageous solution as they gather the waste and save space on the building site. In this case, production waste can be directly reused in production.

http://www.stybenex.nl



PART 3 Pilot projects at local and regional level - the APPRICOD project

1 Introduction

This chapter will describe the main outcomes of the implementation of pilot projects at local and regional level within the Life project "APPRICOD". A variety of scenarios were tested in order to assess the sorting, selective collection and recycling of plastics in the C&D sector.

These pilot projects were established by four local or regional environmental authorities (LRAs):

- Agència de Residus de Catalunya - ARC (Spain) (62)
- Brussels Institute for Management of the Environment - IBGE-BIM (Belgium) (63)
- Provincia di Ancona (Italy) (64)
- Serviço intermunicipalizado de gestao de residuos do grande Porto - LIPOR (Portugal) (65)

The first step included making contact with contractors, collectors and recyclers at local level. The idea was to define scenarios in consultation with local and regional stakeholders, to determine that these scenarios were in line with local and regional objectives, and also to take account of current practices and opportunities as well as existing recycling infrastructure.

In each LRA, the objective was to work out at least 3 complete schemes for sorting and collection. Each scheme is a combination of:
1) means of collection (big bags, containers, bags, etc.),
2) sorting on site, at a working site or in a deposit centre owned by the contractor, and
3) sorting into different fractions:

- a mixed fraction with plastics, wood, glass, metal separated from the inert fraction;
- a mixed fraction with all types of plastics separated from other waste;
- separation of soft plastic waste from hard plastic waste;
- separation of PVC waste from other plastic waste;
- separation of PVC waste, thermosets and thermoplastics; and
- separation of the various polymers (PVC, PE, PP, PA).

Concretely, during the pilot project phase, for each scenario, the waste quantities generated by the worksite were measured, the plastic fraction was weighed, sorting methods were assessed and the availability of local recycling processes was studied. In complement, a qualitative survey was carried out in order to learn the opinions of actors in the field, i.e. contractors, recyclers, workers, architects, site supervisors.

2 Description of scenarios and implementation of the pilot project:

> 2.1. Brussels-Capital Region

2.1.1. Local context

BRUXELLES ENVIRONNEMENT
LEEFMILIEU BRUSSEL
-IBGE-BIM-

Since the Brussels-Capital Region is an urban region, there is a high density of buildings and construction. The pilot projects were conceived to take account of this specific characteristic of an urban area.

The construction and demolition sector is an important target in the regional waste prevention and management plan not only because the quantities of waste arising are high (nearly 60% of total waste), or because of the recycling potential of this waste, but also because the sector produces some hazardous waste, like PCBs and asbestos.
The Third Waste Plan (2003-2007) aims to optimise waste management, and details specific objectives for the construction and demolition waste:

- 90% recycling objective for construction and demolition waste;
- selective dismantling (to attain maximum recycling);
- use of recycled materials in the construction works;
- development of eco-construction (using ecological materials);
- compliance with the decree of 1995 on mandatory recycling of construction waste; and
- careful treatment of hazardous waste (especially for asbestos and PCBs).

There is no obligation in the Brussels Capital Region to sort plastic C&D waste; and it is generally landfilled even when it has been sorted (in neighbouring Flanders or Wallonia, as there are no landfill sites in Brussels).

There are no fiscal incentives (subsidies or taxes) to foster the recycling of C&D waste.

There is one sorting facility but there are no recycling facilities in the Region, mainly because of a lack of space. Recycling options for plastics C&D waste are quite limited nationally.
On the specific issue of plastics, various recycling options are developing in Belgium while sorting and collecting are improving.

As the recycling options for construction and demolition plastic are currently limited in Belgium, sorted soft plastic waste was generally landfilled, except for the plastic waste (tarpaulins) produced on the Atomium site (see box p43), which was recycled in Germany (with very high associated transportation costs).

(62) Agència de Residus de Catalunya - ARC: http://www.arc-cat.net
(63) Brussels Institute for the Management of the Environment - IBGE-BIM: http://www.ibgebim.be
(64) Provincia di Ancona: http://www.provincia.ancona.it
(65) Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto - LIPOR: http://www.lipor.pt

2.1.2. Methodology for selection of scenarios

The IBGE-BIM implemented different plastic waste selective collection scenarios in different types of works with different conditions, such as

- location,
- space available for sorting,
- type of waste produced, and
- type of work (construction, demolition, renovation).

Three types of scenarios were implemented on six sites in the Brussels Region:

- **Scenario 1: sorting of hard and soft plastics**

This scenario is the separation of plastics into two (hard & soft plastics) or more (e.g. hard, soft and polyurethane panels) flows, according to the works.

- **Scenario 2: sorting of mixed plastics**

Separate collection of mixed plastics in big bags is more readily accepted by contractors but there is no real sorting on the building site.

- **Scenario 3: sorting of soft plastics**

Soft plastics, in particular packaging and tarpaulins, are easy to recognise and to sort.

2.1.3. Costs

The extra cost of sorting plastic waste from the other waste fractions in C&D works in the Brussels pilots varied a lot ranging from approximately 600 EUR/tonne to 5,800 EUR/tonne. The most expensive options were those where supervision costs, transportation costs and the sorting cost were high because of small waste quantities.

2.1.4. Conclusions

The results of the project in Brussels were positive because a lot of ideas and suggestions originated from the C&D sector in order to develop the options for plastic C&D waste sorting and recycling. The project seems to have led to some public and private initiatives in order to continue finding solutions to the problem of plastic C&D waste management.

Example of a poster for plastics sorting in a pilot project

ATOMIUM

The renovation of the Atomium was an example of soft plastics sorting and recycling. 2.16 tonnes of tarpaulins (used for the sandblasting of the Atomium) were collected and sorted manually. Sorting the tarpaulins on the site did not generate significant extra labour and recycling costs were half that of landfilling. However the extra transport costs to Germany caused a (non-economic) cost increase.

©asbl Atomium

> 2.2. Catalonia

2.2.1. Local context

The specific characteristic of the Catalonian approach is that waste policy is based on the recycling market. ARC (Agència de Residus de Catalunya) has a good knowledge of the local recycling market and the Agency is well involved in generating a motivation to sort within the C&D sector.

The main destination for waste generated in construction and demolition activities in Catalonia is the landfill site. There is an extended facility network of 54 sites that covers the whole region of Catalonia.

These landfills are only used for this type of waste and are cheaper than the other ones dedicated to non hazardous wastes (domestic and industrial). For the moment there is no extra tax applied to C&D waste landfill but is an option that is being studied.

In C&D waste landfill, the presence of any hazardous waste mixed with the rest is forbidden.

Within the project, ARC's intention was to calculate, using a strict methodology, the extra cost of plastic waste sorting in relation to the total amount of C&D waste generated by the work site.

In order to obtain coherent hypotheses, a study from ITeC (Catalan Institute for Construction Technology)[66] was the basis for calculating the quantity of waste generated according to the volume:

Table 8 : Calculation of waste quantity based on volume and weight through density estimation[67]

Materials	m^3/m^2 of area constructed	density	kg/m^2 of area constructed
Bricks, stone materials, concrete and mortar	0.0685	1.800 kg/m^3	123.30
Timber	0.0142	230 kg/m^3	3.27
Metals	0.0038	500 kg/m^3	1.90
Plastics	0.0105	150 kg/m^3	1.57
Paper and cardboard	0.0114	200 kg/m^3	2.28
Gypsum	0.0100	600 kg/m^3	6.00
Other	0.0011	250 kg/m^3	0.27
TOTAL	**0.1195 m^3/m^2**		**138.59 kg/m^2**

2.2.2. Methodology

For each pilot site, the cost of 3 options have been estimated:

- **Option 1** - **Use of only one container (all mixed);** the hazardous waste is collected separately, and the rest is put into a single container for sorting off site.
- **Option 2** - **Use of two containers:** one for inert waste and one for mixed waste (papers, plastics, metals and wood, i.e. light waste container). Hazardous waste collected separately.
- **Option 3** - **Application of an APPRICOD model:** use of two containers as in option 2, plus plastics separation, either in the worksite or at the sorting plant (collection in big bags or in containers), use of a press for soft plastics (packaging). Hazardous waste collected separately.

HOSPITAL D'IGUALADA

One of the pilot projects, Hospital d'Igualada, focused on the sorting of plastic films, that were separated in the building site. Rigid waste was collected with the light fraction. Then followed a second sorting in a sorting centre to separate rigid plastics from the light fraction waste. ARC estimated the costs and highlighted the financial need for selective collection and recycling of plastics.
2.69 tonnes of waste plastics were collected out of 238 tonnes of C&D waste generated by the works.

(66) Construction waste recycling as heat insulation, 2001
(67) Agència de Residus de Catalunya - ARC: http://www.arc-cat.net

2.2.3. Costs

For each pilot project, the extra cost on the work site (labour cost, use of a press machine, etc.) and/or in the sorting centre (complementary sorting, shredding, cleaning) was estimated.

For each pilot project, the total C&D waste generated by the works was compared with the total plastic waste generated (weighed fraction) in order to compare the APPRICOD extra costs in relation to the total C&D waste, thus enabling the recycler, with the income from selling plastic waste, and other valuable fractions, to calculate whether he wins or loses with plastic waste.

2.2.4. Conclusions

The use of a vertical press for plastic films arises as a good solution for this kind of plastic waste. This film is easily recycled because if it is collected on the building site and is quite clean, it can be mixed with commercial and industrial plastic film.

Also, collecting plastic waste in big bags separated from the rest of light fraction waste seems to be a good option because workers do not mix other waste types in the big bag and their quality increases. Also the cost of managing one big bag is not very high. The only condition is that long off-cuts must be cut before being put in the big bag.

Table 9 : Calculation of the extra-costs in Catalonia [68]

Work	IDBAPS Barcelona, Laboratory renovation	Igualada, New Hospital	Les Franqueses, Dwelling houses	Lleida, Diocesà Museum
Collection Model	Plastic collected with the rest of light fraction waste	Film pressed and collected apart and rigid film collected with the rest of light fraction waste	Film and rigid plastic collected in a 5 m^3 container, only for plastics	Film and rigid plastic collected in 1 m^3 big bags
Total waste produced	40 t	238 t	113 t	38,8 t
Plastic collected	0.453 t	2.690 t	1.280 t	0.44 t
Total extra cost for sorting the plastic fraction, compared to the management cost before APPRICOD	480 EUR	3,248 EUR	568 EUR	420 EUR
Extra cost / tonne of plastic waste	1059.6 EUR/t	1.207.4 EUR/t	443.75 EUR/t	954.5 EUR/t
Extra cost / tonne of C&D waste generated	48 EUR/t	25 EUR/t	7.5 EUR/t	13.5 EUR/t

(68) Agència de Residus de Catalunya - ARC: http://www.arc-cat.net

> 2.3. Porto

2.3.1. Local context

Lipor (Serviço intermunicipalizado de gestao de residuos do grande Porto) is the entity responsible for the management, treatment and recovery of waste produced in eight municipalities of Porto Metropolitan Area (Póvoa de Varzim, Vila do Conde, Maia, Matosinhos, Porto, Gondomar, Valongo and Espinho). These eight municipalities represent 0.8% in area and about 1 million citizens (around 10% of Portugal's total population).
Remark: under a previous project conducted in partnership with ACR+ and the plastics industry, Lipor developed two different collection schemes to collect demolition waste in 2003. In one of the demolition sites there was a previous visit to define the material to collect before the demolition activities. This experience allowed the recovery of a variety of materials (e.g. wood, plastic, metal and scrap).

Another scheme established was the collection of material after demolition activities.

This proved to be a very difficult task with little material collected (e.g. wood). As a result, the concept of selective demolition was an initial step, with some demolition companies now starting to introduce these strategies into their working plans. An example is the selective demolition of football stadia.

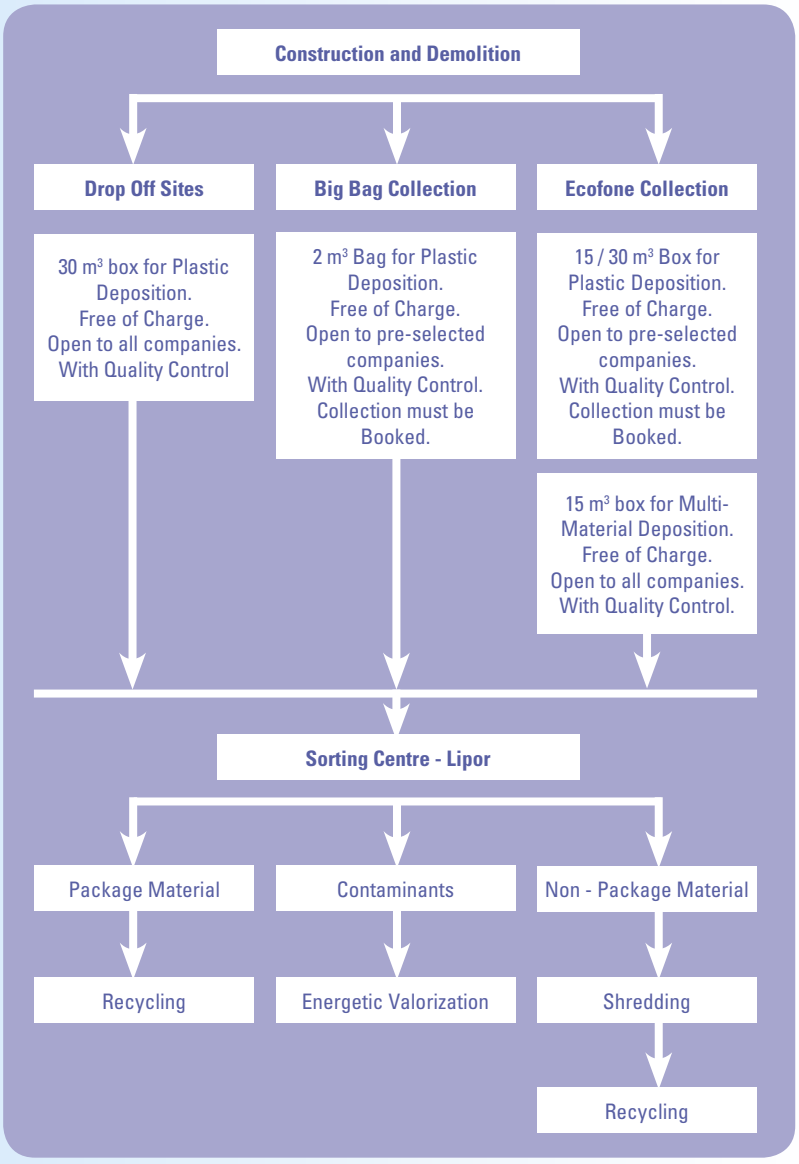
2.3.2. Methodology for selection of scenarios

> Defining C&D waste strategy

Lipor undertook various initiatives in order to evaluate C&D waste production and its final destination, together with the current municipal regulations and practices, and created a working group focused on construction and demolition activities.

Several construction companies were contacted in order to evaluate the differing production of waste in each phase of construction and demolition activities.
The objective was to implement a flexible collection scheme that could be adjusted to different scenarios in the C&D sector and could be conducive to the correct management of waste.
National and international experiences were observed in order to implement the best collection scheme.

Figure 10 : Organization chart of the process[69]



(69) Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto – LIPOR: http://www.lipor.pt

> Pilot projects

Three types of scenarios were implemented:

- **Scenario 1 - drop off sites**: this involved sites where plastic C&D waste could be deposited in 30m³ boxes; this system was accessible for all companies and was free of charge; the waste was subject to quality control;
- **Scenario 2 - big bag collection**: 2m³ big bags were put on the worksite and could be used for depositing plastic waste. Collection of the filled big bags by Lipor had to be booked in advance by the C&D company concerned. The waste was subject to quality control. This system was accessible only to pre-selected companies and was free of charge.
- **Scenario 3 - Ecofone collection**: plastic C&D waste was deposited into 15 or 30m³ boxes. Lipor collected them free of charge and conducted quality control on the waste content. This system was accessible to pre-selected companies only. 15m³ boxes could also be used for multi-material waste.

The waste was then transported to the Lipor sorting centre where it was separated into packaging plastic waste, non-packaging plastic waste and contaminants.

> Materials Quality

For the collection process, plastics passed through a selection process, which consisted of evaluating the materials' quality. Parameters such as the plastic's polymers or levels of contamination were strictly monitored. Elements such as cement, ink or even considerable quantities of dust rendered the material inapplicable.

The collector visiting construction and demolition sites was trained on materials and quality parameters. If there were contaminants (visible) such as glass, inert fraction, clothes, etc., the material was not collected and responsibility for its destination lay with the producer.

When the material arrived at the Lipor Sorting Centre, if contaminants were detected, a quality report was made by Lipor with a photographic record and sent to the producer. The producer was required to take measures to avoid this problem (new formation campaigns for example). If the problem persisted, the company was banned from the project.

2.3.3. Implementation of the selective collection scenarios

In order to characterise the different plastic materials produced in each phase of construction and also to evaluate behaviours and practices, several construction sites were selected. The identification of different constructions, evaluation of waste production and type of waste, helped Lipor to launch an awareness campaign focussing on plastics flows. Along with this training in waste separation, a collection system with deposit points was also introduced. The aim was to create a waste separation area on the construction site where workers could deposit recyclable materials produced by their activities.

2.3.4. Costs

The extra costs varied from approximately 280 EUR/tonne to approximately 670 EUR/tonne. The high collection, sorting, supervision & transportation costs were partly compensated by a high recycling revenue.

2.3.5. Conclusions

The various collection schemes presented represent a significant effort by Lipor. Current regulations concerning C&D waste are not very favourable to the establishment of selective collection programs since results depend on the good will of the constructor.

Also, the inert fraction that represents higher collection costs to the constructor was not covered by the project. This reveals the need for an integrated management system with different players from different sectors.

The collection scheme proposed (and implemented) was shown to be practical for the constructor and for Lipor, but process costs were not covered by material sales. Completing the cycle by introducing recyclable materials on new construction sites would promote better separation and develop the market.

The collection schemes presented were flexible, allowing changes to adjust to needs. Developing collection schemes was a key factor, however, other projects must follow up on this development. New regulations, separation centres and recyclable materials are an important aspect that is now being studied by Lipor. This is the only way to gain a global perspective of the system and adjust it to the sustainability being sought.

> 2.4. Province of Ancona

2.4.1. Local context

The Province of Ancona is in charge of waste management in its region.
The specific characteristic of this region compared to the other ones in the project is that local data on C&D activities and waste production are absent and that few plastics are used in buildings. The approach used by the Province for the pilot projects was to work with a recycling company as a point of contact with building companies.

A survey of building enterprises in the Province regarding the amount of plastic reconverted showed that this type of material was often not separated and selected with the attention required.
Waste produced by the building activity did however come to the waste sorting plants. The plastic produced by these activities was for the most part impure, which is why it was often dumped rather than being used in plastics recycling plants.

One of the causes of this attitude was surely the lack of plastics recycling plants in the province.

2.4.2. Methodology for selection of scenarios

> Company selection

The five building contractors taking part in the plan were selected on the basis of their various activities (construction, demolition and renovation), their varying approaches to the disposal of waste produced on site and even on the basis of the type of work they planned to do in the course of 2005, the monitoring phase of the APPRICOD plan.

The Province tried to identify the most efficient and economic recycling procedure and the most feasible given the circumstances in the Province.
Building contractors with sites in different areas of the Province were selected in order to evaluate the transfer costs.

> Definition of the four scenarios

- **Scenario 1:** collection of all on-site waste, inert excepted, and transport to a sorting centre (one container for all waste collected on-site).
- **Scenario 2**: collection of all on-site plastic waste and transport to a recovery centre (one container for collection of plastic waste).
- **Scenario 3**: on-site collection of all plastic waste and on-site separation of PVC from other plastics (two containers for plastics: one for PVC and the other for all remaining plastic material).
- **Scenario 4**: on-site plastic collection system: PVC, Polypropylene, Polyethylene (three different containers for plastics).

2.4.3. Costs

Costs were estimated and, as in the other LRAs, the results show big differences and make any comparison difficult.

2.4.4. Conclusions

The pilot projects carried out within the Life project "APPRICOD" have allowed the initiation of a series of contacts between building contractors and plastics sorting and collection companies, showing that the various actors operating in this field are ready to cooperate.

Another conclusion is the need to develop a network within the province for collection of the waste produced on worksites. This would allow the labour costs for on-site sorting to be recouped, and would overcome the obstacle of the small quantities of plastic waste produced in some building activities.

The intention of the three building contractors to continue with recycling rather than plastic waste disposal shows the way to proceed, and that an agreement with recycling federations should be proposed to the association of building constructors in order to make this process easier and render it immediately applicable.

EDIL-GENGA

The EDIL-GENGA renovation project is an example of the complex operation of sorting 3 plastic fractions (PVC, polyethylene and polypropylene) into containers divided into 3 sections, using a grouping point on the contractor's premises. To ease plastics sorting operations, special posters with practical information and pictures were placed on each container.

3 Results and conclusions from the pilot projects

> Plastic C&D waste management vs. public authorities

In general, C&D waste management does not currently include the obligation to separate the plastic fraction, it is thus not very common to separate plastics on building sites and this type of waste usually ends up in landfill along with other non-hazardous waste.

> No optimal collection scenario

There are many options for the collection of plastic waste according to the different types of waste, the quantities involved and other parameters. Each must be suited to the type of building site, to the regulatory framework, and to the practices of each region.

The various parameters, for selective collection that is suited to the work, are:

- The type and the size of the building site.
- The space available and the phase of the work (there is more packaging in the finishing phase).
- The number of sub-contractors: with more sub-contractors, it is more difficult to manage the waste and to raise awareness among the various groups of workers.
- The quantity and the quality of the waste (clean or not, easy to sort or not, etc.).
- The cost of recycling in relation to the cost of landfill.
- The rental cost of the containers, the road tax cost, the transport costs.
- ...

> Training & communication aspects

Educational sessions and awareness-raising materials for subcontractors and workers could facilitate sorting on site. Indeed, they are generally not sufficiently well trained in sorting different types of waste.
Therefore, it is crucial that sorting is defined in the initial contract with the subcontractors and that it is explained at the kick-off meetings, and at subsequent meetings if necessary. If sorting is planned from the outset, it is more easily accepted and carried out. The distribution of an easy-to-read folder (with many pictures) could also be very useful.

> Sorting on site

The sorting of hazardous waste is mandatory. Generally, if time and space permit, waste is sorted into wood, metals and other fractions. Some contractors use on-site sorting whenever it is possible (subject to constraints of space, organization, etc.), and even sort mixed waste by type.
In some cases, sorting plastics could be added to the more traditional sorting if they are put in a mixed waste container (no sorting into different kinds of plastics on site). It is important to note that there is no single recycling solution for all types of plastics.

> Limits of the scenarios

The limited number of pilot projects and their limited scale in time and quantities obviously mean that the results must be treated with caution. It should be noted in particular that the issue of cost was largely influenced by the innovative nature of the processes that were put in place, by the limited amounts of plastic waste collected and by the current absence of recycling solutions.

However, the scenarios give us a very good picture of the qualitative aspects to be borne in mind when assessing the options for sorting, selectively collecting and recycling plastic C&D waste.

> Costs and economic aspects

The main costs in sorting waste are the extra labour costs, transport costs and high road tax costs for containers in urban areas. Distance to the recycling facility is an important issue. Transport costs can be reduced using a press (and this also avoids public waste because these containers are closed). This method is easy to use with packaging.

But if we compare the costs of landfill disposal and recycling without considering any other criteria, waste recycling is cheaper. The higher cost is influenced by upstream costs (sorting on site, containers, transport).

A large price differential between sorted containers and the mixed waste containers can be a motivation for waste sorting, as is the case for inert, wood or metal waste containers which cost less than mixed waste containers (or even yield revenues, like metal waste). For plastics, this is not the case. One reason for sorting plastics can be to obtain a cleaner inert fraction without impurities.

Generally, the cost of removing waste is the most important parameter for contractors. The time available for the work, brand image and environmental awareness are also crucial for contractors and sub-contractors.

It has also been pointed out that having a cost approach based on weight might lead to incomplete conclusions: the plastic fraction represents an important volume to be handled, this has consequences on space, transport, cost estimation, etc.

> Demolition vs. construction

There is a significant difference between construction and demolition waste. The waste from construction is much smaller in quantity, but the waste is generally speaking not linked or contaminated with other materials and is therefore better suited to separate collection. In demolition there is more mixed waste, and it becomes available at one time. Specific selective demolition activities could take a lot of time, which would be incompatible with current practice. Also the waste stream at demolition is definitively different from that during construction activities. For instance no packaging waste arises on demolition sites. A renovation site often involves a mixture of demolition and construction, where the various demolition steps are not necessarily planned in a continuous order, but are often interrupted by construction activities. According to contractors, it is more beneficial to sort construction (or renovation) plastic waste than demolition waste because it is not known what type of waste will be found in demolition waste and the plastic fraction might be difficult to isolate from the rest (e.g. pipe stuck in concrete).

PART 4 Recommendations and good practices




1 Recommendations to public authorities for sustainable plastic C&D waste management

> 1.1. General recommendations

This chapter aims to identify ideas and suggestions to be implemented by public authorities in order to stimulate the selective collection and recycling of plastics in C&D waste. Depending on the share of competences in each Member State, these "recommendations" will in some cases require the intervention of national authorities or can be implemented by local and regional authorities. In addition, it has to be said that European authorities have a key role to play with the objective of creating a global framework that on one side favours national, regional and local initiatives and on the other side helps the emergence of recycling schemes and facilities on a European-wide basis.

Some of these suggestions imply a close partnership with the private sector, either the plastic industry, or the construction and demolition sector, or both.

C&D waste in general (including plastic C&D waste) is of particular interest for public authorities for at least two reasons:

- its volume is often higher than that of domestic waste; and
- its nature and the potential hazardousness of some C&D waste

Even if C&D waste collection is rarely directly managed by the public authorities, as they do for other types of waste (e.g. domestic waste, even if they do manage C&D waste produced by households), the main responsibility for public authorities is to guarantee appropriate management in order to protect public health and the environment whilst also favouring local economic development and employment. For C&D waste the instruments for this include:

- drawing up a strategy and including C&D waste into their waste management plans,
- monitoring and controlling waste flows (including cross-border movements),
- creating a legal framework,
- contributing to the development and dissemination of technical tools,
- fostering the creation of appropriate infrastructures, and
- applying financial instruments

in order to direct the sectors involved towards the management of these wastes by the most sustainable practices.

It is interesting to note that the current initiatives for the selective collection and recycling of plastic C&D waste have emerged in specifically determined legal, financial or economical contexts. But even if they have been driven by these contexts, which were created by public authorities, we can observe that their implementation has required significant involvement from private actors, including the plastics industry.

The plastics industry and the C&D sector have an interest in being involved in more sustainable ways of managing plastic C&D waste. Their main concern is to assure their members that their activity will take place in a stable, financially viable and technically feasible context that takes account of the evolving constraints and opportunities of the market.

> **An initial preliminary conclusion** which will serve as a "guiding thread" in the following recommendations is thus that well understood cooperation and win-win partnership between public authorities and private sector is a strong success factor in implementing sustainable plastic C&D waste management. Of course, each partner must recognise the specific role of the other and the main responsibility for organising "the life in society" continues to lie with public authorities

> In link with the previous item, **a second preliminary point** is that an economical approach is needed in analysing the plastic C&D waste issue. As we have seen in previous chapters, in most parts of Europe, the selective collection and recycling of plastic C&D waste is at present more expensive than current disposal practises in the C&D sector. There is obviously a "financial need" that has to be covered in order to ensure efficient and stable systems for sorting and recycling plastic C&D waste.
It is certainly the role of the public authorities to ensure that, when such a system (or a market) is put in place, it can operate in a secure context and includes most of the market players so that freeloaders do not put it at risk. It is also important to stress that one cannot reflect on solutions for plastic C&D waste recycling without having a market approach based on supply (based on selective collection, quality and quantity of plastic waste, and availability of recycling facilities) and demand (secondary raw material use, recycled products use).

> **A third and final preliminary remark** is that it might be very interesting to analyse plastic C&D waste in isolation in order to identify the constraints and opportunities that are specific to this particular waste flow. However, in a second step, it might be more efficient, especially when it comes to local management policies, to include this analysis in the broader context of global (C&D) waste management. As a matter of fact, selective collection of plastic C&D waste either on work sites or in sorting centres can be associated with the sorting and selective collection of other flows of materials like metals, or wood. In addition, the recycling objectives for the inert fraction that already present advanced results throughout Europe can be a good driver for the introduction of complementary separation of other flows, namely to ensure an optimal quality for inert C&D recycled waste and to reduce as far as possible the residual fraction, for which the cost of disposal is constantly increasing.

> **Important notice**

The following list of items is not to be considered as a list of recommendations or a to do list, it is intended to serve as a check-list of possible interventions by public authorities or important elements to bear in mind in order to foster sustainable plastic C&D waste management. Implementing an efficient system for plastic C&D waste selective collection and recycling will certainly presuppose a combination of a series of the tools mentioned below, thus working simultaneously on the regulatory, financial, technical and communication levels.

> 1.2. Regulatory instruments

- Landfill ban of C&D waste: this ban can apply to unsorted waste or to recyclable or recoverable waste, including C&D waste in general or specific organic materials such as plastics, rubber, textiles or paper.
- Incineration ban of C&D waste: this ban can apply to specific flows including C&D waste in general or plastics specifically.
- Very strict (and thus expensive) technical requirements for disposal installations: by requiring very strict conditions and environmental performance for disposal installations, the real environmental cost can be an incentive for choosing recycling.
- Mandatory sorting and selective collection of certain waste types: plastic sorting and selective collection can be integrated into a more global regulatory framework for C&D waste, as one fraction to be sorted among other C&D materials).
- Mandatory recycling of certain waste types: this can include targets to be reached for each sector in general or each type of waste in particular. A combination of mandatory sorting and recycling is also a possibility for a coherent approach.
- Standards & norms: certification that the quality of the recycled product is equivalent to a new product or at least compatible with some specific applications can help strengthen the recycling market. Standards and norms can also be used in establishing requirements for the utilization of recycled products in new construction projects or in setting minimum percentages of secondary raw materials in new products.
- An obligation to draw up a specific integrated C&D waste management plan.
- Regulatory prescriptions for construction/demolition projects (permit condition) including mandatory selective collection if minimum quantities (for each material) are reached.
- An obligation to sort and recycle for public works or buildings: authorities can set an example, this will promote sorting / recycling to building companies.

> 1.3. Economic, financial and fiscal instruments

> Financial instruments

- Taxation of landfill: in order to discourage landfilling for certain types of waste, a landfill tax can be imposed, reducing the financial gap with recycling. The utilization of tax incomes by the public authorities can also be an important tool. Taxation systems can include differentiated rates depending on the type of landfill and the type of waste to be disposed of.
- Taxation of incineration: in order to discourage incineration for certain types of waste, an incineration tax can be imposed, reducing the financial gap with recycling. The utilization of tax incomes can also be an important tool.
- A combination of the two options above (landfilling taxation/incineration) may be necessary.
- Producer responsibility for (plastic) products used in C&D sector: public authorities can put in place a legal framework imposing a take back system or negotiate voluntary agreements with the private sector.
- Economic incentive or tax reduction for the constructor if he uses recycled materials.
- Reduction of VAT for recycling activities.
- Public authorities can cover the financial gap between recycling and alternative treatments by means of public subsidies, incentives, tax allowances, etc.

> Market related instruments

Even if public authorities are not (or nearly not) acting directly on the recycling market, they can, by their actions, help to create a favourable framework for the emergence or the reinforcement of the market, taking the following into account:

- Stimulate the existence of a market for secondary raw materials by private sector commitment and green public procurement.
- Recycling costs comparable to (or ideally lower than) disposal costs (by the implementation of some of above regulatory/financial instruments.
- Landfill costs cheaper for residual sorted waste.
- Ensure stable and regular plastic waste flows to recycling facilities by putting in place or favouring a collection and grouping system at local, regional or national level (by type of product or by type of polymer).
- Require the use of recycled products in civil works and public building projects in order to foster demand for recycled materials & products.
- The creation of a "level playing field" at European level with similar waste treatment conditions in all member states and security and stability in legislation. Otherwise, there is a risk that the differences in national waste management policies create waste export to countries where disposal is easier (e.g. no landfill ban) and disposal costs are lower (than the local disposal or recycling costs).
- Ensuring good cooperation between supply and demand, for plastic C&D waste and recycled C&D plastic, by developing a centralised exchange system.

> Voluntary agreements

- Public authorities and private sector can conclude voluntary agreements with the objective of sorting and recycling the plastic fraction (and/or other fractions) of C&D waste. These agreements can include the plastic industry as well as the C&D sector.
- They can also conclude voluntary agreements for the implementation of specific C&D waste management schemes to be respected by the C&D sector (possibly with the help of the authorities). These can differentiate between construction and renovation on one side and selective demolition on the other.
- Even if public authorities are not a party to such agreements, they can encourage voluntary agreements by companies and private sector trade associations.

> 1.4. Technical aspects to bear in mind

The following points are to be kept in mind by the public authorities when deciding on implementing a strategy for plastic C&D waste management. Most of these items are developed further in the section dedicated to the C&D sector as they concern either the C&D sector or the recycling sector, but they can usefully be integrated into any reflection on the topic by any of the actors concerned.

- Firstly, in order to identify the environmental impacts of recycling, in-depth life cycle analysis (LCA) could be useful in some cases.

> Collection

- A collection and recycling scheme depends on a range of parameters. The choice must be made in the light of what is already done in the region to stimulate complementarities and with a knowledge of local recycling infrastructures.
- Local authorities can reduce or increase the container road costs (local tax) to encourage separate collection on building sites.
- Public authorities can foster selective collection on C&D sites, on container parks and/or on drop off sites.

> Sorting

- Ensure the quality of sorting, and the availability and use of efficient sorting facilities, i.e. that the process produces well-sorted waste that can be used in recycling.
- Take into account the time and space needed for sorting on site.
- Organise good grouping and/or transportation schemes (between collection, sorting and recycling points).
- Generally, the cost of removing the waste is the most decisive parameter for contractors. The time schedule for the work, brand image and environmental awareness are also important.

> Recycling

- Large and regular plastic waste quantities will favour investments in recycling facilities (if the waste flow is expected to remain quite constant over a certain period of time).
- Recycling facilities must ideally be located in the area.
- The sorted plastics must be sufficiently pure and well-sorted to respond to demand, and they must be compatible with processing techniques and lead to secondary raw materials that can be used as a substitute for new materials.
- The price of recycled plastic must be competitive in comparison with new virgin material.
- The conditions/criteria for recycled or secondary raw material must not be stricter than for the raw materials.

All these considerations stress the importance of constructive dialogue between public authorities and private sector.

> 1.5. Communication instruments

- Awareness-raising campaigns: In order to motivate the different actors of the waste treatment chain (waste producers/contractors, collectors, sorters, transporters, recyclers), these must include information on what happens to sorted plastics and what new product is made from them. Also promoting recycled products.
- Awareness campaigns and training for actors in the C&D sector.
- Guides on good practices in C&D waste management
- Toolbox for site supervisors in order to train workers in plastic waste sorting.

> 1.6. Specific tools for local and regional authorities

- In order to develop a strategy and implement selective collection and recycling schemes, the authorities need a picture of the quantity/quality of plastics potentially available (inventory), the collection facilities, the sorting centres, the collection companies, the waste associations, the recycling market, etc., and ensure there is good cooperation between all actors.
- Stimulate and help in creating installations: grouping centres, sorting centres, recycling facilities. This can be done for instance by favourable land planning measures.
- Public container parks managed by LRAs can be used for collecting plastic C&D waste generated by small construction works (also for small and medium-sized construction companies through a paying service).
- The authorities have a role to play in working as a focal point in order to put waste suppliers and waste recyclers/transporters in contact with one another.
- The authorities can play a demonstrative role by including selective sorting and recycling requirements in their public tenders for public buildings construction projects (and through green public procurement in general, favouring the use of recycled products).
- The authorities have to guarantee an effective control on the ground of any regulatory measure in order to ensure secure conditions for actors on the market.
- LRAs have an opportunity to integrate the waste prevention concept in eco-building, i.e. use of materials or building techniques that will reduce waste generation during the construction phase and in the future when demolished or renovated.

2 Good practices for the C&D sector

> 2.1. Rationale for sustainable plastic C&D waste management

The thematic strategy on the urban environment (EC communication) states that buildings and the built environment are the defining elements of the urban environment. The quality of the built environment therefore has a strong influence on the quality of the urban environment but this influence runs much deeper than purely aesthetic considerations.

When taken together, the "cradle to grave" aspects linked to the creation, use and disposal of built facilities constitute major environmental impacts. The heating and lighting of buildings account for the largest single share of energy use (42%, of which 70% is for heating) and produce 35% of all greenhouse gas emissions.

The Communication "Towards a Thematic Strategy on the Prevention and Recycling of Waste" notes that construction and demolition waste volumes are rising and that the nature of the waste is becoming more complex as the range of materials used in buildings grows.

A large proportion of it is concrete, bricks and tiles, which are well suited to being crushed and recycled as a substitute for newly quarried aggregates in certain lower grade applications. The nature of C&DW is directly linked to the building techniques that were used when the buildings and other structures that are now being demolished were built. Thus, as an increasing variety of materials are used in buildings, the complexity of managing waste from demolition activities will also rise.

Plastics are an example of a material whose use in construction has increased remarkably, both in volume and in applications. The building and construction (B&C) industry uses plastics for a range of applications from insulation to piping, window frames to interior design.

Plastics consumption in the building and construction sector in Europe has almost doubled in the space of 10 years and now accounts for 8.7 million tonnes (2004 data) as compared to 4.9 million tonnes in 1995. However, as a proportion of total building materials, the volume of plastics used remains low at about 1%.

The average working life of all plastics applications in construction is around 35 years but, depending on the specific application, this has a wide variation between 5 years (as is the case for wallpaper) and possibly 100 years or more (as is the case for pipes). This also means that an ever-increasing proportion of plastics will be present in C&D waste.

This raises the question of how it should be managed when it becomes a waste as the C&D plastics waste deposit may possibly reach 1.3 million tonnes in 2010, compared to 1.1 million tonnes today[70].

Together with continuously increasing costs and taxes for removal via landfill or incineration, or even landfill bans for specific kinds of waste, this makes sustainable plastic C&D waste management a worthwhile topic for contractors and construction sites.

(70) PlasticsEurope: http://www.plasticseurope.org

> 2.2. Recommendations

2.2.1. On the level of the general contractor or the building site

The first business of a contractor is to complete the building or construction work to the satisfaction of the client and with the expected revenue (economic, strategic, etc.).

In the set-up and running of a construction project, waste handling does not contribute to the quality of the final product, the erected building. Waste handling has little financial or technical impact on the final outcome of a construction work.

So, why bother? Effective waste handling contributes to a further cost reduction in an increasingly competitive market, it promotes safety on the construction site and, last but not least, waste is a significant environmental aspect of sustainable construction.

> Decision phase

The decision to include plastic waste management in the construction work activities can be split into four main evaluation criteria:

- *Integrated waste management as a prerequisite: including plastics or not.*
  The basic requirement for incorporating plastic waste is to have effective waste management for the major waste streams on the building site, most often the inert fraction, metal and sometimes wood (in addition to the obligatory dangerous waste fraction or other identified streams). Only if this basic waste management is in place and the contractor and his workforce are familiar with it can the incorporation of plastic waste into on-site waste management be an option. Plastic waste handling on site then becomes part of a larger integrated waste management plan.
- *Quantities of plastic waste: small, but not to be neglected.*
  A minimal amount of plastic waste should become available within a reasonable time span, to optimise the extra efforts for collection, storing and evacuation. Although plastic waste can be as low as 0.2% but can reach up to 1% of the total waste on a building site, a minimum quantity of plastic waste to fill one big bag (or container) will easily be found in construction works that go a little way beyond the construction of a typical family house.
- *Recycling (or removal) outlets: still in development.*
  An important decisive factor is the outlets for separately collected plastic waste. Recycling outlets depend on the type and purity of the plastic waste collected and on the recycling market in general. Besides minimum quantities and purity, transport is the main decisive factor in determining cost.
- *Practical constraints: more than you would like.*
  Some obvious practical constraints are the available time-frame for the works and the awareness of the workforce, the space available and the phase of the construction works, the location for containers or big-bags, the number of building workers and sub-contractors, their attitude or experience vis-à-vis integrated waste management and plastics in particular, the services of the waste collecting company, etc.

> Inclusion of plastic waste in the integrated waste management

- *Integrated waste management plan*
  The type of construction works and all the above-mentioned practical constraints influence the nature of the waste management plan. Construction phases and available space often determine the extent of possible waste management. The services of the waste collecting company with a choice of containers or big-bags and collection times are also important. The waste management plan should try to avoid recipients that are not filled regularly enough (to prevent pollution with other fractions in the course of time).
  The project manager or project supervisor should preferably identify the waste management plan before works commence to ensure a smooth start to waste collection. Several plastic waste management scenarios are possible with a (combination of) sorting off site in a waste handling centre, collection on site of mixed plastic waste, packaging plastic waste or rigid PVC or non-PVC waste fractions.
- *Contractual obligations*
  Contractual clauses on waste handling and costs have entered the standard contracts for construction works. As plastic waste management is fairly innovative, it is necessary, in order to avoid conflicts, to make clear agreements with all the sub-contractors that might be involved during the works. These agreements can be further clarified in a building site code of conduct, or detailed at the sub-contractor starting (kick-off) meeting.
  Such contractual clauses can allow sub-contractors to make use of the overall waste handling infrastructure and practice put in place by the general contractor, or on the other hand oblige them to handle all the waste generated by the sub-contractor themselves (including the plastic fraction).
- *Communication and awareness-raising*
  Construction workers need to be informed of the specific requirements related to plastic waste management. This should include the differences in the types of plastics to be sorted and how to recognise them. Raising the workforce's awareness using clear figures on amounts, cost issues, impact on the environment, recycling outlets and possible recycled building products using plastics will improve on-site sorting. The importance of this item is not to be underestimated, especially on construction sites that lack practical experience of waste management. A tool-box for communication and awareness-raising has been developed as part of the APPRICOD project.

- *Follow-up*

As a last point of attention, continuous follow up to good practice and behaviour by both own workforces and sub-contractors is necessary in order to obtain the desired quality of plastic waste. Misuse or misunderstandings in collection or sorting could spoil all joint efforts by creating a contaminated or impure plastic fraction.

2.2.2. On the level of the specific building professions and plastic waste streams

A number of building professions face plastic waste streams that are quite significant in quantity for their activity, and which have some clear or emerging recycling outlets.

These building professions are the fitter (and electrician), the roofer and the window carpenter. They have the advantage that the plastic waste is directly linked to the core of their activity – pipes for the fitter, roofing membranes for the roofer and PVC window frames and shutters for the carpenter. Offcut waste and especially waste generated in renovation works are important for these professions.

- *Contractors' skill in plastic type recognition*
  The direct link between the plastic waste and their profession also implies that these contractors - and normally also the workforce - are very well aware of the types of plastic within their range of construction products and, moreover, they are able to recognise the different plastic types in their usual C&D waste.

- *Plastic handling and storage via intermediate storage*
  As these waste streams are quite specific to these contractors, waste handling via intermediate storage at the contractors' facilities (depot or workplace) can easily be organised: waste from the building and renovation sites is transported together with the workforce and stockpiled until the amount is big enough to call a waste transporter or arrange joint transport to a waste collection or take back point (buy and take back).

- *Reduction of waste costs in sub-contracting*
  Generally the cost of waste handling and removal in construction works with a general contractor is spread over the different sub-contractors, in relation to some key-figures (based on type of waste and/or budget). Specialised sub-contractors such as fitters, roofers and window carpenters can negotiate a reduced ratio due to the intermediate storage and collection at their own premises.

A more cross-cutting plastic waste stream, applicable to all contractors, is plastic packaging waste. Abundant in quantity and present on every site, packaging waste sorting and collection could develop to become an extra item of standard waste management, together with inert waste, wood and metal.

2.2.3. On the level of the building federations or the building sector in general

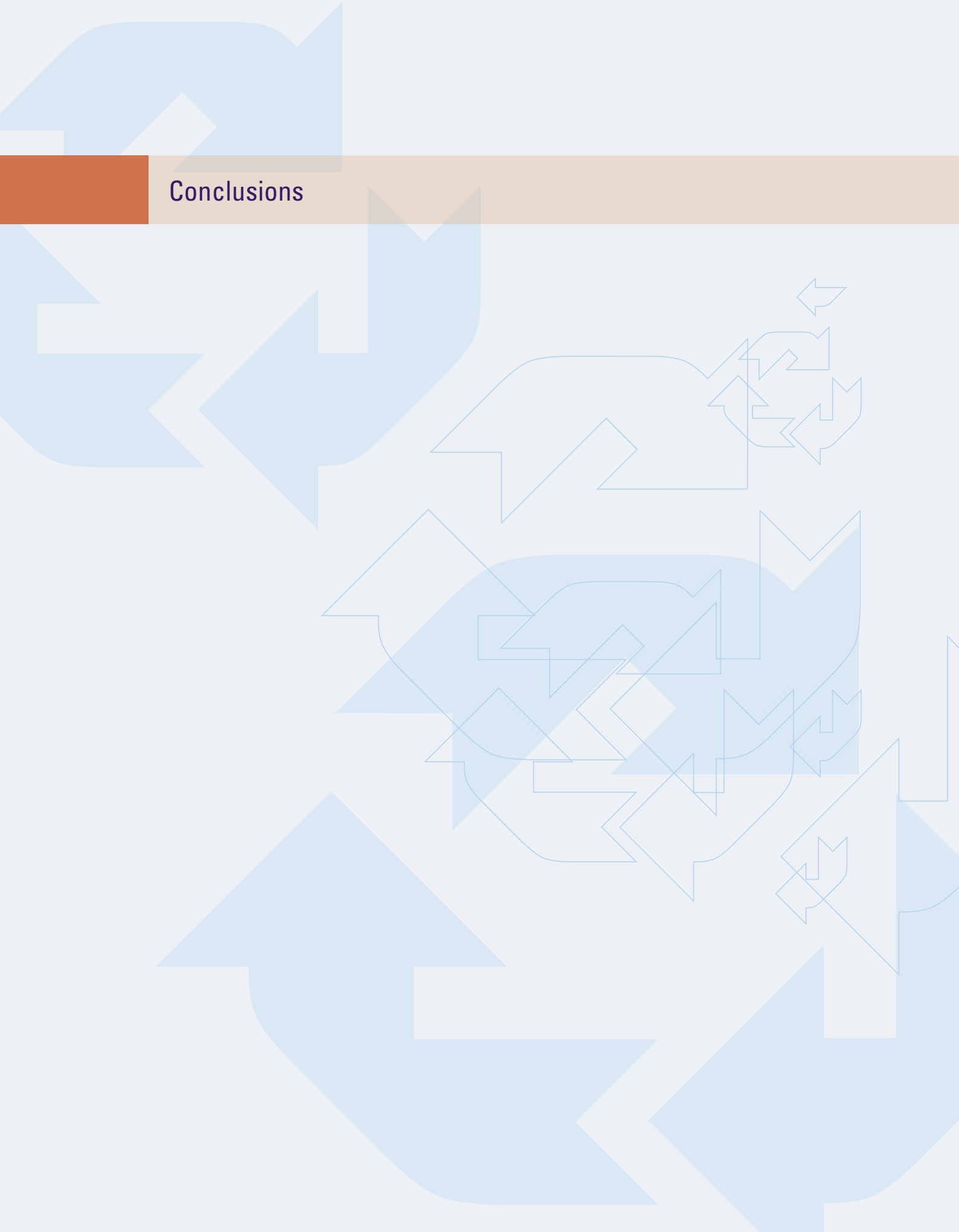
The building sector is not interested in extra obligations to sort or recycle, neither for waste in general nor for plastics in particular. Therefore the impact of waste on the construction process is too small and alternatives exist with specialised waste sorting centres.

However the building sector could benefit from a better-performing plastic collection and recycling industry that could offer specific services and support to contractors in handling their waste.

To this extent the building sector, in collaboration with the producers of plastic construction products and recyclers, could work together to facilitate the development of the collection and construction market. A main item is the step towards minimal quantities for a viable recycling industry through a combined effort by the numerous contractors in the construction industry. This initiative could possibly be limited to some specific plastic waste products such as packaging, pipes, mixed hard plastics, etc. With a construction sector supported approach minimal quantities could be guaranteed to the plastic recycling industry whilst at the same time reducing removal costs.

Another possible item for action by the building federations is the option of reduced labour costs for the sorting of (plastic) waste on site. As labour costs are often a bottleneck for effective sorting on site, this could once again promote sorting on site and recycling.

Conclusions



This guide is one element of a global project co-funded by the Life-Environment Programme of the European Commission: the APPRICOD project aimed at Assessing the Potential of Plastic Recycling in the Construction and Demolition Activities. The APPRICOD project brought together 3 main groups of stakeholders concerned with plastic C&D waste management: the C&D sector, the plastics industry (producers and recyclers) and local and regional public authorities.

In this guide, we have intended to answer the following questions.

> Why play attention to the plastic C&D waste?

- Plastics consumption is still increasing in the C&D sector.
- The lifespan of these products is several decades and thus the issue of waste management is only now emerging.
- Available forecasts predict a significant increase in plastic waste arising in C&D applications.
- The environmental impact of plastic C&D waste disposal can be reduced by using recycling instead of landfill or incineration.
- Recycled plastics can be used as secondary raw materials, thus sparing primary resources and energy, feeding a circular economic system.
- Within the present and future legal and financial frameworks at local, national and European level, the economic costs of waste disposal will increase and alternative solutions to landfill and incineration have to be found.
- Plastic is a contaminant for the recycling of other fractions, removing it is beneficial as it can increase the quality of sorted materials.

> What is the challenge for recycling plastic C&D waste?

- There is a need for efficient selective collection and sorting systems to ensure a good quality plastic waste fraction.
- There are big differences in approach between post-producer plastic C&D waste recycling and post-consumer plastic C&D waste recycling which is much more difficult to organise.
- There are various types of plastic to be separated for recycling, and they are difficult to identify.
- If it is to develop, the recycling sector needs a guarantee of stable and regular quantities over a long period.
- Depending on the type of product, plastic C&D waste is treated through mechanical recycling or chemical (feedstock) recycling or a combination of these.
- The techniques already exist and the infrastructure is available, but locally there might have some need for intermediary infrastructure to group quantities, reduce transport (and thus cost and gas emissions) and create sustainable employment opportunities.
- The recycling market is demand AND supply-driven: i.e. on the supply side it must be capable of offering stable quantities of raw materials (it thus depends on stable inputs). Concerning the demand side, there is a need to ensure the use of secondary raw materials with the help of quality standards, certification and the promotion of recycled products in new applications.
- There is a need for a European level playing field for plastic C&D waste recycling and harmonization.

> Who is involved in this process? What is the role of the key players?

C&D sector

- The C&D sector is one of the most important economic sectors in Europe. Consequently it generates a huge waste stream (180 million tonnes in the EU15) through its activities (demolition, renovation and construction of buildings).
- It is estimated that only 1% of C&D waste is plastic waste, however this means 1.8 million tonnes at European level and it will increase significantly in the near future.

- The C&D sector is interested in finding the best solutions for evacuating its waste: cost is an issue as disposal becomes more complicated and sorting and recycling obligations already apply to several fractions.
- The C&D sector is also interested in having an environmental policy.

Plastics industry

- The plastics sector is also a very significant industry in Europe with plastic consumption standing at 8.7 million tonnes and plastic waste arising at 0.84 million tonnes
- The plastics industry is particularly involved in promoting its products while minimizing their potential environmental impact and adapting to evolving legislation.
- Developing a recycling industry has positive economic and environmental impacts.
- The PVC industry is engaged in a Voluntary Agreement called Vinyl 2010 that includes objectives for PVC C&D waste recycling and various collection and recycling initiatives have been undertaken at local, national or European levels to achieve this goal.

Public authorities

- Public authorities at local, national and European levels are concerned with the huge quantities of (plastic) C&D waste to be managed.
- They have a key role to play in promoting selective collection and recycling by putting in place legal frameworks (e.g. landfill ban or waste sorting obligations), financial instruments (e.g. tax or incentive), concluding agreements with the private sector (and ensure an equal treatment on respecting these), help in developing collection or recycling systems, etc.
- They have also a demonstrative and awareness-raising role to play. Indeed the public authorities can ask to pay the real price for sorting the waste from their works. They might mention a special post for the management, sorting and recycling of all the C&D waste in the specifications for a public work or building.

Better cooperation is needed between these different actors and seems a necessary precondition for the development of local, national or European strategies for sustainable plastic C&D waste management.

> What instruments are needed to develop sustainable plastic C&D waste management?

- Based on the experience of four front running countries (Germany, Austria, Denmark, the Netherlands), the importance of the legal and financial frameworks decided by the public authorities has been demonstrated. Among others, the following instruments were identified: landfill/incineration bans, landfill/incineration taxes, incentives for sorted waste, increased disposal costs, producer responsibility systems, voluntary agreements.
- Such instruments favour voluntary agreements and efficient collection and recycling systems for plastic C&D waste implemented by the private sector.
- These initiatives concentrate on different types of plastic C&D waste such as window frames, floor coverings, roof membranes, pipes, cables, insulation materials, packaging, etc.
- These existing systems offer suitable collection schemes and recycling techniques. In most cases, the costs are compensated either by a contribution from the C&D sector (waste owner/producer), either by the plastics sector (product producer) or a combination of both, based on the "polluter pays" principle

> What are the practical issues for sorting plastic C&D waste based on the demonstration projects at local and regional level?

- Taking as basis the pilot projects implemented as part of the Life project "APPRICOD" in four local or regional authorities (Provincia di Ancona, Brussels-Capital Region, Catalonia and Greater Porto), the practical issues for sorting plastic waste on building sites, as well as the logistical and financial issues and the role that local or regional authorities can play, were examined.
- Some main conclusions from the pilot projects were:
  - that there is no optimal sorting and collection scenario;
  - that there are multiple options for collecting the plastic waste depending on the various types of plastic, the quantities, the type (and phase) of works;
  - that the training of the workers is crucial;
  - that plastic sorting is very complex compared to other fractions due to identification problems, space and volume;
  - that the main costs are the extra labour costs, transport costs and high road tax costs for containers in urban areas;
  - that general C&D waste sorting costs (excluding plastics) are not well known so it is difficult to assess the extra costs for plastic sorting (hypothesis: they are not significant when compared to the overall budget for a building project);
  - that there is a large difference between construction and demolition waste and the way to deal with plastic sorting;
  - that if plastic quantities are too small then sorting and recycling are not economically viable, and collection systems and grouping points must be put in place;

  - that it is necessary to identify the local plastics recyclers beforehand and to develop close partnerships between them and representatives of the C&D sector;
  - that the existence of a (local) recycling market is needed.

> What are the recommendations to public authorities, in particular to local and regional authorities?

- Public authorities have a role to play in fostering the selective collection and recycling of plastics in C&D waste.
- Managing plastic C&D waste implies a close partnership between public authorities and private sector (plastics industry, construction and demolition sector or both).
- The instruments authorities can use to direct the management of this waste towards the most sustainable practices by the sectors involved include:
  - drawing up strategies and including C&D waste into their waste management plans;
  - monitoring and controlling waste flows and waste disposal options;
  - creating a legal framework and regulatory tools;
  - assisting in the elaboration and diffusion of technical tools;
  - using financial instruments;

- putting waste owners and collectors/recyclers in contact with one another;
- favouring the creation of suitable infrastructure; and
- playing a demonstrative and awareness-raising role.

> What good practices can be implemented by the C&D sector to improve plastic waste sorting and recycling?

- In a construction project, waste handling does not influence the quality of the final product, the erected building.
- Waste handling has a small financial or technical impact on the final outcome of a construction work BUT effective waste handling contributes to a further cost reduction in a competitive market, promotes cleanliness and safety on the construction site, and contributes to sustainable construction.
- The waste management plan should preferably be identified before the start of the works to ensure a smooth start to waste collection.
- Several plastic waste management scenarios are possible with (a combination of) off-site sorting in a sorting centre, on-site collection of mixed plastic waste, plastic packaging waste or rigid PVC or non-PVC waste fractions.
- Contractual clauses can be useful. As plastic waste management is fairly innovative, it is necessary to make clear agreements with all the sub-contractors involved in order to avoid conflicts.
- Communication with and awareness-raising among workers are crucial: these must cover the type of plastics to be sorted and how to recognise them, clear figures on amounts, cost issues, impact on the environment, recycling outlets and building products that might use recycled plastics.
- Some specific building professionals face plastic waste streams that are significant in terms of quantity (the electrician, the roofer and the window carpenter) and can easily be included in any initiative (skills in plastic type recognition, intermediate storage, reduction of waste costs in sub-contracting).

> What are the common conclusions of the stakeholders?

Moving towards sustainable plastic C&D waste management raises three main types of issues (technical, economical and regulatory issues) that are deeply interrelated. The technical issues, such as sorting techniques, collection systems, recycling opportunities, etc., are directly linked to economic aspects such as extra costs, the recycling market, the commitment of the sectors concerned, etc.

In turn, these economic aspects can largely be influenced and/or secured by public initiatives in terms of legislation, taxation, control, etc.

To conclude, it is thus essential that firm and effective cooperation takes places between the main actors, i.e. the C&D sector, the plastics industry and public authorities. Dialogue, transparency and well-understood common objectives could then rapidly lead to a comprehensive and efficient European system for plastic C&D waste recycling.

Annexes and bibliography

Annexe 1: List of plastic elements used in the construction sector

	STAGES OF THE WORK	PLASTIC ELEMENTS	TYPES OF PLASTICS
PART 0	**CONTRACTING / SITE**		
0	Introduction / general		
1	Contracting terms		
2	Building site provisions		
3	Demolition & buttressing works		
4	Health and safety plan		
PART 1	**SUBSTRUCTURE**		
10	Substructure excavation		
11	Support & clearance works		
12	Steel foundations	Foundation base/strips (Damp proof layer-film)	PE
13	Special foundations	Raft foundations - pouring concrete / reinforced (Reinforcement)	Synthetic fibres
		Raft foundations - pouring concrete / reinforced & polished (Reinforcement)	Synthetic fibres
		Foundation walls (Reinforcement)	Synthetic fibres
14	Substructure masonry	Foundation walls (Damp insulation)	
		Breaking through & drilling - connecting bend (Telephone, television distribution, electricity, gas, water guide pipes)	
		Breaking through & drilling - energy stone (The prefab module: synthetic panels, synthetic pipes)	
		Breaking through & drilling - housing pipes (Pipes from thermo-plastic material)	PVC, PE, ...
		Ventilation elements - telescopic shafts (T-shaped telescopic ventilation shafts)	PVC, PE
15	Substructure flooring	Purity layers - pouring concrete / not reinforced (film)	PE
		Supporting floors on full ground - pouring concrete / reinforced (Damp proofing insulation: film)	PE
		Damp-proofing layers (films)	PE, PIB, EPDM, HPDE
16	Thermal insulation substructure	Insulation plates on full ground - polyurethane	PUR
		Insulation plates on full ground - polystyrene / extruded	XPS
		Insulation plates on full ground - polystyrene / expanded	EPS
		Insulation plates underground walls - polyurethane	PUR
		Insulation plates underground walls - polystyrene / extruded	XPS
	Drainage elements substructure	Sewage pipes	PVC, PE, PP
		Drainage pipes	PVC, PE
		Manholes	PVC, PE, Polyester
		Rainwater drains	HDPE, Polyester
PART 2	**SUPERSTRUCTURE**		
20	Rising masonry	Anticapillary membranes	PVC, PE
21	Non-bearing interior masonry	Anticapillary membranes	PVC, PE

	STAGES OF THE WORK	PLASTIC ELEMENTS	TYPES OF PLASTICS
22	Wall insulation superstructure	Cavity insulation / thermal	Polystyrene / extruded (XPS), thermal - polyurethane (PUR), expanded polystyrene (EPS)
		Cavity insulation / acoustic	Polystyrene / extruded (XPS)
23	Façade masonry	Damp proofing insulation / cavity (films)	PE, PVC, PIB
24	Façade elements / Building bricks		
25	Smoke & Ventilation ducts	Chimney elements (pipes)	Synthetics (CLV)
26	Structural elements Reinforced concrete		
27	Structural elements Steel		
28	Bearing floors / Reinforced concrete	Beams & filling blocks	Expanded polystyrene (EPS)
29	Structural elements Wood		
PART 3	**ROOFING**		
30	Pitched roof / Roof construction	Eaves - membranes	Multi-walled synthetics: PP - synthetics: synthetic fibres (polypropylene, polyethylene or polyolefin), reinforced synthetic film from PE / PVC
31	Pitched roof / thermal insulation	Insulation plates	Polyurethane foam (PUR), extruded polystyrene (XPS)
		Damp screens (film)	PE
		Insulating roof elements - one-scale (Insulation Material)	Extruded polystyrene (XPS), polyurethane (PUR),
		Insulating roof elements - two scale (Insulation core Material)	Expanded polystyrene foam (EPS), extruded polystyrene (XPS), polyurethane (PUR),
32	Pitched roof / Roof covering	Synthetic plates	
		Synthetic glazing - acrylate	PMMA
33	Flat roof / Roof floor	Insulating roof elements	CORRESPONDING TO: 31.41 and 31.42
34	Flat roof / thermal insulation	Insulating plates	Polystyrene / expanded (EPS), polyurethane foam (PUR), extruded polystyrene (XPS)
		Damp screen (film)	PE, APP- or SBS-polymer bitumen, PIB-film (SBS = Styrene Butadiene Styrene rubber) (APP = atactic polypropylene)
35	Flat roof / Roof sealing	Flat roof / roof sealing	Sealing: synthetic films, APP or SBS-polymer bitumen (SBS = Styrene Butadiene Styrene rubber), (APP = atactic polypropylene)
		Multi-layer / elastomer bitumen (SBS)	APP or SBS- polymer bitumen (SBS = Styrene Butadiene Styrene rubber).
36	Skylight openings	Roof flat windows - synthetic (laminated wooden core, profiles)	Polyurethane, PVC
		Roof flat windows - cantilever windows / synthetic (light-permeable cover, wooden frame interior tray and a covering piece adapted to the type of tile and/or slates	Polyethylene or polyurethane.
		Dome (impact-resistant glazing)	PC/polyester / ...
		Skylights	
37	Edges of the roof & Coves	Roof edge profiles - steel / enamelled (finishing profile intended for roof closing)	PVC
		Roof edge profiles - synthetics (UV-stabilised synthetics - reinforced glass fibre)	Polyester / ...
		Wall coping - synthetic (UV-stabilised synthetics, reinforced glass fibre)	Polyester / PVC / PE / ...
		Covering of coving & canopy roofs - planchettes	PVC
38	Roof guttering	Tray guttering sealing - sheets / zinc (Ventilating under layer, studded film)	HDPE
		Tray gutter sealing - elastomer bitumen strips (gutter sealing)	SBS = Styrene Butadiene Styrene rubber, APP = atactic polypropylene
		Tray gutter sealing - plastomer bitumen	APP = atactic polypropylene
		Tray guttering sealing - high polymer membranes / EPDM	SBS-bitumen (SBS = Styrene Butadiene Styrene rubber)

	STAGES OF THE WORK	PLASTIC ELEMENTS	TYPES OF PLASTICS
		Hanging guttering	Synthetics / polyester /
		Fall pipes	Synthetics / PVC / PE
		End pieces - impact-resistant synthetic material	PE
		Accessories - rook outlet & tapping pipes	
		Accessories - balcony drains	PP / PE
		Accessories - emergency overflows	PE
		Accessories - ventilation caps / flat roofs	Aluminium with PP-inner pipe / synthetics EPDM / ...
PART 4	**FAÇADE CLOSURE**		
40	Exterior doors & windows	Profiles / PVC	
		Hanging & locking work - doorhandles	Colourfast synthetics.
		Doorsteps / profile systems - synthetic	
		Accessories - protective plates	Scratch resistant synthetics
		Accessories - door stops	High quality synthetics
41	Exterior glazing & Filling elements	Synthetic glazing	Polycarbonate (PC), acrylate (PMMA), polyvinyl chloride (PVC), polyester (GRP),
		Filling elements - synthetic / thermal insulating	Hard PVC
42	Exterior doors & shutters	Cantilever doors - door leaf / PVC	
		Window roller blinds - synthetic / PVC (Join to exterior carpentry)	PVC
43	Façade pointing & Sealing	Façade pointing & sealing (Join to exterior carpentry)	PVC
		Join base - polyethylene foam	PE
`		Join filler	Elastic / MS-polymer, elastic / polyurethane,
		Join covering profiles - synthetic	
44	Façade covering	Coating planchettes - synthetic	
45	Exterior plastering	Exterior façade insulation systems - on expanded polystyrene	EPS
46	Outside doors & banisters	Handles - synthetic	
47	Façade renovations		
PART 5	**INTERIOR FINISHING**		
50	Interior plastering	Interior plastering (Light additional materials)	XPS-granules
		Wall plastering - lime mortar / prescribed composition (light additional materials)	XPS-granules / synthetic fibres
		Ceiling plastering - lime mortar / prescribed composition (light additional materials)	XPS-granules / synthetic fibres
51	Finishing interior plate	Coating / pipe shafts - wood (surface finish)	Synthetic film
52	Covering and company floors	Insulating filler layers - cement compound / polystyrene granules	
		Insulating filling layers - sprayed polyurethane	
		Damp resistant layers (film)	PE, PVC, PIB
		Thermal floor insulation	Extruded polystyrene (XPS), expanded polystyrene (EPS), polyurethane (PUR)
		Acoustic floor insulation (film, edge)	PE, extruded PE-foam
		Acoustic floor insulation - polyethylene	PE
		Acoustic floor insulation - polyurethane	PUR
		Ordinary covering (water resistant layer: film)	PE

	STAGES OF THE WORK	PLASTIC ELEMENTS	TYPES OF PLASTICS
		Special covering - synthetic anhydrate / non-adhesive (synthetic net)	
53	Finishing interior flooring	Wooden flooring (Mats)	from PE-foam mats
		Flexible flooring - vinyl / PVC	vinyl / PVC
		Plinths - synthetic / PVC	PVC
		Plinths - synthetic / rubber	Free of PVC
		Accessories - floor mats (profiles, covering film)	Nylon fibres, PVC, PP/PES
		Accessories - floor covering	PVC
		Accessories - floor grids	PVC
		Accessories - door stops	Synthetics
54	Interior doors & windows	Door leafs - folding doors / synthetic	PVC
		Hanging- & locking - door handles	Steel core covered in nylon
		Accessories - door stops	Synthetics
		Accessories - door grills	Synthetics (PVC, ...)
55	Interior glazing & filling elements	Safety glazing / single - layered	Polyvinyl butyral (PVB)
		Synthetic glazing	Polycarbonate, polyacrylate
56	Interior stairs & banisters	Handles - synthetic	
57	Fixed interior furnishings	/	/
58	Sills- & Wall covering	Windowsills - synthetic	PVC
PART 6	**TECHNICAL / FLUIDS**		
60	Sanitary / pipe work	Drainage pipes (siphons)	PVC, PE, PP
		Ventilation pipes	PVC, PE
		Ventilation pipes - synthetic / PVC	PVC-C (Chlorinated PVC) / PVC-U (Non-plasti-fied PVC)
		Ventilation pipes - synthetic / PE	Polyethylene (PE)
		Ventilation pipes - aeration valves	ABS, PE
		Drain covers / internal - synthetic	PVC / PE / PP / ABS
		Drain covers / internal - synthetic	PVC / PE / PP / ABS
		Supply pipes & accessories - pipes / synthetic	PVC-U, PE, PEX, PVC-C, PB, PP, VPE (cross-linked polyethylene), HDPE, PEX
		Supply pipes & accessories - pipe insulation	Polyurethane / extruded polyethylene
61	Sanitary / Equipment & Accessories	Toilet bowls & accessories	Hard synthetics
		Toilet bowls & accessories - hanging	Synthetics /thermo hardening synthetics/ wood sprayed with synthetics
		Hand basins & accessories	Siphon: chromed polypropylene - Accessories
		Baths (Valve, drainage equipment, Siphon)	Chromed synthetics - polypropylene (PPR), polyethylene (PE), PVC-C - heat resistant PPR / PE / PVC-C
		Showers (Cover, draining equipment, Siphon)	Chromed synthetics - polypropylene (PPR), polyethylene (PE), PVC-C - heat resistant PPR / PE / PVC-C
		Special accessories - shower rail and curtain	Heavy PVC
		Special accessories - shower seats	
62	Sanitary / Taps & Valves	Installation taps - stop cock / synthetic	
		Installation tapes - stop cocks with draw-off tap / synthetic	
63	Sanitary / Hot water provision	Flow through gas-fired water heaters - supplied by the management	
64	Gas installations	Gas pipes - synthetics / PE	Polyethylene (PE)
65	Heating / individual installations	Pipe network & accessories - pipes / synthetic (piping, casing pipe)	PEX (VPE) (cross-linked polyethylene) - HDPE, PP (Polypropylene)

	STAGES OF THE WORK	PLASTIC ELEMENTS	TYPES OF PLASTICS
		Pipe network & accessories - piping insulation	Polyurethane foam / extruded polyethylene, equipped with a hard PVC-protective case
		Pipe network & accessories - fire-resistant pipes (Piping)	PE
		Heat regulation & accessories - manometer	
		Heat regulation & accessories - thermometer	
66	Heating / Special installations		
67	Fire-fighting	Fire extinguishing water / external - piping	
		Fire resistant protection (Casing pipe)	PVC - U
68	Ventilation & Air-conditioning	Ventilation ducts	PVC, PVC-C, HDPE
		Ventilation ducts - synthetics / rectangular or oval (film, laminate)	Layers of aluminium and polyester or aluminium polyester laminate
		Ventilation ducts / accessories - filters Polypropylene, synthetic fibres	
		Ventilation ducts / accessories - one-way valves	High quality recyclable synthetics
		Ventilators - residence ventilators	
		Ventilators - ventilator ducts	Polypropylene
		Ventilators - sanitary ventilators	ABS, ...
		Ventilation valves & grids	Synthetics (PP, ...)
PART 7	**TECHNICAL / ELECTRO**		
70	Electricity / Interior network	Earth - additional equipotential connections	Insulating synthetics
		Wiring - Cables	PVC
		Draw-in boxes & connection boxes	
71	Electricity / Switches & Sockets	Sockets	
		Connection boxes - food / washing & dishwashing	PP
		Special accessories	
72	Electricity / Light fittings	Interior fittings / E27	
73	Electricity / Bell & Bell & door entry telephone	Door entry telephone installation	
74	Electricity / Telecom & Automation		
75	Electricity / Heating		
76	Electro mechanics / Lifts	Cage equipment - lift for people	PVC
77	Fire detection & Alarm systems		
PART 8	**PAINTWORK**		
80	Interior paintwork		
81	Exterior paintwork		
PART 9	**LANDSCAPING WORKS**		
90	External paving	Tiles - tactile surfaces	Polyurethane
91	External constructions & Fencing		
92	Exterior furniture & Equipment elements	Rubbish bins - synthetic	
		Tree surrounds - grids / synthetics	Polyethylene (HMPM) / recycled synthetics / ....
93	Landscape gardening & Maintenance		

Annexe 2: APPRICOD partners contact list

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Chapter 1: European context
Chapter 2: Management of the plastic waste from C&D waste in the partners cities and regions
Chapter 3: Case studies and relevant experiences
Chapter 4: Benchmarking of best performing European countries in the field of construction and demolition plastic waste management: Germany, Austria, Denmark and the Netherlands
Chapter 5: Identification of progress and blocking factors
Chapter 6: Description of different existing collection and recycling schemes

Appricod Task 2 reports: "Definition of pilot selective collection schemes focused on plastic waste"

Chapter 1: LA/RA reports
Chapter 2: Determination of the required quality for the plastics recycling
Chapter 3: Follow-up procedures

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Chapter 2: Evaluation and improvement of the follow-up
Chapter 3: Report on experiences and lessons from pilot projects

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