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Best Practices for the mechanical recycling of post-user plastics.

Appendices report: Detailed description of recycling schemes considered. (Annex to TNO-report no. 00 PO 891 HDG)

A study commissioned by APME

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Introduction

This appendices report accompanies the report 'Best Practices for the mechanical recycling of post-user plastics', no. 00 PO 891 HDG, further mentioned as the main report. Both reports are written by TNO Institute of Industrial Technology.

This report consists of a number of Appendices. The information described in the Appendices has served as the basis for the results and conclusions presented in the main report. Appendix 1 gives an overall view on the European collection systems. Appendices 2 to 13 deal with several plastics waste categories and are all drafted in the same layout. For each plastics waste category a general or specific set-up of a recycling scheme is described. Further the economic, legal, social and organisational aspects are described. The progress and blocking factors are presented in a matrix. Also the eco-profile considerations are described. At the end of each Appendix a list of references is presented.
In Appendix 14 the table with the key progress and blocking factors of mechanical recycling from the TNO/Sofres report 'Potential for post-user plastic waste recycling', March 1998, is represented.

A list of general references is as follows:

General references

- Main report 'Best Practices for the mechanical recycling of post-user plastics', Report number 00 PO 891 HDG, TNO Institute of Industrial Technology, The Netherlands, February 2000.
- TNO-Sofres study, 'Potential for post-user plastic waste recycling'. Study commissioned by APME from TNO and Sofres, Final report, March 1998.
- Perchards, "Packaging Legislation in Europe (Perchards), updates 17 September 1999 and 21 July 1999.
- Brandrup, 'Recycling and Recovery of Plastics', Dr. J. Brandrup, editor, Hanser Publishers, 1996, ISBN 3-446-18258-6.
- Interview with Flavio Previro, Sorema, Via dei Platini, 11, 22040 Alzate Brianza (Como), Italy, May 1999.
- Interview with George Dehay, Elf Atochem, 4, CoursMichelet, La Défense 10, 92091 Paris La Défense, France, June 1999.
- Several discussions with specific task forces of APME (1999)
- Study Eco Emballages, 'Le recyclage des emballages plastiques en Europe', December 1998, kindly made available by Mr. Yvan Liziard, Material Reprocessing Department, 44 Avenue Georges Pompidou, P.O.Box 306, 92302 Levallois-Perret Cedex, France.

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1. European collection systems for recycling post consumer plastic waste

1.1 Introduction

The European Union developed a Directive on Packaging & Packaging Waste (94/62/EC), that came into force in 1994. A European Directive was necessary to remove obstacles to trade arising from the range of regulations within a single market. By 2001 packaging in general must achieve an overall recycling rate of 25 - 45% with a minimum for any given material (e.g. plastics) of 15%. The EC Directive sets no targets for individual polymers and makes no distinction between used household and commercial/industrial packaging. In total over 50% of packaging waste must be directed to recovery processes that create value from (valorise) the waste. (This includes means such as recycling and waste-to-energy). Countries must refer back to the EU before exceeding 65% recovery or 45% recycling of packaging to ensure that such action does not unfairly disadvantage other member states. All EU member states must have introduced systems for collection and recovery of packaging either by the year 2001 (or 2005 in the case of some member states).

Most countries have already adopted strategies in response to the Packaging Waste Directive, which have included the setting up of comprehensive collection programmes for household packaging waste. This Appendix describes the way European countries organise their collection and recycling of post consumer packaging waste. Of these countries, twelve introduced a Green Dot system in which a packager has to pay fees to a national packaging recovery company. Two other countries organised their recycling activities via a covenant system in which it is the producers responsibility to collect and recycle the packaging. Some other countries introduced their own specific system.

1.2 Green Dot system

As described above, the Green Dot system is a system in which a packager has to pay Green Dot fees to a national packaging recovery company. In order to prevent the creation of trade barriers as the European Packaging Directive was implemented, the Packaging Recovery Organisation Europe (PRO Europe) was established to award the mark “Der Grüne Punkt” or the Green Dot as it is known in English, and to establish it as a European trade mark. The Green Dot trademark is solely a financing mark and, as such, is neither a recycling symbol nor an environmental label.

With the Green Dot fees, the national collection and recovery schemes for packaging waste (including glass, paper/carton, metals, plastics etc.) are financed in Austria by ARA AG, in Belgium by Fost Plus, in France by Eco-Emballages S.A., in Germany by Duales System Deutschland AG, in Luxembourg by Valorlux asbl, in Spain by Ecoembalajes España S.A. and in Portugal by Sociedade Ponto Verde S.A. Repak Ltd. in Ireland has joined the PRO Europe organisation from January 2000. In Norway, Materialretur has taken the decision to adopt the Green Dot in the second half of 1999, but merely for control reasons against free riders in their own system.

Each company wishing to transfer the obligations imposed on it by the Packaging Ordinance to a national green dot company becomes a licensee of the “green dot company”. The company, which can be packaging manufacturers, fillers, importers or retailers, pays licence fees depending on the quantity and type of packaging it puts onto the market. The fee is dependent on the efficiency and scope of the collecting systems, percentage of population covered and percentage of green dot licensees in the country. These licence fees are used to finance the waste management services.

Joining the national green dot system means a company is exempt from its obligations under the legislation, which are intricate and comprehensive. As proof of the participation the licensee has the right to attach the green dot to his packaging. In order to ensure the efficiency of the green dot system the Packaging Ordinance of each country specifies recycling and recovery quotas/targets. According to the Austrian Ordinance for example, 20% of the plastic packaging material placed on the Austrian market in the years '96-'98 must be delivered to a recycling plant.

Guarantors for plastics recycling

With the Green Dot system great importance is attached to the so-called guarantors at the interface between sorting and recycling. This is because they have contractually guaranteed to accept and recycle the material forwarded to them. For each material group (plastics, glass, metals etc) a guarantor is responsible for the recycling of that material.

The guarantors for plastics recycling realised that they needed to exchange information about collection and recycling and, if possible, to co-operate in order to be better able to meet the EU directive's regulations. For this, EPRO, the European Association of Plastics Recycling and Recovery Organisations, was founded. This platform organises meetings in which the members can participate and discuss their items. National organisations partic ipating in EPRO are:

- ÖKK (Austria)
- Plarebel (Belgium)
- DKR (Germany)
- Suomen Uusiomuovi Oy (Finland)
- Valorplast (France)
- CO.RE.PLA (Italy)
- Plastretur (Norway)

- Plastval (Portugal)
- Cicloplast (Spain)
- Plastkretsen (Sweden)

Of these organisations those from Italy, Finland and Sweden are not a member of the Green Dot system. However, also for these national organisations the exchange of information is an important factor.

All national systems are organising the collection of packaging waste from households and similar facilities. In most countries also the collection of waste for trade and industry has also been developed. In Norway and Sweden (and in The Netherlands and Ireland, two non-EPRO members) plastic waste from agriculture is also organised. All common types of plastic wastes are collected, except for the German system, which is collecting according to the shape of the product, and the French system, which only collects bottles (consisting of PET, PVC and HDPE).

1.3 Covenant system (producers responsibility)

In The Netherlands and Norway a covenant is set between the Ministry of Environment and trade and industry. As a general rule, the strategy of the Dutch (and Norwegian) government has been to negotiate with industry in order to implement producer responsibility through voluntary agreements rather than traditional regulations. The voluntary agreements, or covenants, between government and industry associations are meant to implement the so-called Extended Producers Responsibility (EPR) within sectors of industry, mainly in areas where legislation already exists and government can exercise control such as through issuing licenses. In this manner, covenants serve as a management tool by providing a specific implementation programme for the allocation of roles, funding and goals within a more general legal framework.

As an example, the Dutch situation will be described. All Dutch companies in the packaging and packaging goods sector are subject to the Dutch packaging and packaging waste regulation, the Packaging Covenant II. The regulation introduced producer responsibility in a statutory framework (formerly it was voluntary), making it obligatory for everyone who markets a product for the first time to recover 65% of packaging waste (material recycling + incineration with energy recovery), and of this at least 45% by material recycling. For the plastics waste in The Netherlands the recycling percentage to be achieved in 2001 is 27% in order to reach the overall target of 65% for all materials (for example the target for glass is 90%).

An essential element of the regulation is, that all individual obligations lapse for businesses (producers as well as importers) which are party to a covenant: these companies will contribute to achieving the targets agreed but will not be held individually responsible for meeting the targets, notifying the measures taken, reporting on these and monitoring the final results. The covenant ensures that the

targets will be met for all materials. This is a strong incentive, as the obligations in the regulation are complicated and costly for individual enterprises to implement.

In The Netherlands most attention is paid to the collection of post-use industrial and commercial packaging. The reason for this is that it represents the most practical and economic part of the packaging waste to collect and recycle:

- up to 50% of the used plastic packaging in The Netherlands comes from these sectors and
- this plastic waste is (or can be) less contaminated and can be separately collected.

For films and EPS the industry is itself responsible for the collection and recycling. The Dutch industry set up organisations for implementing the collection and processing of end-of-life packaging products on their behalf. These representative organisations are financed through funding from the companies involved, and are organised under the foundation "Vereniging Milieubeheer Kunststofverpakkingen" (VMK), the party who undersigned the integration covenant on behalf of the plastics packaging industry. VMK is the environmental management organisation for the plastics packaging industry in The Netherlands.

The one waste stream from households included in the covenant, PET bottles, are collected at a rate of more than 95% through a deposit system.
The enforcement of the Dutch Covenant is slow to develop with a clear increase of recycling plastic packaging not yet visible.

As is the case with the green dot systems, the Norwegian and Dutch systems have guaranteed purchasing of collected plastics by the recyclers.

1.4 Other systems

An example of another system is the compliance scheme of Valpak in the United Kingdom. Valpak was the first multi-material, multi-product recovery organisation in the UK. Valpak's business plan stated that its main activities would be contracting with accredited reprocessors and other waste holders to fund the recycling or recovery of packaging waste in exchange for documentary evidence of compliance to match the total obligation of all its members. Revenue from Valpak contracts was expected to be used by local authorities, waste management companies, reprocessors and joint venture projects to justify additional capital expenditure for collection, sorting and reprocessing capacity. Valpak has in fact established partnerships with two major waste management companies. This results in direct access to household and commercial/industrial waste collection, landfill operations and waste-to-energy plants.
A basic principle of the Regulations is that companies which recycle packaging that becomes waste on their premises can use Packaging Recovery Notes (or PRN's) or other evidence of recovery to meet part of their obligations. Valpak thus acquires

PRN's and other evidence of members' own recycling activities on a 'cost neutral' basis.

1.5 Methods for collection

In all national systems one or more of the following methods are used for the collection of packaging waste from households, industry, offices etc.:

- Kerbside collection, in multi-material bags or containers which are collected weekly or other period; drop-off locations, where the public can bring multi-material mixtures (in bags or otherwise).
- Drop-off locations, where the public discards their bottles in collection containers sited at convenient locations. A draw back is the possible high contamination level (10 to 30%).
- Buy-back centres, in which packaging waste is purchased from consumers.
- Return vending whereby consumers give their packaging (bottles, crates) back in return for coupons or tokens.
- Refill and deposit, in which packaging (bottles, crates) are sold with refundable deposits that are redeemable on return of the bottle to participating retail sites.

The lightweight fraction of the waste is mostly collected via two models: kerbside collection and a bring system. In the kerbside collection, lightweight packaging is collected in yellow (sometimes light blue) bags or bins and picked up from the individual households. In the bring system, consumers take the packaging they have collected to recycling stations or containers that have been installed in the vicinity. Valorlux in Luxembourg, for example, collects plastics only door to door, but they note that container parks will offer a useful and important complementary collection system. ARA in Austria and DSD in Germany, for example, already use the combination of container and door to door collection. A dense network of around 860,000 collection containers have been installed for the bring system, whereas for the kerbside system consumers use yellow bags of bins.
Deposit systems are mainly used for collecting PET bottles. These deposits may be charged on both refillable and single-use PET bottles.

1.6 References

See addresses and links of national recycling and recovery organisations in main report.

2. Appendix: Scheme Analysis Crates

2.1 Introduction

Crates are used for various applications and, generally speaking, for many years in the same application. A rough division can be made between bottle crates, crates for material handling and agricultural crates. The latter category of agricultural crates will not be further dealt with in the Appendix. The bottle crates are used for the packaging of beer, juices, soft drinks and dairy products. Format, colour and logo or advertising are often brand specific which supports the return logistics system.
The crates for material handling can be differentiated into crates used in industry e.g. containing parts for assembly lines and crates used in retail chains. In the retail chains the crates are used for the distribution of fresh products such as vegetables and bakery products. These products are transported in the crates directly from the vegetables auction, the bakery or the distribution centre into the shops. Design and colour of the crates are often product specific, so for the packaging of vegetables, bread or meat different formats and colours are used.

In Western Europe every year over 400,000 tons of HDPE and PP (both virgin and recyclate) are used for the production of crates. The choice of the base material usually depends on the field of application, but also current market prices and availability may play a decisive role. So it may occur that two visually identical crates are made out of two different base materials (HDPE and PP).
As for an European average it can be stated that for the bottle crates roughly 80% are made out of HDPE (mostly beer and soft drinks) and 20% out of PP (mostly dairy products). However, country specific situations may significantly deviate from the European average, e.g. in the UK we have the reverse situation with the major part of the bottle crates made out of PP instead of HDPE! (*It should also be noted that concerning transport of bottles across Europe sharp contrasts exist between the different countries. In countries like Italy, France and Spain with a one-way system for soft drink and water bottles, hardly any crates are used because the bottles are transported on wooden pallets covered with shrink film. In countries like Germany, The Netherlands and Sweden almost all bottles are distributed in crates as part of a return system.)*
As for the material handling crates it can be stated that the difference is less pronounced: roughly 60% are made out of HDPE and about 40% out of PP.

2.2 Description of the recycling scheme

Either through damage, weathering condition or replacement through crates with another design or construction, the crates may become available for recycling. As

most of the crates are used in closed loop systems in industry or in pool systems (with a deposit scheme) large quantities of crates become available as an attractive source for recycling: homogeneous, slightly polluted plastic waste which is geographically concentrated. In general, direct collection agreements exist between large crate users or pool managers and recyclers; in addition, specific lots of crates are offered for sale by tender. Some leakage out of the chain occurs through private usage of the crates by consumers; there is also some leakage out of the chain because crates, which are used for export of products (e.g. bulbs), are not always returned for recycling.

Being relatively large and heavy the crates can - if necessary - be cost-effectively sorted by colour and/or type of plastic. Upon sorting the crates are ground into a suitable particle size for further processing in extruders or injection moulding machines. Due to the bulky nature of the empty crates mobile grinders are frequently used to grind the crates on location (with one truck either 3,000 kg of crates can be transported or 22,000 kg in the form of crushed material). The further processing may be carried out either in the vicinity of the grinding location by a local processor or after transport over longer distances (up to 600 or even 1,000 km) in a plant of a recycler or crate producer. A range of distances up to 700 km is possible, which also holds for the trading areas of injection moulding products.
If the crates are contaminated either a washing step of the crates prior to grinding and/or washing of the regrind and/or melt-filtration during further processing contributes to the required quality of the granulate and the final product. In order to meet technical standards converters sometimes need to add virgin materials or stabilisers etc. to regrind.

Major outlets for the recyclate are crates, other packaging, construction products, garbage bins, pallets, pipes, flowerpots etc. (It was stated by one of major European crates recyclers that 90 to 95 % of his quantity of recycled crates are used for the production of new crates, with the balance going into the production of pallets.)

2.3 Economic aspects

As the waste crates become available in a geographically concentrated location the costs for collection are quite moderate. Processing costs strongly depend on contamination rate and the necessity to include washing and/or melt-filtration steps. Generally speaking, the total costs (collection and processing) will not exceed 275 euro/ton (range 125 – 275 euro/ton, inclusive transport costs of regrind from the grinding site to the converter ranging from 20 to 75 euro per ton, depending on destination). With virgin prices for HDPE at 1,000 euro/ton and for PP at 750 euro/ton (Q4/99) and selling prices for recyclate at 80% of virgin, the recycling of crates can be a profitable business, even if the recyclers have to pay 300 to 400 euro/ton for the crates. It was mentioned by one of the recyclers that even a margin of 125Euro/ton between buying and selling price can be profitable in some specific

cases (not requiring a washing or extrusion step but covering costs for transport, grinding, de-dusting, packing in big-bags, marketing/selling). However, another recycler mentioned that selling prices for the large volumes of recyclate are at present (Q4, 1999) at only about 50-55% of virgin (historically they should be at about 70-80%). With sales prices at 50 – 55% of virgin and increasing purchase prices, margins are small if not negative. With these conditions the recycling of crates was not actually a profitable business at that moment (Q4, 99) meaning that the ROI is very low. Only by processing large volumes, small overhead and a flexible workforce one can react and make some profit. Plastic recycling as a stand-alone activity seems to be hardly possible anymore.
Some regrind (e.g. from the Eastern European countries) is being offered at levels of around 450 euro/ton free delivered at converter. These regrinds are reported to contain heavy metals and as such are therefore illegally imported into the EU. For Western European recyclers that are complying with the legislation this implies false competition and an enormous disturbance of the market.
Remark: This shows that even for a homogeneous stream of material, which is available in larger quantities (and seen as one of the more favourable plastics waste streams for recycling), recycling is not always profitable, even in times where the virgin prices are high as they were at the time of writing the report.

2.4 Legal, governmental aspects

The recycling of crates was a successful industrial activity long before the introduction of the European Directive on Packaging Waste. As such, one would expect that legislation hardly contributes to further expansion of recycling activities. However, as there is disagreement between some parties on the degree of coverage of the collection and recycling schemes of crates, legislation might stimulate additional recycling activities in this area if there is a surplus of non recycled crates somewhere available on the European market.
A problem is that the authorities should control the East borders and even more the traders. This is still not done and therefore present legislation is working against the West European recyclers as they are facing fierce false competition.

As for the “Cadmium” issue (besides cadmium also lead, mercury and chrome-VI are mentioned as the four relevant heavy metals in several EU directives) it can be noted that legislation (Derogation 1999/1771 EC) recently has been agreed whereby the recycling of plastic waste containing heavy metals is possible (there are estimates that over 90% of the discarded crates contain some cadmium).
Specific conditions which need to be met are:

- The owners of crates containing heavy metals will remain ultimately responsible for correct disposal or recycling of the waste. If new crates are produced with regrind they should have < 100 ppm cadmium and < 250 ppm for the sum of the four heavy metals together in order to be considered and declared ‘heavy metal free’.

- All crates with > 100 ppm cadmium or > 250 ppm for the sum of the four heavy metals together are to be considered as containing heavy metals and can only be re-used in crates or pallets in closed circuits.
- All players in the recycling chain (from the owners to the recyclers) are obliged to correctly register all transactions in their books.

Environmental legislation in general favours the existence of 'standards for recycling' as described in paragraph 2.6.
In case regrinds are 'heavy metal free' there are no limitations for its use.
It should be remarked that unfortunately not all converters and crate recyclers comply with the aforementioned rules, and often purchase 'not-specified' (and often 'heavy metal' containing) regrind for prices which are not feasible for the recyclers that do comply with the rules. It is also clear that a lot of this 'not-specified' regrind is not used for the production of crates and plastic pallets! In order to prevent legislation working against the 'legal' West European recyclers as they face fierce false competition, the authorities should control the suspect borders and even more the traders, both in some Western as well as Eastern countries.

2.5 Social aspects

Crates are highly visible in our society, in households as well as in industry. The paid deposit, the required storage accommodation and the need for continuous delivery of the packaged product contribute highly to the effectiveness of the return logistics process. Some leakage out of the crate chains occurs through usage of the crates by consumers for private storage and material handling. Most of the crates are used in a closed loop system. Generally speaking, a good co-operation exists in the total chain (e.g. between disposers and upgraders) as well as for the sector itself.

2.6 Organisational aspects

The distribution and collection of the crates is part of a well-organised closed loop system. Throughout the whole crate chain a high degree of control holds for all different steps: distribution and take back of the crates, collection for recycling, recycling and marketing of the recycled granulates and products.

It is estimated that in Europe approximately 150,000 tons of crates were recycled in 1998 with four to five large recyclers accounting for about 70% of the required recycling capacity (with involvement of other recyclers and processors) and a number of smaller recyclers taking care of the remainder. Between some of the larger recyclers, which are recycling themselves some 20,000 tons of crates, reliable information about the recycling volumes and material streams of about 80 – 100,000 tons of material is available. In Europe about 60 recyclers are active in the field of

crates recycling, of which 10 recyclers recycle mainly crates and very little other plastics waste.
Between leading plastic crates recyclers and leading European producers of crates agreements are presently put into place on the conditions for collection, recycling and delivery of recyclates. These agreements have also been discussed with sector organisations of beverage industries among others in order to achieve a chain commitment. It is the intention to use this same scheme all over Europe, which has already been initiated in the North European countries. So far, the traders are generally not willing to subject themselves to the same control mechanism and interfere heavily with these industry initiatives.

2.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of crates combined with a selection of the relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A2.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for crates have been identified and weighted according to the procedure described in the main report. (See table A2.2.)

2.8 Eco-profile considerations

Due to the fact that most of the old crates are recycled and frequently applied in high quality applications (and to a large extent even in a closed loop to crates again) a considerable decrease in the demand for virgin resources and related energy use occurs. As a result also the amounts of emissions and waste will decrease.
Especially in the case of crates recycling we have a high quality recycling process where the virgin plastic is substituted close to 1:1 with recycled material in several plastics applications. In general huge amounts of rather clean and homogeneous crates are processed. Together this results in a positive eco-profile for the recycling scheme of crates

2.9 Conclusions

In view of the tendency of the progress and blocking factors (table A2.1) as well as the very positive scores of the decisive criteria (table A2.2) it can be concluded that the market-driven recycling scheme of crates is rather successful. The high level of control by the main actors in the chain, the good logistics structure, the high quality

of the recycled material and the positive environmental profile make this recycling scheme one of the best examples of good practice in plastics recycling.
As for the economic profile that has been rather positive in the past, one should keep in mind the remark about the profitability in § 2.3!

2.10 References

- Interview with Bernard Merkx, GT Recycling B.V., P.O.Box 176, 7770 AD Hardenberg, The Netherlands, November 1999.
- Interview with Eric Morssinkhof, Morssinkhof Plastics b.v., Dieselstraat 11, 7131 PC Lichtenvoorde, The Netherlands, March 1999.
- Information from earlier interview with Michel ten Bok, Bekuplast, Industriestrasse 1, 49824 Ringe, Germany, 1998.
- Personal communication with marketing staff of DSM, Lankhorst and BP, 1997.

Table A2.1 Progress / blocking factors for crates recycling

Theme	Progress factors	Blocking factors
Economic	• Market pull activity • Open and transparent market • Availability of sufficient market outlets for recyclates as well as regrind • Relatively good margins concerning profitability • Specifications for recycling process and deliverables • Specification for technology and costs structure of the recycling process • Low processing costs	• Improper competition through local subsidy schemes for recyclers (e.g. in Germany some recyclers were given subsidies for large scale investments in new recycling equipment primarily meant for recycling of household packaging waste, but also capable for the recycling of crates) • Access to capital for investments not always easy: very low ROI if any • Lower margins between the prices of virgin plastics and recyclates hampers the buying of recycled materials • Required administrative burden negatively influences margins • False competition from trading companies and (sometimes illegal) imports from Eastern European countries put market under severe pressure
Legal, governmental	• Regulations on packaging recycling • Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates).	• Basel convention; definition waste versus raw material, transport of plastic waste sometimes hampered by regulations concerning ‘waste • Legislation on heavy metals is actually a progress factor, but without control and checks by the authorities it may turn against the complying recyclers!
Social	• Very positive eco-efficiency; proven sustainability of the closed loop system for the crates. • Good co-operation between most of the main market players • The greater part of the players in the collection and recycling chain of crates is under control, notably in the trade circuit • Effective consultation structure within umbrella organisation for recycling, EUPR and national sector organisations • Pro-active attitude of major bottle crate producers, also concerning normalisation and processing of waste • Acceptance of recyclates by producers (partly closed loop) • Good bookkeeping/ISO 14001 and 2 positively contribute to (acceptance of crate recycling in) the public imago • Recycling processes have to comply with the regulations • The recycling of crates (closing the loop) is well accepted in society.	• Negative opinion on recycling activities in general may block or obstruct structural growth (especially concerning investments) • The heavy metals issue is still a matter of concern for the environmental pressure groups • Producers of transport crates and vegetable crates are still less pro-active
Organisational	• Availability of sufficient recycling capacity • Large number of crates at a limited number of sources • Relatively simple process, so easy introduction of new competitors in bottom end of market	• Uncontrolled "leakage" of crates out of the loop

Table A.2.2 Decisive criteria and scores for recycling scheme crates

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	+	
1.2 Quantity	+	
1.3 Number of disposers	++	+/++
1.4 Contamination level	+	
1.5 Markets	+	
1.6 Substitution threat	+	
1.7 Recycling costs	++	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	+
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	++	
3.2 Sector co-operation	++	+/++
3.3 Participation disposers	++	
3.4 Society pressure	0	
3.5 Successful recycling stories	++	
4 Organisational		
4.1 Disposal system	++	
4.2 Take back logistics	++	+/++
4.3 Processing capacity	+	
4.4 Certification secondary products	+	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

3. Appendix: Scheme Analysis Commercial and Distribution Films

3.1 Introduction

Commercial and distribution films are mainly PE films, of which LDPE is mostly used alongside LLDPE and HDPE. LLDPE is used for stretch wrap applications, to secure goods to pallets. Shrink wrap is produced from LDPE and is used to secure smaller quantities of goods together or to a corrugated tray. Another application for LDPE, as for HDPE, is in bags. From this description of applications it can be deduced that most of the waste films should not be very contaminated. Films from offices or stores (like supermarkets) don't have direct contact with products like food and should not get dirty during transport.

Due to these characteristics of the film waste and from the economic attractiveness of its recycling, a number of collection systems have been set-up. In The Netherlands three film sorting companies founded the Stichting Knapzak, which puts collection bags or containers at the disposal of the disposers for separate collection of films. These bags and containers are picked up by the collector on regular basis. Also other companies are active in this field: the Dutch VKR (Vereniging van Kunststof Recyclers) acts in the interest of 40 collection/sorting companies. It was estimated that around 130,000 tonnes of film waste was collected in 1998 in The Netherlands.

In Austria the recycling scheme for commercial and distribution films is organised by ARA AG which also takes care of the household packaging. The ARA system is comprised of privately operating non-profit organisations, which are independent of each other and organise collection and/or recycling of the packaging waste. ARA collects licence-fees and transfers the money to ARGEV for the collection sorting and to ÖKK for the recovery of the plastic waste. In 1998 ÖKK recycled around 20,000 tons of plastic commercial films, which is about 15% of the market quantity of films in Austria.

In Germany the RIGK, the Corporation for Recovery of Plastic Packagings from Industry and Commerce, was founded at the end of 1992. This organisation not only recovers films (mainly by mechanical recycling), but also containers, bottles, fabric packagings etc. all from industrial and commercial companies.

Because most of the clean fraction of the film waste is being collected in some countries, new collection initiatives are often confronted with waste which is much more contaminated. This makes new initiatives and increase of existing systems a lot more difficult than the initial ones.

3.2 Description of the Recycling Scheme

In Europe PE film recycling (which accounts for the largest proportion of recycling markets) increased by 10-12% in 1998, with further scope for increase predicted. A reason for this is that these films are relatively easy to collect; they are released in a less diffused manner and are less dirty than films in household waste. On the other hand, recyclers notice that disposers are not always very accurate in collection, resulting in a too heavy contaminated waste for high value recycling. In order to be able to recycle the films into high value products most recycling companies have high input quality requirements for the waste. Preferably no foreign particles, like paper, other plastics, wood etc, should be present. These requirements imply high requirements to the quality of collection by both the disposer and the collector.

After collection the films are generally sorted into the separate types of film and material. The sorted film is then transported to the recycler. The recycling process consists of roughly the following steps:

- De-baling
- Handsorting if required
- Conveyor → (one or two stage) shredder, possibly with friction washing
- Two stage washing including float/sink stage to remove contaminants
- Drying
- Extrusion – regranulation
- Storage

Because of the characteristics of LLDPE stretch film (very thin and sticky) recycling of this requires different machinery to that for the thicker shrink film and bags. With an ever increasing share of this type of film, several initiatives were taken to tackle the problem of recycling such films. After a rather long experimental phase, the recycling of stretch films in now operational on an industrial scale. Compared to shrink film recycling the capacity is still limited. Recycling of mixtures of LDPE and LLDPE film types is possible, but only if the amount LLDPE is not too high. As a general rule it can be stated that all types of plastic should preferably be completely separated.

Outlets for recyclate of the industrial and commercial films can be found in several sectors:

- Garbage bags
- Silage films, horticultural sacks
- Shopping bags
- Films for applications in construction
- 10 – 20% admixture in new shrink films
- Other industrial packaging and non-packaging applications (eg. pipes)

So far no recyclate (either arising from food packaging or distribution films) is allowed in food packaging. As food packaging has a large share in the consumption

of packaging films this implies that a large part of the film market is not available for closed-loop use of recycled material.

3.3 Economic aspects

A number of facts make the recycling of commercial and distribution films potentially economically attractive. In the first place, due to the fact that this waste stream could be relatively clean (at least compared to e.g. household waste) recycling costs are relatively low. As mentioned before, this quality is strongly dependent on the collection discipline of the disposer. This relatively high waste quality normally results in competitive prices for recycled PE from films. These prices should at least be 25% lower than the virgin price for the recycler to be able to compete with virgin material producers. This is rather difficult when virgin prices are low.
Non-separate collection results in higher costs both due to more washing and separation steps as well as higher costs for disposal of residual waste from the recycling process.

Secondly, the advantage of the collection of commercial and distribution films is that the sources are relatively concentrated. This makes the collection less expensive compared to the collection of diffused released waste. However, in some cases it may still be possible to reduce collection costs of films. This can be achieved for example by combining the collection with the collection systems for paper.
Third, a large recycling potential exists for this film: on one hand a lot of film is used and on the other hand, this amount of film is relatively easy to collect because of the concentrated release.
The recycling of films from the commercial and industrial sector faces two challenges:

- The continuous reduction of film thickness as a result of the optimisation of the production process and the increase of the mechanical properties of the films. While this meets the objective of prevention by source reduction, the thinner films will result in a lower collection and recycling efficiency.
- The increase of the ratio stretch/shrink film (in 1996 in Europe 40/60 and expected to increase to 70/30 in 2006). This increasing share of (much thinner) stretch film will also result in a lower collection and recycling efficiency.

The following table gives an overview of the costs (euro/ton) in several countries.

	Commercial collectors and Recyclers		Guarantor system
	UK (conversion rate, 1£ ≅ 1.6 euro)	NL	AU
Collection/transport/ sorting	90 – 110	450 – 650	550
Purchase price paid by recycler	100 – 150	0 – 175	
Processing costs	275 – 350	275 – 375	375
License fee paid by packer/filler			50

The prices paid for LDPE regranulate vary between 500 and 750 euro per ton. This implies that over the whole chain cost deficits exist. These deficits are either paid for by the plastic guarantor like ÖKK, or via a commercial approach charged to the disposers. This shows that even recycling of relatively clean and geographically concentrated waste stream is not competitive without some kind of subsidy.

3.4 Legal, governmental aspects

Generally speaking the recycling of commercial and distribution films is (or at least was at the start-up) economically attractive, and therefore market driven. For further enhancement of this recycling activity the driving force for the recycling of commercial and distribution films is the EC Directive on packaging plastics, described earlier.

The way the various European countries deal with this EC directive is very different as described in Appendix 1. The Dutch system is focussed only on industrial plastic packaging of which plastic films is one waste stream using voluntary regulations in so called covenants. In Austria the industrial packaging waste recovery is organised by ARA AG in a Green Dot system in combination with households packaging.

3.5 Social aspects

The economically favourable recycling of the films discussed in this chapter, but also the EC directive on packaging, encourages companies to work together to collect, sort and recycle the films in the most (cost) efficient way. Systems for the organisation of collection already exist in a number of European countries. In some countries it is noticed that the collection quality is getting lower. The communication towards disposers needs to be improved in order to keep clean films

apart and to offer the film fractions in a correct manner. This leads to the conclusion that disposing companies are not as 'green-thinking' as they should be, to make this recycling a success. Market prices will be the main factor for these companies for co-operation. The focus of long-term strategies should be on the end-users (markets) and not on available waste.
Consumers accept recycled material in products such as garbage bags. In other products, such as carrier bags, aspects like colour and texture reduce the willingness to use recycled material to a great extent.

3.6 Organisational aspects

Collection figures for The Netherlands and Austria show that it is possible to collect a large amount of commercial and distribution films for recycling. The collection schemes in The Netherlands and Austria differ slightly. In The Netherlands an industrial collection scheme especially for industrial films is organised by VMK. To help companies with the separate collection of their waste, the Dutch VMK (Vereniging Milieubeheer Kunststofverpakkingen) has written guidelines for this collection. This will help to enhance the quality of the collected waste (as separate as possible), to decrease the costs for sorting and recycling and from that to increase the end-use markets for the recyclate.
It could be stated that collection systems would be most effective if they are organised separately, thus not incorporated in the collection activities of municipalities. For example for collection from shops and supermarkets, the availability of reverse logistics from distribution centres (business to business operation) could be of great advantage. Besides that, one should focus on a limited number of sources where substantial amounts of waste are generated. Furthermore it should be kept in mind that co-collection with other packaging materials (such as e.g. paper) may also influence the feasibility of the collection of the collection scheme.
Furthermore, sufficient recycling capacity has to be available. Specific technologies are sometimes lacking, especially for washing.

3.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of commercial and distribution films combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A3.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for commercial and distribution films have been identified and weighted according to the procedure described in the main report. (See table A3.2.)

3.8 Eco-profile considerations

The low contamination level of commercial and distribution films is one of the main factors that have a positive influence on the eco-profile of the mechanical recycling of this waste stream. Only a limited amount of washing and separation steps are required to obtain a high quality recyclate. Besides that, less residues have to be disposed off. Only the thin stretch films might be less positive, due to the fact that these contain a lot of water after washing resulting in a high energy demand for drying.
The high quality of the regranulate makes it suitable for use in new film products, which would otherwise be produced from virgin material. This substitution of virgin material makes the eco-profile even more positive.
All of this, however, only is valid in the case of accurate, separate and clean collection of the film waste.

3.9 Conclusions

In view of the tendency of the progress and blocking factors (table A3.1) as well as the positive scores of the decisive criteria (table A3.2) it can be concluded that the mechanical recycling scheme of commercial and distribution films could be highly successful and will be market driven if the different kinds of film are collected separately, without foreign materials and as clean as possible. This demands a lot of discipline from disposers of the waste. The collection quality is of great importance for the success of this recovery of films.
In order to obtain a high quality of the collected material, good logistics structures have been introduced in several countries.
The potentially high quality of the collected material, the concentrated release of waste, the large amounts of available film and the positive environmental profile make this recycling scheme a potentially very good one in plastics recycling.

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Table A3.1 Progress / blocking factors for Commercial and Distribution Films recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Subsidies will help to start recycling. • Logistics and processing costs are relatively low. • Reduction of collection costs by co-collection (e.g. with paper). • Partly 'market pull'. • Available funding/subsidies and access to capital.	• Export to low wage countries determines the price for recyclates. • Costs of disposal of residual wastes from the recycling process. • Low pricing and fluctuations of virgin polymers (prices should be over 1,000 euro/ton). • Excessive collection costs.
Legal, governmental	• Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates). • National and EU directive for recycling of packaging waste. • Environmental regulations on waste disposal.	• Prohibition of application of recyclates in some products (e.g. food packaging). • Unclear definitions of wastes/resources. • Inconsistent ((inter)national) legislation. • Limitations in international (border crossing) transport. • Unrealistic political ambitions.
Social	• Existence of institutional and administrative structure (as guarantor and link between legislation and actual waste problems). • Existence of long-term strategies. • Focus business decisions on the end-users (markets) and not on available waste. • Full support for new initiatives, also holding for capital investment. • Stimulate public awareness of the disposers. • Communication and information campaigns to consumers and authorities save sorting and recycling costs.	• No support from producers. • Public resistance to products with recyclates.
Organisational	• Separate, effective collection systems (not incorporated in collection activities of municipalities). • Focus on limited number of sources where substantial amounts of waste are generated. • Plastic composition must be clearly defined. • Use experiences from earlier recycling schemes. • Availability of reverse logistics from distribution centres (business to business operation). • Existence of operational infrastructure on collection, logistics and processing (the traditional channels work best). • Availability of sufficient recycling capacity. • Availability of market outlets for recyclates.	• Mixing of different plastics. • Substitution of LDPE by other polymers ("interpolymer competition"). • Trends towards thinner films (down-gaging). • Availability of alternative disposal options. • Specific technologies are sometimes lacking, especially for washing. • Available sources deliver their plastic waste with steadily increasing level of contamination.

Table A3.2 Decisive criteria and scores for recycling scheme Commercial and Distribution Films

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	++	
1.3 Number of disposers	+	+
1.4 Contamination level	+	
1.5 Markets	+[1]	
1.6 Substitution threat	-	
1.7 Recycling costs (incl. collection costs)	0[2]	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	+
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	++	
3.2 Sector co-operation	+	+
3.3 Participation disposers	+	
3.4 Society pressure	0	
3.5 Successful recycling stories	+	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	+	+
4.3 Processing capacity	+	
4.4 Certification secondary products	0	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

[1] The information in this Appendix is mainly based on information obtained in the last quarter of 1998 and in the first half year of 1999. In August 2000 it was commented that the recycling costs have become much higher and as such negatively influence the marketability of the regranulate.

[2] See note 1

4. Appendix: Scheme Analysis Industrial EPS Packaging

4.1 Introduction

In 1996 a total of 700,000 tons of Expanded Polystyrene (EPS) were used in Europe: 70% was used for insulation purposes, 28% for packaging and 2% for other applications. In packaging applications EPS is used as protective layer (shock-absorber). It has a very low density, varying from 10 to 80 kg/m^3, which means a large volume per weight. This makes the material very useful as packaging material, but makes transportation of the waste material expensive. On the other hand, an advantage for recycling is the easy identification of the material.

Because of its monostructure, EPS is also being successfully recycled throughout the world. There is great demand for large quantities of used EPS packaging by recyclers. The proportion of used EPS packaging that is recovered mainly through mechanical recycling, has more than doubled in the past two years.

Various EPS organisations from more then 25 countries around the world have subscribed to the international Agreement on Re-cycling, an agreement which commits signatories amongst others to:

- To continue to promote the use of recycled polystyrene in a wide variety of end use applications.
- To establish a network to exchange information about EPS environmental and solid waste management programmes between packaging professionals, product manufacturers, government officials, association members and consumers.

In Germany, the EPS-chain is planning to join the DSD system for the collection and transportation of the waste. The waste from smaller areas is collected at collection sites, and from there in big amounts transported to recyclers. Almost all EPS processors in Germany take the used EPS back for recycling.

In the UK EPSRIS, which is part of the British Plastics Federation, has been set up to encourage recovery and recycling of used EPS packaging. Members of the group represent more than 80 per cent of the EPS package moulding in the UK.
Also major electrical and car manufacturers as well as leading electrical retailers have successful, cost-effective EPS recycling schemes. There are more than twenty companies recycling EPS packaging in the UK, each with different requirements in quantity and form depending on the end application.

In Norway Plastretur is responsible for developing and organising the collection and recovery of plastic packaging, like EPS, from households, trade and industry. Plastretur's model ensures that waste owners, collectors, sorting plants and recyclers

receive a financial compensation for sorted plastic packaging. The EPS collection is organised by the EPS industry where the producers and their partners are in charge. The results are reported to Plastretur. In 1999 around 3,500 tons of EPS waste was generated. Of this amount 935 tons were collected and 257 tons were recycled.

In Sweden Svenks EPS Återvinning AB organises the collection and recycling of EPS-packaging. In 1998 440 tons were collected out of 1,500 tons put on the market. 70% was mechanically recycled and 30% processed with energy recovery.

In The Netherlands Stybenex Verpakkingen is the organiser of the collection and recycling system with co-operation of all EPS producers.

Used EPS packaging can be delivered free of charge at the premises of the EPS producers. In 1999 over 4,000 tons of EPS waste was collected and for the majority mechanically recycled. (About 500 tons was delivered in smaller quantities at the collection point and about 3,500 tons collected from large retailers was delivered under contract on behalf of producers of electric and electronic equipment; further a few hundreds of tons of garden trays were collected.) EPS which is too contaminated is dealt with by combustion with energy recovery.

4.2 Description of the recycling scheme

The collection and recovery of EPS packaging is organised in collaboration with large retailers, producers, recyclers and collectors. In order to recycle used EPS packaging, it must be segregated from other materials, preferably through separation at source. EPS is easily recognisable and can be collected at retail outlets, distribution centres, factories or warehouses as suitable. Sometimes this material is compacted at the collection site for more cost-effective transportation. The recycler, who will reprocess the material, will send a lorry to get the material (compacted or not) once there is a full lorry load ready and take the material back to the recycler's factory. Collection of the waste from consumers is much more difficult; consequently, this part of the waste is generally not collected.

In the Netherlands the EPS is collected in big bags of 2 m^3, as bundled stacks or in containers and is, mainly without compacting, transported to the recyclers. Recently an additional collection system was introduced, using so-called “knapsacks” (1,000 or 2,500 liter). This system is also used for the collection of commercial films. Optionally the EPS can be collected by a recycler or transported by the disposer to the recycler or a distribution centre. The last option is money saving for the disposer. Also in other countries large plastic bags (up to 2,500 liter are used to collect the (mostly) industrial EPS packaging.

It is important for a recycler to know whether the collected EPS waste material is considered 'contaminated' or clean. Material is 'contaminated' when it includes any

other material that is not EPS e.g. paper labels, staples, sticky tape, etc. If the previous use of the EPS packaging was carrying fish, plants or seedlings, fruit or vegetables, this will also classify the packaging as 'contaminated'. Clean EPS has generally been used to package electrical goods or car parts. A recycler has to adjust his recycling process to the contamination content of the waste.

EPS is recycled in four main applications:

1. Remoulding into foam: post consumer packaging can be processed, as a partial or direct substitute for virgin polymer, into raw material for the production of loosefill packing or even for new EPS mouldings. In general 5 – 15% addition of clean recycled EPS granules is used for high quality isolation plates and EPS mouldings and up to 100% recyclate use is possible in some specific building applications.
2. Production of ground EPS for drainage or horticultural application (soil conditioning).
3. Re-use in lightweight concrete and building products: grounded EPS is mixed with cement to make a lightweight concrete material for insulating swimming pools, flat roofs, floors etc.
4. Re-use through extrusion into “solid” polystyrene which can be applied as e.g. hardwood replacement in garden furniture, slate replacement for roofing tiles and new plastic items such as coat hangers, CD and video cases, plant pots etc.

4.3 Economic aspects

In the economic evaluation of EPS recycling the costs of collection and transportation play an important role. The costs of the transport of EPS are relatively high because of the large volume and low specific weight. To lower these costs the return logistics of packed products can be used. Another way to decrease transport costs is to combine the collection with other waste from industry and trade, for example with the film waste as happens in The Netherlands with the ‘knapsack’ system. Depending on the structure of the chosen collection system as well as the embedding of that collection system in the total EPS recovery system different costs are reported.
For example in Norway, where the collection and recovery scheme is based on the already existing waste management and industrial reverse logistics infrastructure, the collection costs are estimated at 300 euro/ton. In Sweden the choice is for collection contracts wherein a fixed price is paid per bag of EPS waste regardless of transport distances, resulting in average collection costs of 750 euro/ton. Elsewhere a figure of 200 – 250 euro/ton was reported (collection and densification).

There is a huge demand for recycled EPS, especially in clean and grinded form, which is on the one hand based on the purity of the used EPS packaging and on the other hand on the relative simple processing to come to the required “granules”.

Especially if the used EPS is delivered free of charge at the gate of the producer (which implies that another part of the product chain pays for the collection and transport costs), it is highly profitable to use 10 to 15% of EPS recyclate in the production of EPS isolation blocks or mouldings.
For the Dutch case processing costs (intake, quality control, grinding and storage in silo's) of 100 euro per ton were reported.
For Sweden much higher processing costs (up to 900 euro/ton) were reported; it is not clear which process steps are taken into account (grinding, extrusion, moulding).
Generally speaking, the processing costs to reach solid PS recyclate (grinding, extrusion, degassing and melt filtration) are higher than the costs to reach ground EPS.
For the total costs for collection and recycling of EPS packaging in specific schemes a range of 300 to 1,700 euro/ton is mentioned. In case of private collection initiatives the collection costs alone might even be higher then the 1,700 euro/ton mentioned, depending on the collection system chosen. (When a 1,100 litre container is used for disposal EPS packaging with an average density of say 6 – 8 kg/m^3 and you have to pay about 25 euro for emptying the container, a high price is paid for the EPS-waste!)
Depending on the situation as to the extent the collection and transportation costs have to be taken into account and the chosen outlet, the recycling of EPS packaging can be economically characterised in a range from just feasible up to highly profitable.

4.4 Legal, governmental aspects

Two reasons to start the recycling of EPS were the EC Packaging Directive and a certain threat from competitive materials. (Other reasons include the positive influence on public image of EPS, source of cheap raw material and reduction of pentane emissions.) For more information about the regulations and organisation legal aspects concerning packaging see Appendix 1.

With respect to Plastretur it can be stated that the Norwegian Pollution Control Authority evaluated the covenant set between the Ministry of Environment and trade and industry. The evaluation concluded that trade and industry through Plastretur are achieving the targets determined in the agreement and that the authorities are satisfied with the current development. It is important for Plastretur to have as many recovery alternatives as possible in order to ensure that collected plastic will be sold also in the future. In addition to mechanical recycling, chemical recycling and combustion with energy recovery are options.

4.5 Social aspects

For all countries involved much attention has been spent on achieving a good communication between all parties of the chain involved. Being well aware of a potential negative eco-image of EPS packaging with its high “visibility” in the waste, both producers as well as the industrial users are actively involved in the realisation of national collection and recycling schemes for EPS packaging. There is also a pro-active attitude to contribute in finding solutions for local or regional problems.
As a result the potential negative eco-image of EPS packaging has been converted into a “green image” that is effectively communicated to the general public.

4.6 Organisational aspects

Notwithstanding the often complicated logistics handling of the voluminous EPS packaging waste and the sometimes large distances to be covered, effective solutions have been developed in several countries.
For example by using the existing local or national infrastructure for either waste collection or industrial transport (including return logistics) the EPS packaging waste can be transported effectively from the collection points to the recyclers. Generally speaking the collection points are numerous (e.g. in Germany up to 1,600) and geographically well spread over the countries reviewed. In The Netherlands a different system was chosen with the eight producers and some recyclers acting as a ‘collection site’. The EPS is collected by other parties from the disposers and then transported to the collection sites where the EPS is recycled or otherwise processed. On the other hand specific contracts are set-up with private entrepreneurs that collect the EPS packaging, possibly shred the waste into smaller lumps for a factor 2 to 3 compaction of the volume or even realise “on site” a further compaction by densifying the EPS material in a mechanical and/or thermal way and then transport the EPS to recyclers.
The collection and recycling generally concentrates on clean EPS packaging e.g. used for electric and electronic equipment but also for EPS fish boxes and garden trays, collection and recycling schemes are organised.

If the logistics of the collection and transport of EPS packaging waste are well organised, the further recycling and processing of the waste is not problematic (unless the waste is too contaminated, in which case the waste is combusted, often combined with energy recovery).

4.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of EPS industrial packaging combined with a selection

of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A4.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for industrial EPS packaging have been identified and weighted according to the procedure described in the main report. (See table A4.2.)

4.8 Eco-profile considerations

Concerning the eco-profile of the mechanical recycling of EPS packaging both positive as well as negative aspects can be mentioned. Positive aspects (especially for the clean EPS waste originating from electrical and electronic goods packaging) are the potential for 1:1 replacement of virgin material in foam applications as well as in solid PS applications and the low contamination rate.
Negative aspects are the low specific weight of the EPS waste, the sometimes large transport distances and the higher contamination rate of EPS products like fish boxes and garden trays. By compaction or densification before transport and by making use of existing infrastructure and return logistics of industrial transport the negative impact can be reduced. In case of higher contamination rate the EPS waste is often not recycled but combusted with energy recovery.
Taking into consideration also the composition of the waste stream as well as the partition for the different market outlets, we come to an overall neutral judgement on the Eco-profile of the mechanical recycling of EPS packaging waste. (Considering merely the mechanical recycling of the highest quality of EPS packaging waste might even cause a shift to a slightly positive judgement.)

4.9 Conclusions

The overall picture of the progress and blocking factors (see table A4.1) and the overall score of almost all aspects of the decisive criteria are positive for this recycling scheme. If a chain deficit arises either the producers or the disposers have to support financially (in general the collection costs of) the recycling scheme.
The quality of the recyclate is for the largest part of high quality and the demand for the recyclate is definitely higher than the available quantity. The results of the eco-profile considerations show that from an environmental point of view the recycling of EPS packaging waste is also to be recommended given that the prerequisites are met.

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  - France: http://www.ecopse.fr
  - Norway: http://www.plastretur.no
  - The Netherlands: http://www.stybenexverpakkingen.nl
  - USA: http://www.epspackaging.org
  - Japan: http://www.jepsra.gr.jp

Table A4.1 Progress / blocking factors for Industrial EPS recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Positive attitude of construction sector to accept recycled EPS (in) products • Eco-efficient system • Cost effective system with low administration and information cost (depending on chosen waste stream and local situation • Economy of scale • Availability of market outlets for recyclates	• High volume / weight ratio • Use in food-packaging generally results in higher contamination levels • High processing and collection costs (depending on chosen waste stream and local situation)
Legal, governmental	• National and European packaging directives as well as covenants between parties involved • Stability of policy	•
Social	• Pro-active attitude of producers as well as users • Positive PR based on “green image” of EPS recycling • Active involvement in the realisation of local solutions	•
Organisational	• Shredding and further densification at collection site possible • EPS collection systems in various product sectors • Contracts with fixed price per bag regardless of transport distances (EPS bags as top load on regular goods) • The existing local / national infrastructure for collection / transport can be used • No ownership of the material, the organisation is free in its choice where to collect from in order to reach optimal efficiency	• Complicated logistics handling also caused by large distances

Table A4.2 Decisive criteria and scores for recycling scheme Industrial EPS Packaging

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	+	
1.2 Quantity	0	
1.3 Number of disposers	0	
1.4 Contamination level	+	
1.5 Markets	+	**0**
1.6 Substitution threat	0	
1.7 Recycling costs (incl. collection costs)	0	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	
2.3 Trade obstacles	+	**+**
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	+	
3.2 Sector co-operation	+	
3.3 Participation disposers	+	**+**
3.4 Society pressure	+	
3.5 Successful recycling stories	0	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	+	
4.3 Processing capacity	+	**+**
4.4 Certification secondary products	0	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

5. Appendix: Scheme Analysis PET bottles

5.1 Introduction

PET bottles have become the main substitute for glass bottles for the packaging of mineral waters and soft drinks. Also all kinds of other liquid food and non-food products are packed in PET bottles nowadays. The advantage of PET bottles over glass is that they are lightweight and much less breakable.

This Appendix mainly deals with PET bottles (1.5 - 2 litre) for mineral waters and soft drinks. Most of the PET for these bottles in Europe is consumed in countries such as Italy, United Kingdom, France and Spain, where the PET bottles are mainly one-way (single use) bottles. This is in contrast to other countries such as The Netherlands, Scandinavia, Germany, Austria and Switzerland, where PET-bottles are used in refillable delivery systems, in some cases in combination with a one-way system.

PETCORE (PET Container Recycling Europe) is a non-profit making association, founded (1994) and funded by PET resin producers and bottle makers, which promotes the recycling of PET containers in Europe. PETCORE assists authorities or communities interested in establishing recycling programmes that include PET bottles, or those willing to incorporate PET bottles into an existing programme. In addition, PETCORE can assist communities with information about the processing, reclamation and remanufacture of post-consumer PET bottles.

The collection schemes for PET bottles - partly initiated by the European Directive - are now beginning to yield higher returns. In 1999 219,000 ton PET bottles were collected for recycling in Europe, which is 25% more than in 1998.

5.2 Description of the recycling scheme

Three types of collection schemes for PET bottles exist in Europe: Drop-off without deposit (64%), drop-off with deposit (13%) and kerbside bank collection (23%).
In Belgium the bottles are collected in PMD-bags (plastics, metals and drink packaging) through a kerbside collection system. This resulted in over 13,000 tons of PET being collected and sent for recycling in 1998.
Refill and deposit is most common in Scandinavian countries, The Netherlands, Germany, Switzerland (not for single use bottles) and Austria. PET deposit programmes are achieving very high return rates (up to and even over 95%) with very low levels of contamination. In Austria and Germany (both countries support the green dot system) the deposit and kerbside/bottle bank systems exist side by

side. In Italy over 40% of the population had access in 1998 to some 24,500 PET “igloos” or containers. Bottle banks are becoming well established in countries such as Switzerland (over 12,000 drop-off points for single use bottles), France (over 5,000 sites) and the UK (over 3,000 sites).
An important difference between these collection systems is the type of bottle collected. In deposit systems only PET bottles for water and soft drinks will be collected. In all other systems this waste stream may be 'contaminated' with PET bottles for other products, like oil products, as well as bottles made out of other plastics. This may require the use of different recycling processes in order to obtain the required quality of flakes.

The collected non-refill bottles in Austria, Germany, France and Italy are sorted by material group into PET, HDPE and/or PVC and then split up into coloured and clear bottles.

In the UK, bottles collected through a deposit scheme may be sorted manually in the sorting centre or by sophisticated reverse vending machines at the retail point. Bottles from drop-off or kerbside schemes will be taken to a local sorting centre. In manual sorting PET bottles are hand picked from a sorting line, using simple features to identify PET bottles. More recently, high speed X-ray and near infrared sensors linked to a central processor and ejector system are being used to speed up sorting and to reduce costs. Automatic bottle sorting systems handling over 1 ton per hour are operating in France, Germany, UK, Italy and Switzerland. The US Environmental Protection Agency has identified cost savings of some 25%.

After sorting the graded bottles are compacted into bales for transport to reprocessors, reducing the volume by up to a factor 10.

The recycling of PET bottles is relatively simple with a limited number of process steps (shredding, cleaning and separation of foreign materials). Currently, most collected PET bottles are cleaned (washed), flaked and either used directly or blended with virgin polymer, before processing in a similar way to virgin polymer. For PET recycling the development of a flake separation system to eliminate the last bits of PVC contamination was a technological breakthrough to solve a major quality problem. The bottles designed according to the design for recycling rules of PETCORE will give, potentially, the highest quality RPET (Recycled PET). More recently also other recycling processes have been developed using a combination of extrusion and solid state polymerisation resulting in a regranulate with a high purity as well as a considerable higher IV. Such regranulate can be used directly in the production of new (also food approved) packaging.

In the last two decades a lot of experience has been obtained on PET recycling, enhancing the technological possibilities and resulting in more and more outlets for RPET, depending on market prices.

To enable a further growth in RPET sales it is essential that new outlets are developed. The fibre industry is still one of the most important markets for RPET. In addition, the availability of 'food grade' RPET will possibly enhance the use of RPET in new soft drink bottles. This is, of course, dependent on market prices. Other markets are strapping, sheet and non-food contact containers. Furthermore, possibilities of outlets in the automotive and transport industries are being studied.

A renewed interest in chemical recycling (also known as feedstock recycling) of PET resulted in the development of new processes (e.g. the Eastman process). These processes might influence the mechanical recycling of PET. However, these technologies are still more expensive than mechanical recycling and are regarded to have potentially better opportunities in the recycling of more 'difficult' PET waste streams such as bottles with barrier layers or coloured bottles. Compared to mechanical recycling, chemical recycling of PET is to date only applied on a limited scale.

5.3 Economic aspects

From an economic point of view the recycling of PET bottles was attractive because of low transportation costs and the residual value of the PET material after use, especially when the virgin prices were high. However, the profitability of PET recycling is inextricably linked to the price of virgin PET as supplied to end-user markets. With low prices in 1998 it must be remarked that even with a 25% increase in recycling figures and a slight price increase for 1999 the profitability of PET recycling is still not sufficient to guarantee a strong financial position.

The collection and sorting costs of post-consumer waste show a wide range from around 350 – 800 euro/ton, depending on country and chosen collection system. According to PETCORE the average costs are:

- Collection: 350 euro per ton
- Sorting: 150 euro per ton
- Processing: 225 euro per ton (for flakes production)

This results in a total of 725 euro per ton. PETCORE aims a total cost of at 550 euro per ton by reducing the collection costs to 175 euro per ton. With the current (Q1, 1999) low prices for virgin PET, the recycling of PET bottles is economically less attractive than a few years ago. It is estimated that a PET virgin price of 900 euro/ton gives RPET a healthy chance.

The price for virgin PET declined during 1998 and early 1999 for several reasons, such as reduction in the market prices of raw materials, excess in production capacity for PET in Europe and a strong inflow of low priced material from Asia. All these factors changed in 1999 resulting in increasing virgin PET prices. Another point is that also the export of PET bottles to Asia will keep having a strong influence on the European market for virgin PET and RPET.

5.4 Legal, governmental aspects

Member states have introduced or are developing national measures to meet the EC Directive targets (see Appendix 1) and other related local objectives. Often, the national targets for PET containers are more demanding than the broad directive targets. Economic instruments are increasingly being employed to encourage waste minimisation and packaging recovery. Examples of economic instruments are householder charging and Eco-taxes. In the case of householder charging the local governments require householders to buy special bags in which to set out refuse. Applying a direct cost to the householder for the generation of waste encourages greater recycling. This can reduce the total costs to the municipality and the householder.

5.5 Social aspects

Different countries deal with the PET bottles in quite a different way. In The Netherlands consumers were already used to the deposit systems for glass bottles for soft drinks as well as milk, yoghurt and dairy products. The change to PET bottles did not change this habit. Also in other countries consumers are willing to return bottles to bottle bank and collection centres. This situation differs to a large extent from country to country.
The soft drink industry strongly supports the collection and recycling of PET bottles, as they are aware of the green image that goes with it. On the other hand it should be remarked that - possibly due to a small economic disadvantage - producers do not always comply with the ‘design for recycling rules’ of PETCORE, which hampers recyclers to deliver good RPET quality. As for the consumers, it may be remarked that, knowing that PET bottles can be recycled into e.g. useful products like sweaters, they can be stimulated to actually collect the bottles. Spreading this kind of information is one of the other tasks of PETCORE.

The co-operation between collection industry, recyclers and reprocessing industry is shaping up well. PETCORE effectively stimulates this chain co-operation. A good communication between chain parties results in higher quality streams for mechanical recycling. Information about the (reasons for the) required sorting quality as well as control on the sorting centres (which is sometimes lacking) reduces the recycling costs. So the communication between sorting centres and recyclers contributes to higher quality flakes. The higher the quality of the flakes the higher value products (e.g. new bottles) can be produced of the RPET.

In some countries consumers are not aware of the benefits of PET recycling and don't co-operate in the separate collection of PET bottles. This results in PET bottles disappearing into the residual fraction of their household waste. In other countries the communication about these subjects is very good, resulting in high collection

rates, even in bring systems. Also deposit (bring) systems result in a very effective collection of in general high quality bottle waste.

5.6 Organisational aspects

Despite the low prices for virgin PET, the volume of produced RPET has strongly increased in recent years. The reason is that, driven by EU legislation for packaging, the collection of PET bottles is firmly stimulated by the newly founded collection organisations in a number of countries. New recycling plants as well as production plants for reprocessing RPET have been erected. PETCORE plays an important role in helping to set up new collection and recycling schemes.

5.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of PET bottles in combination with a selection of relevant remarks made in interviews and questionnaires results in a listing of the relevant progress and blocking factors. (See table A5.1).

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for PET bottles have been identified and weighted according to the procedure described in the main report. (See table A5.2.)

5.8 Eco-profile considerations

The recycling of PET with its high intrinsic quality and with a moderate contamination level results in a good quality RPET with a high IV and an excellent transparency (that is, if the flakes are further extruded in combination with SSP treatment). This RPET can both replace virgin PET 1:1 in specific applications or can be added to virgin PET in 10 – 40% concentrations in other applications. This aspect of virgin substitution contributes highly to the positive eco-profile of PET bottle recycling. Otherwise the RPET can be used in fibre applications.
Design for recycling, although not applied by all producers of soft drink and water bottles, may further contribute to the reduction of the share of residual waste of the recycling process, which is an additional positive aspect. The collection and transport are well organised. The contamination rate strongly depends on the chosen collection system and the degree of communication between all chain partners.

5.9 Conclusions

In Europe only a few countries concentrate their collection programme on the whole range of consumer packaging, rigid or flexible. The majority of the countries have plastic bottles targeted for collection, all including or even concentrating on PET bottles. This implies that large quantities of PET bottles are available for recycling. The good chain co-operation, the well organised collection and transport infrastructure, the availability of sufficient recycling capacity, the high quality of RPET and available outlets, as well as the positive eco-profile: all these aspect together make PET bottle recycling to one of the most successful examples of recycling of post-consumer household waste.
As the profitability of PET recycling is inextricably bound up with the price of virgin PET and as that price-level is currently at a much lower level than a few years ago it can be concluded that a chain-deficit exists. Only when (part of) the collection costs are paid for by the municipalities combined with virgin prices at a level of around 900 euro per ton, the profitability of PET recycling might become sufficient to guarantee a stronger financial position for the PET recycling chain.

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Table A5.1 Progress / blocking factors for PET bottle recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Recycling is "market pull" • Subsidies will help to start recycling • Ample supply of PET bales • Collection is organised by municipalities that also pays for the collection costs • Strong growth in PET applications for packaging resulting in more waste available for recycling • Awarding of effective collection (consumers and municipalities)	• The costs of the recycling scheme are relatively high: the resulting costs strongly depend on local regulations • Low prices and fluctuations in prices of virgins and recyclates • Export to low wage countries determines the price for recyclates. • High costs for disposal of residues of plastic recycling (residual waste from collection and/or sorting) • Amount of administration before invoicing (Green Dot organisations) • Bank guarantees; low R.O.I. • Too high investments for current foreseen output • Community taxes on waste disposal
Legal, governmental	• National and EU directives on recycling of packaging waste • Standards for application of recyclates, certification of recyclate and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates).	• National “thinking” of governments instead of looking at PET recycling as an internationally oriented business activity • Limitations in international (border crossing) transport • Prohibition of application of recyclates in some products; food approval depends on state regulations and applied recycling process • Rigid ‘legislation’ on definition of waste and on application of secondary materials (so that e.g. second choice off-spec is no longer considered as waste). • Availability alternative disposal options like e.g. energy recovery
Social	• Support by drinks and beverage industry; industrial awareness of necessity of PET-recycling (vertical chain integration); pro-active producers. • International knowledge transfer from countries with successful PET recycling to countries with initiatives. • Long-term contracts with e.g. Fost Plus • Much expertise (also from industry) available. • Effective communication will result in stimulating public awareness of consumers and municipalities • Open days in sorting centres • Information and communication about PET recycling to sorting centres • Positive public opinion about collection and recycling	• No direct contact between sorting centres and recyclers with regard to prices, specifications, quality control, etc. • Public opinion: Plastics are burned! • Public resistance, with question marks about ER plant and on acceptance of recycled products • Non-homogenous participation of collectors
Organisational	• Available capacity for PET recycling • Collection by municipalities • Existence of operational infrastructure • No emissions by recycling process (water treatment integrated in recycling plant)	• The municipalities mainly focus on their own responsibilities, paying less attention to the consequences for the rest of the chain. • Inflexibility of e.g. sorting procedure/specification • Stringent technical specifications for recyclates for reusing in bottle applications • Availability of alternative disposal options • Lack of official control on sorting centres • Some producers do not comply with guidelines for design for recycling

Table A5.2 Decisive criteria and scores for recycling scheme PET bottles

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	+	
1.2 Quantity	++	
1.3 Number of disposers	0	+
1.4 Contamination level	0	
1.5 Markets	+	
1.6 Substitution threat	+	
1.7 Recycling costs (incl. collection costs)	0	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	+
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	++	
3.2 Sector co-operation	++	+/++
3.3 Participation disposers	+	
3.4 Society pressure	+	
3.5 Successful recycling stories	+	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	++	+/++
4.3 Processing capacity	++	
4.4 Certification secondary products	0	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

6. Appendix : Scheme Analysis HDPE Bottles

6.1 Introduction

In Western Europe around 760,000 tons of HDPE are used (97/98) for the production of bottles and containers (of which 110,000 tons for containers ≥ 5 l). The marketsplit for the 650,000 tons of bottles and smaller containers was as follows:

Product packed	**Marketshare, %**
milk	20
detergents / cleaners	42
toiletries, cosmetics, hair care	25
others, inclusive automotive	13

In a number of European countries, e.g. France, Italy, Belgium and the UK, the collection of packaging waste from households mainly concentrates on bottles of which the HDPE bottles are one type. These HDPE bottles from household waste are used for milk, juice, soap, shampoo etc.

In the UK for example, RECOUP is the national plastic bottle recycling organisation. It is a non-profit company funded by voluntary subscriptions from its members involved in the plastic packaging recycling chain. In 1997 RECOUP arranged the transport for over 2,000 tons of plastic bottles. There are about 250,000 tons of plastics bottles used each year in homes throughout Britain. An amount of 10,000 tons of plastic bottles were collected during 1998, an increase of 42% on the previous year. A survey of RECOUP indicates that plastic bottle recycling is still growing, with the recovery level expected to rise to 12,500 tons in 2001.

In Belgium and Luxembourg 'Plarebel' (merger of Belvaplast and BEPET) was founded to organise the collection and reprocessing of the HDPE, PVC and PET bottles within the framework of the Fost Plus system (Green Dot System; see Appendix 1). In 1998 22,000 to 25,000 tons of HDPE bottles were consumed in Belgium of which 7,000 tons were collected (5,000 tons by kerbside collection and 2,000 tons through container parks). The target for 1999 is to collect 7,000 tons by kerbside collection.

In The Netherlands the main focus for the recycling of plastic packaging is put on packaging waste streams from trade and industry (shops, offices, services, small and medium enterprises and industry). A number of pilot projects were carried out to establish the economical, technical feasibility and environmental impact of the collection and recycling of HDPE bottles from households.

One of the projects was organised and executed in 1995 and 1996 by the VMK, a branch organisation representing the plastic packaging industry in The Netherlands. In an urban and rural area of each 100,000 inhabitants and in a close co-operation with local authorities the feasibility of the collection and mechanical recycling of HDPE bottles was investigated. The bottles were collected using a bring system with bottle banks (1 container per 2,500 inhabitants) similar to the way glass is collected in The Netherlands. The result of this project has led to the expectation that after a sensitisation period of ten years or even more a response of 60% could be possible. Another project was carried out by the VAM, who studied the possibilities to sort the bottles from the total household fraction. It was concluded that the system is technically feasible, whereas the cost-efficiency depends on the robot technology (to be developed) in combination with quality of the sorted bottles.

6.2 Description of the recycling scheme

HDPE bottles are collected in both kerbside and bring systems together with other packagings like PET and PVC bottles, metals and carton packaging in specially designed bags or boxes. The collected bottles are transported to a sorting centre, where they are in most cases sorted manually by material group.
Even though the focus on bottles instead of the whole mixture of consumer packaging considerably simplifies the sorting process, the collected bottle streams remain relatively complex and necessitate elaborate sorting facilities either by hand or, increasingly, by automatic systems. There is also quite a variation between different countries. If e.g. Italy is compared with the UK the following distribution results:

Bottle type		Italy	UK
PET	Clear	40 %	40 %
	Light blue	19 %	-
	Other	18 %	4 %
HDPE		22,5 %	50 %
PVC		1,5 %	6 %

The manual identification is difficult, often resulting in mixed waste streams and thus low quality. Technologies for automatic sorting are available, but require a large investment.
The VMK has compared the costs and benefits of automatic and manual sorting. The main conclusion is that due to high investment costs automatic sorting is more expensive than manual sorting. On the other hand automatic sorting results in a better and more consistent quality.
After sorting, the bottles are compressed and baled and purchased by reprocessors. In most cases, these bales are delivered in a baled form according to specifications identified by individual reprocessors. It is important to confirm specifications and

prices with individual companies prior to launching a scheme or purchasing equipment.

At reprocessing plants bottles are chopped into flakes, washed and dried. The bottles can be very contaminated, which makes the washing step important. A next step is to extrude the flakes to yield a (in general a grey/green coloured) regranulate with a colour and odour depending on the kind of HDPE bottle stream recycled. A problem with the recycling of e.g. shampoo bottles is, that these bottles often contain PP caps, which are difficult to separate from the HDPE and may have a negative effect on the quality of the regranulate if the PP concentration is too high. Depending on its characteristics (colour, odour, mechanical properties etc.) the regranulate can be used in a wide variety of plastics applic ations.
The recycling of a mono stream of milk bottles results in an opaque granule with a much wider application potential.

6.3 Economic aspects

In Belgium the consumers have to buy the blue bags for their PMD collection. The collection and transportation costs in Belgium of HDPE bottles are 190 euro per ton. The costs for sorting the HDPE bottles (in the sorting centres) are 200 euro per ton. The Green Dot fee paid by the licensees for the collecting and sorting of HDPE, PET and PVC bottles is 300 euro per ton (in 1999). The bales are sold for 30 euro per ton to the reprocessors. The deficit between collection plus sorting costs and proceeds are passed on to the citizens. (The total cost of the Fostplus system to the average consumer is approximately 8.5 euro/year.)
In the UK the collection and processing costs are estimated at the equivalent of 270 euro/ton.

The VMK has scaled up the results of the pilot project to a scheme for The Netherlands. Based on a response of 40%, expected to be achieved in a five years sensitisation period, the costs of collection and sorting come to 740 euro/ton or 0.96 euro per inhabitant. At a HDPE virgin price of 660 euro/ton or higher the costs of recycling are lower than the revenues for the regranulate. The VMK calculations do take in consideration the avoided costs of collection and energy recovery of the grey fraction due to the separate collection of bottles.

The collection and sorting costs are relatively high due to:
- The high collection frequency.
- Sorting from other types of bottles (no separate collection in bottle banks).
- The low specific weight of the bottles, making transport expensive.
- Up to 10% of the bottle weight is in the cap. The caps add considerably to the waste and incur extra costs to remove them.

Also reprocessing costs (incl. washing, separation and extrusion steps) are relatively high, due to the high percentage of contamination of the bottle. This contamination requires a hot washing process and leads to a high percentage of residue (from caps, labels and other materials). The costs of residues processing add to the total recycling costs.

The costs of collection and reprocessing have been a constraint to growth, especially in the last few years in which low prices and fluctuations of virgin material determine the recyclate market. Also, in some periods export to low wage countries determines the price for resources/feed stocks for recyclates.

The market for HDPE recyclate depends on the quality of the material. Colour and odour, especially in case of soap bottles, can be blocking factors for reuse. The reason is that the odour of these products is difficult to remove during the reprocessing. Furthermore, the colour of a mixture of coloured HDPE bottles is grey/green and is hard to change to other colours, limiting the potential outlets (pastel colours often required).

Concerning the mechanical properties, the HDPE recyclate is comparable to the virgin material so long as the sources are comparable. For that reason it can very well be used in low quality or multi-layer applications, such as new bottles, extrusion applications (sheet, pipes) or injection moulding products (containers, buckets). HDPE recyclate from HDPE bottles has to compete with production waste and off-spec material, which finds a lot of application in new bottles, pallets etc.

6.4 Legal, governmental aspects

Member states have introduced or are developing national measures to meet the targets of European Directive on Packaging Waste (see Appendix1) and other related local objectives.
Even in periods of high HDPE virgin prices the overall costs for collection, sorting and recycling of bottles always exceed the revenues from the recycled bottle polymers and credits for avoided waste processing. The recycling of plastic bottles from households therefore only will take place if law enforces it or if a subsidy or funding system is footing the bill.
In Belgium the ecotax law provides for exemptions from the tax if certain recycling targets (set and measured by the regional authorities) are met.

For several products, like pallets, containers etc., regulations exist which prescribe virgin material. In some countries this has been changed, thus creating more markets for post-consumer waste.
Besides these kind of regulations, governments could adapt their own strategy by buying more products (e.g. for maintenance of gardens, facing, sheet piling, sheetpile walls etc.) with recycled content.

6.5 Social aspects

The recycling of HDPE bottles only will be a success if consumers are willing to separately collect their bottle waste. Good communication and information campaigns to consumers and authorities will result in a positive public opinion about collection and recycling. Consumers have to know why they should participate in collecting and which products are made out of the recycled material. High collection rates are for instance obtained in Italy and Belgium. In Belgium 80 to 90% of the population are actively participating in the intensive selective collection scheme.

Contrary to the PET recycling, the different actors in the chain or the sector organisations are, generally speaking, less willing to enhance collection and recycling of HDPE bottles.

Another aspect for the success of HDPE bottle recycling is the question whether the recycled content of new bottles or other products is a key issue for major companies in order to obtain a 'green' image. This will enhance the market for HDPE recyclate. However, it is noted that the support for use of recycled material from for example the detergents industry decreases (withdrawal from 'green marketing' initiative). This attitude on the other hand, results in no effort to introduce design for recycling, which could make recycling cheaper.
Besides that there is some public resistance to the acceptance of recycled products, which makes producers hesitate to use recycled material.

6.6 Organisational aspects

Combination of the collection system with the collection of other packagings is necessary in order to reach acceptable collection costs. For example, when the situation in The Netherlands is compared with Belgium it appears that in The Netherlands a deposit system exists for PET bottles, which is not suitable for HDPE or other bottles. Also no other collection system has been set up for these other packagings. In Belgium the kerbside collection system for packaging includes metal, plastic bottles and carton packagings, so costs are shared by all packaging producers. Besides having a proper collection system, good communication with the consumers may highly influence both the willingness to collect the used bottles as well as the quality of the collected waste.

Without specifications enforced by the reprocessor and ultimately the end user, the Local Authority and the public will not know what to collect.

For better and easier identifying and recycling plastic bottles by sorters, design criteria must be drawn up. Due to lack of communication and/or normalisation no such design for recycling criteria exist yet. Consistency of the quality and absence of

contamination are the most important demands. Certification of the recycled materials will increase the demand for recycled resins.

Currently alternative disposal options like energy recovery are available.

6.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of HDPE bottles combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A6.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for HDPE bottles have been identified and weighted according to the procedure described in the main report. (See table A6.2.)

6.8 Eco-profile considerations

When the mechanical recycling of HDPE bottles concentrates on fractions which are easy to collect and have a low contamination rate and is included as a part of an integrated solid waste management system a reduction of system total energy can be obtained which is a positive element for the eco-profile. However, the product to be recycled is present in a range of availabilities and levels of contaminations. The more geographically dispersed or contaminated a product becomes, the more energy and materials will be required, which negatively influences the eco-profile. Depending on the composition of the waste stream and the applied recycling process the quality of the recyclate ranges form rather high (suitable to replace virgin materials in specific products) to low (only suitable for wood or concrete substitution) Taking all these aspects in consideration, the eco-profile of the overall mechanical recycling of HDPE bottles is evaluated to be neutral. [3]

6.9 Conclusions

The mechanical recycling of HDPE bottles is economically not feasible without subsidy or another external funding system. High collection costs and an on average relatively high contamination level in combination with low polymer prices and limited high quality outlets are all aspects which are less positive for the promotion

[3] According to the results of the VMK bottle project and the conclusions of the report 'Disposal of plastics household waste: analysis of environmental impacts and costs' the eco-profile for the collection and recycling of HDPE bottles is certainly positive.

of HDPE bottle recycling schemes. Together with a neutral eco-profile one has to take all specific local conditions in consideration in deciding whether to start up new recycling schemes in this field.[4] [5]

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[4] In Sweden rigid packaging (including bottles) was specifically targeted for collection and mechanical recycling on the basis of a LCA evaluation of the Swedish system.

[5] The VMK has evaluated the balance between the costs and environmental benefits of its bottle project. For that a closer look was given to the contribution of the project to the avoidance of the greenhouse gas carbon dioxide.
The collection and recycling of 1 ton of plastic bottles results in the avoidance of 1.77 ton carbon dioxide. At a response level of 60% the costs to avoid 1 ton of carbon dioxide come to euro 385. The costs to avoid carbon dioxide by generating electricity from wind vary between euro 27 and euro 58. As it is accepted in The Netherlands that the avoidance of carbon dioxide may cost up to euro 100, the collection and recycling of plastic bottles is for the time being not seen as an eco-efficient measure.

Table A6.1 Progress / blocking factors for HDPE bottle recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• External payment of costs for collection • Available funding • No emissions in recycling process (water treatment integrated in recycling plant)	• Low prices and fluctuations in prices of virgins and recyclates • Export to low wages countries determines the price for resources/feed stocks for recyclates • Relatively high transport costs. • Limited market outlets. • Costs of residues processing • Lack of design for recycling • Contamination with aluminium seals or PP caps and PETG bottles
Legal, governmental	• National and EU directive for recycling of packaging waste (for example: long term strategy, aimed at 50 – 65% recovery) • Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates)	• Limitations in international (border crossing) transport • Prohibition of application of recyclates in some products • Definition of wastes requiring changes in regulations and certification procedures
Social	• Managerial capacity & responsibility of organising body • Much expertise (also from industry) available • Communication and information campaigns to consumers and authorities e.g. PR campaigns till 2-3 years ago with a restart in the near future • Positive public opinion about collection and recycling	• No support from detergents industry (withdrawal from “green marketing” initiative) • Non-homogeneous participation of collectors
Organisational	• Co-collection with PET and PVC bottles • Availability of sufficient recycling capacity • Existence of operational infrastructure (Replastic experience with over 1,000,000 tons PET/HDPE recycling)	• Availability alternative disposal options, e.g. ER • Lack of available technologies for feasible automatic sorting

Table A6.2 Decisive criteria and scores for recycling scheme HDPE bottles

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	+	
1.3 Number of disposers	0	**0**
1.4 Contamination level	-	
1.5 Markets	0	
1.6 Substitution threat	0	
1.7 Recycling costs (incl. collection costs)	0	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	**+**
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	0	
3.2 Sector co-operation	-	**-**
3.3 Participation disposers	0	
3.4 Society pressure	0	
3.5 Successful recycling stories	0	
4 Organisational		
4.1 Disposal system	0	
4.2 Take back logistics	0	**0**
4.3 Processing capacity	+	
4.4 Certification secondary products	+	

+ + very positive
+ positive
o neutral
- negative
- - very negative

7. Appendix: Scheme Analysis PS coffee cups

7.1 Introduction

In The Netherlands and the United Kingdom recycling schemes for Polystyrene coffee cups are organised by the chain itself. Shareholders are the vending and food service industry, cup manufacturers and polymer suppliers. The separate collection and processing of the used coffee cups is in The Netherlands co-ordinated by the Foundation Recycling Disposables Benelux (named Retour) and in the United Kingdom by Save a Cup Recycling Company Ltd.

The supply chain and the disposers finance the Dutch system. A fixed fee is added to the price of new cups (per thousand) and the disposers of the used coffee cups pay for the remainder of the chain deficit. This last group has to pay a specific collection price for a certain amount of plastic sacks or carton boxes. The system runs since 1991 and is accepted in several institutions, such as offices, schools and factories. About 1,300 gross tons/year is collected.
Save a Cup Recycling Company Ltd was established in 1992. Until April 1999 cup manufacturers funded the system. From April 1999 onwards a new funding structure was introduced: the cup manufacturers and ingredient suppliers pay a one-off payment a year and additional revenue is generated by the introduction of an environmental charge. This charge amounts 10 pence/1,000 cups (or 0.16 euro/1,000 cups with 1 £ ≅ 1.6 euro) and is being paid for by the parties involved further down the supply chain. In the United Kingdom about 800 gross tons/year is collected.

7.2 Description of the recycling scheme

In The Netherlands the entire collection scheme is realised by one transporter. The collection frequency is variable and is determined by the disposers: it can be weekly, monthly, etc. With dedicated trucks the carton boxes and plastic sacks, maximally filled with cups, are collected at source and transported to a transfer station, centrally located in The Netherlands. At this transfer station the boxes and sacks are gathered in big transport containers. When these containers are full they are transported to a recycling plant. The two-step recycling process consists of a pre-cleaning/baling stage and a de-baling/regranulation stage. The final recyclate can be applied for the production of trays, plant pots, etc.

The pre-cleaning/baling stage is characterised by the following steps:
- Removal of the boxes and sacks
- Separation of large contaminants
- Sorting of white and coloured cups

- Disentangling of the piled up cups
- Separation of small contaminants by screening
- Manual removal of the residual contaminants
- Baling of the cleaned PS cups

Then the bales are transported to the second stage: the recycling facility. This stage is characterised by the next steps: de-baling, disentangling of the bales, pre-washing of the cups, shredding, washing, wet separation of non-PS materials, drying and regranulation.

The collection costs of the Dutch system are 270-450 euro/ton. The pre-sorting-, cleaning-, baling-, de-baling- and regranulation costs are about 360-450 euro/ton. The net costs (processing costs minus benefits secondary PS) amount 135-200 euro/ton.
The UK Save a Cup Group gives an indication of £ 120-800/ton (or 192-1,280 euro/ton with 1 £ ≅ 1.6 euro) for collection costs; these costs are not fixed but depend among others on the area of the region and the collection method used.

In conclusion it can be stated that the collection costs are relatively high and that recycling needs a gate-fee.

7.3 Economic aspects

The quality of the secondary PS is rather good, which implies that outlets for this material can readily be found. Examples of market outlets are pots, trays, video and audio cassette casings, coat hangers and non-food packaging. The selling price is about 80% of the virgin price. As mentioned before a chain deficit will always occur due to the relative high collection and processing costs. Normally the chain deficit is in the range of 135-200 euro/ton, but is strongly dependent of virgin PS prices. For example in 1998 (with low virgin prices) this deficit was about 360 euro/ton for the Dutch system. Only with continuing financial support by the disposers and/or the supply chain the recycling scheme can be retained.

The collection costs are relatively high because of :
- the collection of light (and in the case of improper piling the cups also voluminous) material
- the number of participants versus the collection area
- the collection frequency

These costs can be lowered when other fractions will be co-collected.

The processing costs are relatively high because of :
- the unpacking and disentangling activities
- the relative high contamination level: 20-40% (separating costs)
- the costs for disposal of the contaminants

The collected and processed volumes in both countries are relatively low: about 5-10% of the total PS cup consumption. The generated streams (in The Netherlands 1,300 gross tons/year and in the United Kingdom about 800 gross tons/year) are not large enough to have a recycling line specifically build for those cups alone. This implies that batches of cups have to be processed in a plant, which is either designed for other plastic materials or not optimally designed, because batches of a variety of different plastic materials have to be processed.
The conclusion is that when the collected volumes will increase the realisation of a more optimal recycling scheme will be easier.

7.4 Legal, governmental aspects

The realisation of recycling schemes in The Netherlands and the United Kingdom took place even before the introduction of the European Directive on Packaging and Packaging Waste (94/62EC). But the introduction of this Directive stimulated the preservation of the introduced recycling structure. When the application of alternative methods (such as landfill and municipal solid waste incineration) will become less attractive this might further stimulate (to continue or start-up) such recycling initiatives. In the future landfill is forbidden in some countries (e.g. France, Germany and The Netherlands) and the price for incineration will be increased by the introduction of taxes. The drive for finding alternatives will then be of more interest.

7.5 Social aspects

The general public and companies have a higher level of environmental concern nowadays. The companies involved aim at a more environmental friendly image ("green"). Therefore, the whole supply chain has organised the recycling structure for PS cups. Recycling is positively accepted by society, a fact that is enforced by the willingness of the chain to substantially contribute to the financing of the chain deficit.
The disposers co-operate and the degree of this co-operation is stabilising in The Netherlands (5,000 participants dispose 1,300 gross tons/year) and still increasing in the United Kingdom (the collected volume is expected to increase from the current 800 gross tons/year to 2,200 gross tons/year in 2002). The willingness of the participating actors will be stimulated and the participation degree will increase when the high collection costs will be lowered in the future (resulting in an equally lower chain deficit). The introduction of co-collection systems (more discarded products are separately collected at the same time with the same collection vehicle) may further positively influence the financial situation for the recycling of PS cups.

7.6 Organisational aspects

The supply chain has organised itself and the result is the realisation of a recycling structure. This structure is characterised by relatively high collection and processing costs. The introduction of co-collection structures will probably lower the collection costs. The contamination level of 20-40% (coffee, sachets, paper, pieces of cigarettes, etc.) is partly responsible for the high processing costs. A lower contamination level will result in lower processing costs.
When larger amounts have to be processed costs will also decrease. However, the realisation of a dedicated process for the recycling of only coffee cups is not expected due to the inability to meet the required yearly tonnage.
Markets exist for the good quality PS recyclate; the drive to enlarge the existing markets and to find new markets is distinguished.

7.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of PS coffee cups combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A7.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for PS coffee cups have been identified and weighted according to the procedure described in the main report. (See table A7.2.)

7.8 Eco-profile considerations

The high contamination rate of the coffee cups and the often inefficient collection structure (transport of light, voluminous waste over longer distances) are partly balanced by the good quality of the PS recyclate that can be used to replace virgin PS in several applications. This application of secondary resources into new products results in a decrease of the use of new resources and energy as well as of the amounts of emissions and waste. Considering all aspects together we concluded the eco-profile of the recycling scheme of PS coffee cups to be neutral. This profile becomes positive when greater volumes are source collected with a lower contamination level.

7.9 Conclusions

The EU Directive on Packaging and Packaging Waste (94/62EC) is in favour of setting up recycling schemes when feasible. As can be seen in table A7.2, the

economic criteria do not encourage the recycling of PS coffee cups. Nowadays this recycling is only possible because of the strong financial and organisational support of the manufacturing industry. The recycling scheme is far from a self-financing or self-supporting level. Several actors in the chain have to closely co-operate and to broadly support the initiative and the succeeding actions.
Added to the weak economic criteria comes a neutral eco-profile (with possibilities of a positive profile) of the recycling scheme. Notwithstanding the positive image such recycling schemes (may) have in society we must come to the conclusion that initiatives to introduce new recycling activities or to broaden the operative scale of existing activities in this field are not advised.

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Table A7.1 Progress / blocking factors PS coffee cups recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Limited fee by manufacturers to recycling • Gate fee to recyclers • Major part of fee is generated by the disposing persons/organisations • Rising costs of waste disposal • Good quality of secondary PS	• High recycling costs • No growing market; reduction in UK • Disposal of residues from recycling process (high costs) • Low prices of virgin plastics/recyclates and fluctuations in it • Relatively high collection costs
Legal, governmental	• National and EU directive on recycling of packaging • Landfill will be forbidden in some European countries	• Prohibition of application of recyclates in some products (e.g. food contact)
Social	• Positive attitude of consumers to recycling • Involvement of manufacturers in recycling initiatives (NL, UK)	• No stimulation of collection • Discussion about disposables in society
Organizational	• Existence of separate collection system and organisation • Set up of collection system by establishing specific fund • Co-extrusion is possible	• High contamination rate

Table A7.2 Decisive criteria and scores for recycling scheme PS cups

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	-	
1.3 Number of disposers	0	-
1.4 Contamination level	- -	
1.5 Markets	0	
1.6 Substitution threat	0	
1.7 Recycling costs	- -	
2 Legal		
2.1 Laws / directives	+	+
2.2 Governmental agreement	+	
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	+ +	
3.2 Sector co-operation	+	+
3.3 Participation disposers	0	
3.4 Society pressure	+	
3.5 Successful recycling stories	0	
4 Organisational		
4.1 Disposal system	+	0
4.2 Take back logistics	+ +	
4.3 Processing capacity	-	
4.4 Certification secondary products	-	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

8. Appendix: Scheme Analysis Mixed Plastics

8.1 Introduction

For the current study 'Mixed Plastics' is defined as the largest material fraction that remains after the sorting of the good separable plastic fraction from the household packaging waste, sometimes in combination with industrial or commercial waste streams.
Only a few European countries actually recycle the 'mixed plastics' fraction, viz. Germany, France[6] and Austria. The composition and the quality of the waste strongly depends on the collection system of the waste and the following washing and separation steps. After separation of the heavy plastics like PS, PVC, PET etc. it will consist of mainly PE and PP
As in Germany relatively the largest quantity of 'mixed plastics' is recycled we will further concentrate on the German system with relevant remarks on the other systems where appropriate.

The current trends in the development of mechanical recycling technologies for the plastics fraction of household waste are new automated, mechanical sorting processes, adapted comminution and extrusion techniques and additives to upgrade recyclates for applications in high quality products. Real time identification technologies such as near-infrared spectre analysis together with self learning algorithms (artificial intelligence based), integrated washing and separating in hydrocyclone type units and recyclate tailored additives to upgrade blends from mixed plastics fractions are promising examples of technical progress in this field.

In the DSD system in Germany, it appeared that the 'mixed plastics' fraction amounts to about two thirds of the total consumer plastic packaging waste and contains various types of plastics (usually small, contaminated items). Since mono-fraction sorting is too labour- and cost-intensive, these plastics are kept together as a 'mixed plastics' fraction at the sorting plant and not separated further. In Germany the 'mixed plastics' fraction is processed into agglomerate and forwarded for feedstock recycling and, in some cases, for mechanical recycling.

[6] Note: Contrary to the situation in Germany and Austria, in France the recycling of mixed plastics concentrates on a plastics / paper fraction (roughly 3:1), which is segregated out of a waste stream resulting from selective collection of MSW (clean + dry fraction).

8.2 Description of the recycling scheme

In Appendix 1 the recycling scheme of the collected DSD waste is described. The 'mixed plastics' fraction resulting after sorting of the DSD waste is pressed into bales and conveyed to preparation plants where it is processed to mixed plastic agglomerate after shredding, removal of impurities (by wet or dry techniques) and compacting. The material must fulfil strict requirements with respect to chlorine content, bulk density, ash content and residual moisture for use in feedstock or mechanical recycling facilities.

A lot of effort in Germany has been and is still being put into avoiding of the production of the mixed waste plastics. A new plant for sorting and processing of lightweight packaging waste has been developed and demonstrated (Sortec 3.0). A fully automated sorting and reprocessing plant has started full operation at EXPO 2000 in Hannover. A Sortec plant not only separates lightweight packaging from yellow bags and bins into the individual material fractions, it also prepares plastics. The process is based on a new combination of techniques: dry mechanical presorting, wet mechanical preparation and plastics processing. This allows the waste to be sorted on the basis of the material properties. The plant does not produce a mixed plastic fraction but actually 4 plastic fractions:

- PET bottles (1.5%)
- Polyolefins agglomerate (23%)
- PE regranulate (13%)
- PS regranulate (3.5%)

All the packaging is processed completely into recyclable products. Calculations have shown that 80 to 100 plants of this type could replace 250 sorting plants for lightweight packaging. It is quite likely that this changeover on its own could lower sorting costs by 30 percent and could even reach 50 percent in the case of plastics.

Until recently most of the plastics / paper fraction in France was processed via extrusion or intrusion in to rather coarse profiles for different applications with a low market value. From 1998 on the whole process has been considerably improved by adding a co-extrusion step as well as through a multi-stage optimisation programme. A range of new outlets has been developed following a market study into specific customers demand.
It was reported that the processing costs were considerably decreased with an increase in the final product quality.

The 'mixed plastics' agglomerate can be processed in several ways into, generally speaking, thick walled articles, which are quite suitable for the intended purpose. Intrusion, a sort of pressure-less extrusion, can be used to produce profiles with specific dimensions. Transfer moulding is another way to process the 'mixed plastics' agglomerate directly into end products. The agglomerate is melted directly with the aid of pressure and heat; then the molten mass is fed into a moulding die where it is shaped into the desired form. It generally concerns coarser, robust

moulded products like e.g. thick sheets and transport pallets, with readily available market outlets.
Other examples of thick walled product outlets are e.g. elements for noise protection walls, honey comb-type paving stones as well as products for shore protection.

Another new development is the solid state shear pulverisation technology (based on a combination of German and USA know-how), that produces a powder from the mixed plastic waste, which can be used in direct moulding and extrusion.

One of the problems encountered with the recycling of mixed plastics waste as arising from selective collection of household packaging waste is the ever changing composition, which is unfavourable to reaching a constant end product quality. However, by the optimisation of the upgrading processes as well as the conversion in final products by extrusion and/or compression or injection moulding (as e.g. in France), or by sorting out specific plastic fractions and removal of specific contaminations in the further upgrading process (as in the DSD system), specified end products or certified agglomerate of 'mixed plastics' waste can be obtained.

8.3 Economic aspects

The costs incurred in 1998 for plastics recycling within the frame-work of the DSD are dropped by 15% since 1996. The average cost of recycling (collection and sorting are not included) one ton of mixed plastics was in 1998 370 euro per ton (1996: 415). This amount covers all costs in respect of recycling and processing, including storage, transportation and quality testing.
Although specific costs for the recycling of 'mixed plastics' are not available, it was reported (for Austria) that the recycling costs for household packaging per ton of plastics were reduced to 215 euro by 1999 whereby the costs for energy saving, feedstock and mechanical recycling have more or less balanced out. In 1993 those costs amounted to 510 euro, a reduction of 60%.
The price that end-users are willing to pay for this mixed plastics waste depends on the quality (composition and contamination). Whether in fact this price will be higher than the costs of production is not clear.

8.4 Legal, governmental aspects

See Appendix 1 for packaging waste legislation.

8.5 Social aspects

Generally speaking the mechanical recycling of mixed plastics waste as arising from selective collection of household packaging waste or resulting from a segregation

process out of integrally collected MSW is neither feasible or fully accepted in society.
Especially in Germany a lot of effort (and money) was put into the development of products from (generally) controlled mixtures of plastic waste (EWVK, mid 1990's). Several products have made it to the market but only small market niches are being served.
As also products made out of (specifically) mixed plastics have to meet specifications, the products are seldom cheaper than products made out of new materials (which are clearly preferred by the customers).
Having a limited marketing potential the actors in the packaging chain (including the sector organisations) are not very inclined to spend time and/or money in the organisation of specific recycling schemes or in the development of products out of recycled mixed plastics.

8.6 Organisational aspects

The 'Mixed Plastics' fraction becomes available as a residual fraction of the plastics packaging waste from household upon segregation of specific plastic products. As such, both the quality and quantity as well as the organisation of the recycling activities and the marketing of the products obtained strongly depend of the organisation of collection and recycling of the total plastics fraction, generally speaking under responsibility of the national plastics guarantor associations (see further Appendix 1)

8.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of 'mixed plastics' combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A8.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for the mixed plastic fraction have been identified and weighted according to the procedure described in the main report. (See table A8.2.)

8.8 Eco-profile considerations

If successful, mixed plastics recycling programmes will help to reduce the volume of plastics in MSW and in turn reduce pressure on landfill, which is generally considered as the least favourable form of disposal. Also, recycled mixed plastics provide a cheap (if considered as a rest fraction of the sorting plant) alternative to

traditional building and construction materials, especially wood, which helps in the conservation of valuable natural resources. (However, it should be remarked that this economic benefit does not always show in market prices.)
However, compared to the other plastics fractions that are recycled, the contamination rate of the 'Mixed Plastics' fraction is rather high and as such requires significant additional processing steps to reach the intended quality (required for feasible marketing of the end-product). Taking also into consideration that no virgin plastics are substituted 1:1 and that a substantial residue remains after processing, it is concluded that the overall eco-profile of total 'Mixed Plastics' fraction is not favourable for mechanical recycling.

8.9 Conclusions

It is neither economically nor environmentally feasible to mechanically recycle the 'mixed plastics' fraction to a large extent. Only on a very limited scale some outlets are available for products with a specified quality, requiring rather elaborate processing steps. Both the poor overall score of the critical success factors (see main report) as well as the rather negative eco-profile do not support the promotion of this recycling scheme, albeit that if specific conditions are met some market niches can be served.
Possibly the large-scale introduction of the newly developed Sortec technology may result in a reduction of the 'produced' quantity of the 'mixed plastics' fraction. Furthermore, other waste management options (feedstock recycling, energy recovery, alternative fuels) should be considered for the recovery of this major part of the plastics household waste stream.

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Table A8.1 Progress / blocking factors for Mixed plastics recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• 'Mixed Plastics' fraction becomes available as residue of other upgrading processes, which might imply economic benefit	• Low virgin prices • Competition with feedstock recycling • Considerable processing required to obtain targeted quality of end products • Limited feasible market outlets so difficult to arrive at a necessary economy of scale • High contamination rate • Processing of residues • Limited funds available to support the development of additional recycling technology • Hardly any R.O.I.
Legal, governmental	• National and EU packaging directive • Purchase policy by government for stimulating use of products made of recyclates, like public benches, river bank protection plates (wood /concrete applications)	
Social	• Green communication on 'Eco-products' made out of recycled plastic waste	• It is difficult to convince consumers to buy recycled
Organisational	• Intermediate organization is arranged • Large volumes available • Generation as sorting residue by separate collection of packages • Quantities of 'mixed plastics' waste are sufficiently large to develop or operate pilots in regional areas • Experience with earlier recycling schemes	• Limited market outlets in products mentioned under governmental policy (wood/concrete application) • Specification of end-product is difficult due to the great variety in composition of the mixed plastic streams

Table A8.2 Decisive criteria and scores for recycling scheme Mixed plastics

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	++	
1.3 Number of disposers	+	
1.4 Contamination level	- / --	
1.5 Markets	-	**0**
1.6 Substitution threat	0	
1.7 Recycling costs (incl. collection costs)	- / --	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	**+**
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	0	
3.2 Sector co-operation	-	**0**
3.3 Participation disposers	+	
3.4 Society pressure	0	
3.5 Successful recycling stories	-	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	0	**0 / -**
4.3 Processing capacity	-	
4.4 Certification secondary products	-	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

9. Appendix: Scheme Analysis Agricultural Films

9.1 Introduction

Most of the plastics in agricultural applications are used as film or sheet for silage wrap, crop cover and fertiliser sacks. These films are made of LDPE or LLDPE and typically have a relatively short lifetime, usually less than two years. A rough distinction can be made between thick films (≥ 0.1 mm) and stretch films (~ 25 μm), of which the first group is most interesting for recycling. Note that this Appendix only deals with agricultural film, not film from the horticultural sector.

In the UK in 1995, producers of farm films established a scheme to collect used film for recycling at a new British Polythene Industries (BPI) plant in Dumfries. The Farm Film Producer Group (FFPG) classified the collection of these waste plastics from farms and sent them for recycling at BPI. The scheme operated on the basis of a voluntary levy on plastic manufacturers. In 1995 in total, an estimated 3,900 tons out of a possible 20,000 tons of plastic film (19.5%) were collected in this system.

In The Netherlands Folined was founded in 1993 as a result of the Dutch Covenant concerning agricultural films. In 1996 the covenant was replaced by regulations valid for all producers and importers of film for agricultural applications. Folined is a non-profit organisation in which three sectors participate: the producers association, the recyclers association and the agricultural board. In contrast to FFPG Folined collects only silage films/bags thicker than 0.1 mm (fertiliser, feed and other similar bags). In 1998 a total of approximately 8,000 tons were collected by Folined, 30% of the total quantity generated (agricultural and horticultural plastic waste).

Also in Denmark a successful collection and recycling system exists. Collection is effected through the companies from which the supplies of film and packaged products were originally bought. About 2,000 tonnes of LDPE film are collected from the consumed amount of about 6,600 tonnes. The future recycling target is 60%.

In Norway a covenant system exists. In 1999 Plastretur collected 4,500 tons of film waste, which is 70% of the 6,500 tons of plastic films. About 80 – 90% of these collected films are silage films.

9.2 Description of the recycling scheme

The recycling scheme starts with the gathering of film waste by the farmers. In the FFPG system the farmer had to separate sheet/bag and stretch wrap plastics and had

to take care of reasonably clean plastics, free of stones, dirt, twine, water etc. The farmer had to call FFPG after having gathered a minimum of 250 kg of plastic. The FFPG then informed the nearest collector, who picked up the waste of the farmer within 21 days.

In The Netherlands the collection scheme of Folined slightly differs from the FFPG scheme. The Dutch Folined organises the collection of the film waste only once a year (from March until June) nation-wide. The organisation informs the joined farmers when the collection will take place, so that they can prepare their waste. A collector contracted by Folined comes by and collects the films. The collected films are directly weighed at the farm. The farmer receives a note with his total amount delivered films. Folined will charge afterwards the total costs according to the note. In Norway there are about 80 collectors with at least one depot, often more. The films can be disposed at the depots free of charge. For the collection of film waste at the farms a fee has to be paid. There are about 80,000 farmers in Norway, some of them in remote areas. The collection frequency is variable.

In general the collector carries out the first sorting step. The plastic is sorted for example into wrap and sheet plastic and baled. The collector stores the bales until there is enough for a transport truckload. In the UK the FFPG arranged pick-up and delivery to a recycler. In The Netherlands the collector sells the collected films to one of the contracted recyclers. In Norway there are 4 recyclers whereby the transport distances vary between 0 and 1,000 kilometers.

Generally speaking, the recycling process consists of a combination (or selection) of the following process steps: debaling, coarse shredding, friction washing, fine shredding, washing / float-sink segregation, centrifuge, (vented) extrusion with melt filtration, granulation. With stretch wrap material an additional pre-washing step might be included.
The contamination rate strongly varies with local circumstances, the selection of the material to be recycled as well as the chosen collection system (including instructions to the disposers). The contamination rate (soil, water, other materials) ranges between 20 and 70% with a feasible average of 25 – 30%.

Market outlets for film waste are e.g. pallets, stable sheets, ‘geoblocks’, black silage films, construction films, refuse sacks and heavy duty bags. Companies also put sometimes recyclates on the market.
In Norway a part of the white silage films is even recycled into shopping bags.

9.3 Economic aspects

The total costs incurred with the collection and recycling into qualified granulate of agricultural films in the UK is estimated at 520 to 580 euro/ton (contamination rate 25 – 40%).[7] Compared with the price of prime polymer of 680 euro/ton (Q4, 1998, delivered at gate) not much, if any, margin is left.

The Folined system in The Netherlands is partly financed by the producers and importers before putting the film on the Dutch market through a removal fee of 50 euro per ton. The disposer, meaning the farmer, who pays 100 euro per ton of plastic film upon collection by Folined pays for the other part of the recycling costs.

In the Plastretur system of Norway the producers of agricultural films or traders have to pay a fee of 200 euro/ton. With a target of 70% collection, whereof 80% has to be recycled and put on the market again, a balance between fees and costs for collection and recycling was found.[8]
The costs for collection are about 120 euro/ton. A couple of years ago this was co-financed by the local authorities. Nowadays Plastretur contributes to the collection. Processing costs are estimated at 220 euro per ton.
For each ton put on the market 200 euro is paid. 70% collection target results in 0.7 x 120 ≅ 80 euro costs and 80% processing results in 0.8 x 0.7 x 220 ≅ 120 euro costs: together also 200 euro.
Regranulate is sold for prices between 250 and 500 euro per ton and pallets are sold for 950 to 1,100 euro per ton. The contribution of Plastretur in the processing costs will be gradually further reduced in the next 3 years (from 220 euro/ton now to a range of zero to 150 euro per ton depending on the final product that is put on the market.
The average contamination rate of the Norwegian agricultural films is 20% with about 5% soil and 15% water. This low contamination rate is obtained through efficient communication to and education of the disposers.

In general it can be stated that recycling of agricultural films is stimulated by the increase of landfill fees. The set-up of the first collection and recycling systems was commercially driven, under the condition that the collected films are as clean as possible. Contamination results in a relatively expensive recycling process due to more necessary washing steps and the disposal of residues. In combination with the low virgin prices for polyethylene, the contamination makes competition of

[7] The UK information is among others based on the information, obtained in an interview in January 1999. In August 2000 the contamination rate was found to be 45-55% causing total costs of £ 500/ton (or 800 euro/ton with £ 1 ≅ 1.6 euro). Such a high contamination rate with the subsequent high costs has a negative influence on the marketability of the regranulate!
[8] In August 2000 it was commented that the target of 70% for 1999 was met and that the target for 2000 is 80% collection. The costs exceeds the fee.

recycling with virgin material very difficult. Also, the export to low wages countries determines the price for waste to be recycled.
A fee for each ton of film put on the market strongly contributes to a feasible collection and recycling scheme.

9.4 Legal, governmental aspects

In the UK farmers are not allowed to burn the film, but landfill sites are unwilling to accept it. Besides that, the local authorities are not obliged to collect it from the farmers. Non-packaging farm plastics are currently not covered by waste management controls. Without legislative drive it takes a very long period to implementation, if any (BPI has already been involved in agricultural film recycling for more than 8 years and still no fixed procedure exists). The amount of 24,000 tons to 27,000 tons of farm plastics waste is not a significant amount compared to the 11.7 million tons of total packaging waste in the UK, so the farm plastics are not a priority.
All these facts result in big problems for the farmers who asked the government for action to tackle these problems. A consultation paper was drafted by the Department for Trade and Industry and sent to all parties involved.
By 2001 the UK must meet the recovery and recycling targets in the EC Directive on Packaging and Packaging Waste by 2001 (including agricultural films).

In The Netherlands a covenant was signed by a number of agricultural film producers, the NFK (Dutch Plastics Federation) and the government in order to regulate the collection and recycling of agricultural films in 1993. Based on this covenant in 1996 regulations have become valid for waste disposal of thick agricultural non-packaging films. Land filling has been prohibited since January 1, 1996. This regulation is valid for all producers of agricultural film, not only for the producers who signed the covenant. In this way the presence of free riders, which could undercut the recycling system of Folined, is prevented as much as possible.

In Norway also the activities of Plastretur are based on a covenant between government and industrial parties.

9.5 Social aspects

The weakness of the FFPG system in the UK (mentioned in the introduction) was that not all of the plastic manufacturing companies were supporting the voluntary recycling program. Some so-called “free riders”, importers of plastics, sold their plastic films cheaper than the companies participating FFPG to the farmers. It became clear that those participating in the FFPG scheme could not continue in face of this degree of price undercutting by the free riders, and FFPG ceased operation in early 1997. BPI is currently reprocessing a limited quantity of non-packaging farm

plastics from other EU member states. The recycling plant could take up 10,000 tons of non-packaging farm plastics annually.

A good communication with all parties, producers, farmers and recyclers, involved is necessary. This would enhance the willingness for farmers to gather the waste and to gather it as clean as possible. Promotion of clean collections of agricultural plastics is important for higher quality recyclate against lower costs. It would help if the organisation would make (clean) collection the most economically attractive option for the farmers. A method to obtain this is to let the disposer of the waste (the farmer) pay per kilogram offered waste. In this way the farmer has to pay less if he cleans the film (clean film is less heavy than contaminated film which contains stones etc.).
Furthermore, the recyclers have to communicate the requirements of the waste to both the farmers and the collectors. Often no support of film producers exists, because they see (and 'feel') no benefit of recycling. Only high quality and low costs will convince producers to use recyclate.

9.6 Organisational aspects

The highest collection and recycling rate will be obtained when regional or national collection systems are set-up, in which farmers, collectors and recyclers work closely together. An advantage is, that most film comes free as waste at specific periods of the year. The organisation of the waste collection could be adjusted to that.
Sufficient recycling capacity should be available, which is most critical for stretch film. A change from silage films to thinner grass roll films is observed in e.g. The Netherlands. Processing of the thinner film is more difficult and contains relatively more contaminants.
Also important is of course the availability of market outlets for recyclates. High quality will enhance the number of market outlets. Furthermore regulation might stimulate the production of agricultural products for agriculture with recycled content.

9.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of agricultural films combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A9.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for

agricultural films have been identified and weighted according to the procedure described in the main report. (See table A9.2.)

9.8 Eco-profile considerations

The agricultural films that are recycled today are generally speaking free of dangerous contaminants such as pesticides. Residual soil originating from the recycling process can be deposited in the countryside without many problems. The contamination rate (soil and water) can be kept on an acceptable level by adequate communication programs. Although the contamination level is higher than with the commercial and distribution films (Appendix 3), the good quality of the regranulate (that can even replace virgin material in specific applications) balances this somewhat negative aspects of the Eco-profile resulting in a neutral Eco-profile for the mechanical recycling of agricultural films.

9.9 Conclusions

Education of the farmers through efficient communication programmes has resulted in several countries in agricultural film waste streams with a moderate contamination level. Such material can be collected and mechanically recycled rather efficiently, albeit that some financial support is required from producers or traders. The good quality of the regranulate generates a high demand from the market, which still is - but certainly was in the past - one very positive aspect for this market-driven activity. Legislation is another driver for a successful recycling scheme, and sometimes even a necessary prerequisite!
All together the mechanical recycling of agricultural films with its high quality of regranulate, neutral Eco-profile and either budget neutral or requiring a moderate financial support can certainly be seen as one of the better candidates for improving its recycling rate!

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Table A9.1 Progress / blocking factors for Agricultural films recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Commercial driven • Eco-efficient system • Cost effective system with low administration and information costs • Well organised gate fee system • Sufficient outlets • Economy of scale • Increase of landfill tax • Availability of sufficient market outlets • Declaration of 'generally binding' to pay the mandatory removal fee • High prices charged by waste-management companies in UK	• Low prices and fluctuations in prices of virgin plastics and of recyclates. • Export to low wages countries influences the price for recyclates • Contamination of the films (dirt, mainly sand) causes high removal costs • High costs for disposal of residues of plastic recycling • Free riders • Export to neighbouring countries where it is used for energy recovery, especially in the border area
Legal, governmental	• Stringent regulations for collecting and recycling, e.g. prohibition of disposal at landfills • Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates). • Consultation Paper • Stability of policy • Producers responsibility for disposal and recovery of these products after use • Declaration of 'generally binding' to join the agreed system for collection and recycling of agricultural films (like e.g. Folined)	• Inconsistent international legislation c.q. collection systems (e.g. In Sweden and Denmark there is no such system as the Norwegian system) • Limitations in international (border crossing) transport • Lack of legislation; without legislative drive it takes a very long period to implementation, if any (BPI is already for over 8 years involved in agricultural film recycling and still no fixed procedure exists). • Enforcement of legislation or control of compliance with legislation not always clear • Relative easy exemption of the obligations of the declaration of 'generally binding' by the Ministry of Environment to distinct companies
Social	• Good communication with all parties involved: producers, farmers and recyclers • Positive public opinion • Active involvement in the realisation of local solutions • Existence of institutional and administrative structure (as guarantor and link between legislation and actual waste problems) • Good chain co-operation through active involvement of all relevant parties (producers, agricultural sector as well as recyclers)	• No support of producers in some countries • Participation of too many actors in the recycling chain
Organisational	• The existing local/national infrastructure for collection can be used • No ownership for the material; the organisation is free in it's choice where to collect from, in order to reach optimal efficiency • Availability of sufficient recycling capacity • No emissions to air from recycling process • If no specific contaminants like e.g. pesticides are present, the (clean) residual soil can be deposited in the country side	• Change from silage films to thinner grass roll films; processing of the thinner is more difficult • Organisations need to trust/rely on the market and the financial support offered by the organisation to that market • Large distances from farms to local deposits in some areas

Table A9.2 Decisive criteria and scores for recycling scheme Agricultural films

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	0	
1.3 Number of disposers	0	**0**
1.4 Contamination level	-	
1.5 Markets	+[9]	
1.6 Substitution threat	0	
1.7 Recycling costs (incl. collection costs)	0	
2 Legal		
2.1 Laws / directives	0	
2.2 Governmental agreement	+	**0/+**
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	+	
3.2 Sector co-operation	0	**0**
3.3 Participation disposers	0	
3.4 Society pressure	0	
3.5 Successful recycling stories	0	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	+	**+**
4.3 Processing capacity	+	
4.4 Certification secondary products	0	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

[9] See also the remarks in Note 7 at page 81

10. Appendix: Scheme Analysis PVC window profiles

10.1 Introduction

The recycling of post use PVC window profiles is still a young activity, because the product itself is not so long on the market. With the introduction in 1965 and a product lifetime of about 40-50 years nowadays only small amounts of post-use windows are becoming available for recycling. In some European countries such as Germany and The Netherlands a take back system for used PVC windows exists as part of a recycling scheme, organised by the chain itself on initiative of the window and profile producers.

In Germany a nation wide collection system has been established with support of the window profile industry. During the first years the logistic structure is financed through a disposal fee DM 35 per window profile. After collection the profiles are processed in dedicated plants. Started in 1993 one of those plants, VEKA, currently recycles 5,000 tons post use window profiles per year (also imported from other countries in Europe).

In The Netherlands a similar system was set up with financial support of the producing sector. With a contribution of Dfl 5 per window the Foundation Recycling Association of Plastic Window and Profile Producers (SRVKG) is able to organise the whole recycling system. The system has been running since July 1996, and in the period July 1996 - April 1998 70 tons post-use windows (excl. glass) were collected. In 1999 39 tons post-use windows were collected.

10.2 Description of the recycling scheme

VEKA processes profiles originating from collection schemes in France, Germany, Switzerland, Austria, The Netherlands and Denmark. The collection frequency is variable and the windows (mainly from refurbishing projects) are collected in containers by waste disposal companies. Over 700 window producers and a number of waste disposal companies supply a quantity of 15,000 tons window profiles/year, about one-third post-use and for the rest production waste.
PVC window manufacturers, who have signed an eco-contract with VEKA, deliver their outdated or obsolete profiles together with off-cuts, other production scrap and rejects to the VEKA plant. The remainder of the plant feed is supplied by container services, which deliver end of life windows, including steel and glass. The network of collection points is steadily increasing.

The VEKA recycling plant processes complete windows in a fully automatic way. After shredding the ferrous metals are removed with a magnet. With the help of electrostatic separation, air classification, optical separation and sensor separation the following fractions are sequentially separated out of the PVC material flow: non ferrous metals, glass, wood, light and dark PVC and rest metals. The concentrated PVC fraction is controlled to ensure the sorting is correct, is diminished furthermore, dust is removed and the fraction is washed. A final grinding operation and cleaning stage results in a regranulate like fraction for sale to be processed in new profiles or other products. New profiles are co-extruded, with an outer layer of virgin PVC for optical reasons and a recycled PVC interior. The recycled content of the total profile may account for up to 70%, however, with the limited quantities available in general much lower levels of recyclate are applied. Apart from the colour, the recycled PVC is closely or fully comparable to the virgin material.

In The Netherlands the dismantled end of life windows (excl. glass) are put together in containers. The collected profiles are transported to nine sorting companies/depots; from these locations the sorted fractions are transported to five recycling companies, which includes VEKA Environmental Technology itself.

10.3 Economic aspects

With the relative good quality of the recycled PVC no problems are encountered with the application of the recycled PVC in new products. The greater part of the secondary fraction is applied for the production of new window profiles (closed loop system). The recyclate can also be used for the production of other durable PVC applications.
The selling price is about 70-80% of the virgin price. This is too low to cover the high collection and processing costs, so a chain deficit exists. This deficit is about 50-130 euro/ton in Germany and about 135 euro/ton in The Netherlands. The deficit that depends on the level of the virgin price has to be balanced by a contribution of the different actors in the producing chain. Other actors, those in the recycling chain, have to be paid for their activities (this concerns dismantler, sorting company, transport company and recycler).

The collection costs in Germany are 50 euro/ton and in The Netherlands 45 euro/ton. In The Netherlands the additional sorting costs are 70 euro/ton and the costs for transport to the recycler 45 euro/ton; the sorting has benefits of 45 euro/ton.
The processing costs are in the German situation 460 euro/ton and in the Dutch situation 450 euro/ton. The total benefits of the Dutch fraction amounts to 380 euro/ton and VEKA mentions a market price of 600-700 euro/ton.
In Germany as well as in The Netherlands a contribution per new window is needed to pay for the system, because the take back costs and recycling costs together are higher than the benefits.

The take back costs are rather high, because different activities have to be carried out: dismantling, collection, sorting/cleaning, transport to the recycling company. The processing costs are high due to the complex character of the recycling process, which enables the segregation of quite a range of materials whereof PVC with different colours constitutes only a part. It is not expected that these costs can be reduced easily. Only with higher throughputs and the application of more optimal take back structures the costs may be cut.

Nowadays the collected and processed amounts of post-use profiles are relatively low; the PVC window profile is a relatively new product and only limited amounts of end of life profiles are generated. Certainly in the future these amounts will increase. The future target for VEKA is to recycle 30,000 tons/year.
Today, about 60,000 ton/year is becoming available in Western Europe with a forecast for about 150,000 ton/year in 2010 and about 290,000 ton/year in 2020. It may be concluded that these increasing amounts should make it possible to realise more optimal recycling schemes in the future, not only in Germany but also in other countries.

10.4 Legal, governmental aspects

In several European countries there is a threat of legislation against PVC or PVC containing products. The landfill of recyclable or combustible wastes will be forbidden in several countries. These aspects force the industry to react with the establishment of a recycling system. In The Netherlands the producing industry and the government have an agreement that used window profiles will be recycled and that diversion from landfill/incineration is encouraged. A blocking factor is the phenomenon that in several western European countries different regulations exist concerning PVC or PVC containing products. Special attention has to be given to the additive cadmium, which can be used in products with a long life, such as PVC window profiles. Introduction of closed loop systems for cadmium containing products will lower the legislative pressure. Such aspects stimulate the related product chain to realise a recycling scheme.

10.5 Social aspects

Due to strong anti-PVC lobbies in the past, especially by environmental action groups, and the threat of legislation to discourage the application of PVC containing products, the PVC industry has taken the initiative to realise recycling schemes for specific product groups with the objective to close the loop. This has resulted in a decrease of the pressure by society and even in a change of that pressure into a positive attitude of the general public. The fact that the supply chain takes its own responsibility has a positive impact. The window producers have organised the institutional and administrative structure and the other actors in the chain arranged

the pragmatic organisation of the whole (closed loop) recycling scheme. The actual output of discarded PVC is still relatively low, but with the expected further co-operation of disposers/dismantlers a substantial increase of the amount collected and recycled is foreseen in the future.

10.6 Organisational aspects

The reversed logistics and recycling structure has been well organised and there is sufficient processing capacity available. In the current situation rather small quantities of post-use window profiles collected are co-processed with other PVC window profile fractions such as off-cuts and production or process waste. The future prospect is that sufficient quantities of post use profiles waste will become available to match the available recycling capacity. This will result in a higher efficiency of the whole recycling process with lower costs.
In starting up new recycling activities in other countries it might be an option to collect different end of life PVC products together, such as pipes, windows, cables, trays and shutters. Co-collecting the window profiles with other components out of the demolition waste might also contribute to a lower level of collection costs.

10.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of PVC window profiles combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A10.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for PVC window profiles have been identified and weighted according to the procedure described in the main report. (See table A10.2.)

10.8 Eco-profile considerations

Generally speaking, the recycling of PVC window profiles strongly contributes to closing a product loop. The application of secondary resources into new products results in a decrease of new resources and energy as well as of the amounts of emissions and waste. The well-organised reverse logistics system, feasible contamination levels and good outlets for the recycled material, they all together contribute to a positive environmental profile of the recycling scheme of PVC window profiles.
This positive profile was further confirmed by the results of two different studies:

- A Dutch study carried out in 1992 showed that the environmental profile improves by 20% when recycled PVC from discarded profiles is applied during the production of new profiles.
- Recent research shows even better results with the following assumptions:
  - Lifetime of a window profile is 75 years
  - 10 times recycling takes place
  - A profile consists of 30% virgin and 70% secondary material

  The resources and energy needed will be reduced by more than 20%, the level of emissions will decrease by about 30% and the amount of waste will be lowered by almost 40%.

10.9 Conclusions

The overall picture of the progress/blocking factors (see table A10.1) and the overall score of the decisive criteria (see table A10.2, especially with regard to the chain and sector co-operation) is positive for this recycling scheme. The disposers and the producing industry have to support financially the collection and recycling activities in order to compensate the chain deficit.
The quality of the recyclate is good and the demand for the recyclate is much higher than the available quantity. The results of the eco-profile considerations show that also from an environmental point of view the recycling of PVC window profiles is a favourable option.

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Table A10.1 Progress / blocking factors for PVC windows recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Levy on PVC products for financing collection and recycling. • Regional subsidies. • Availability of market outlets for recyclates.	• Low prices and fluctuations in prices of virgin plastics and recyclates. • Export to low wage countries determines the price for recyclates. • Relatively high collection, transport and recycling costs; funds are necessary to close the deficit.
Legal, governmental	• Threat of legislation. • Policy on landfill. • Active support from the government (in the framework of PVC policy). • Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates).	• Lack of harmonization of regulations between the different EU member states on PVC. • Limitations in international (border crossing) transport. • Legislation on Cadmium content. • Standards, regulations and specifications limiting the use of recyclate.
Social	• High pressure on recycling of PVC wastes. • Existence of institutional and administrative structure (as guarantor and link between legislation and actual waste problems), mainly for collection and recycling, and organisation of fee for take back system (suppliers). • Pro-active producers; involvement of producers in collection and recycling organisation. • Well organized gate fee system. • Anti-PVC lobby stimulates recycling initiatives. • Communication with suppliers and authorities. • Positive attitude of general public. • Information campaigns. • Participation level.	• No active role of local authorities in ensuring that profiles are being collected and transported to the dedicated organisations. • Difficulties with acceptance due to mentality in construction area (low educational level staff is difficult to convince to properly handle the waste).
Organisational	• Good quality recyclate. • Network of suppliers. • Availability of sufficient recycling capacity. • Initiatives / existing structure for collection of demolition waste. • Infrastructure for specific collection already available due to delivery system for new products.	• Uncontrolled leakage of part of the discarded profiles out of the established institutional and administrative structure. • Small quantity of post-use PVC window frames. • Degradation of PVC (reduced UV-stabilisation). • Complicated infrastructure needed for full coverage (including low quantity waste locations).

Table A10.2 Decisive criteria and scores for recycling scheme PVC windows

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	-	
1.3 Number of disposers	0	**0**
1.4 Contamination level	0	
1.5 Markets	+	
1.6 Substitution threat	+	
1.7 Recycling costs (incl. collection costs)	0	
2 Legal		
2.1 Laws / directives	0	
2.2 Governmental agreement	+	**0 / +**
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	++	
3.2 Sector co-operation	+	**+**
3.3 Participation disposers	0	
3.4 Society pressure	+	
3.5 Successful recycling stories	0	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	+	**+**
4.3 Processing capacity	+	
4.4 Certification secondary products	0	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

11. Appendix: Scheme Analysis PVC pipes

11.1 Introduction

The recycling of PVC pipes started somewhat earlier than the recycling of PVC window profiles. In the mid-fifties the first PVC pipes were used in the installation of drains and sewers and since then this application has experienced a significant growth. In 1997 1,510 kton of PVC was used for the production of pipes in Western Europe and the volume is still increasing. This means that so far millions of tons of PVC pipes are installed and with an average lifetime for the pipes of 75 years we see that huge amounts have still to come available as waste. Only limited amounts of waste pipes come available due to replacement of old sewer systems as well as demolition and renovation of old buildings. Further, it is rather common practice that old sewer systems are left in place upon replacement and that the new system is laid next to the old system.
In 1991 the Dutch Association of Plastic Pipe System Producers (FKS) started with the collection and processing of post use plastic pipes on a nation-wide basis. All the big Dutch PVC, PE and PP pipe manufacturers are represented in the FKS. A take back system was set up by 6 Dutch producing enterprises, not only for off-cuts but also for all sorts of dismantled PVC and PE pipes. These companies provide financial support to assure the system is self-supporting. The structure runs from 1991 until now with the FKS only compensating the collection costs of 110 euro/ton. In 1998 3,000 tons of post use PVC pipes are processed. As for the PE pipes about 500 tons per year are collected in The Netherlands.
In Germany a similar reverse logistics structure was erected. In 1994 a collection and recycling system operated by the Plastic Pipes Association in Bonn (KRV) was introduced under the management of the Quality Association for Plastic Pipes (GKR).
Besides the relative large recycling schemes of The Netherlands and Germany some other less countrywide organised activities or a single scheme in a start-up phase can be signalled in other parts of Europe.

As the German system was directly derived from the Dutch system and is also very similar, we will further describe the specific details of the Dutch system.

11.2 Description of the recycling scheme

In The Netherlands the collection is organised over more than 160 collection sites. It concerns service points, distributed over the whole country, and sorting plants, where used pipes are sorted out of building and demolition waste. The discarded pipes waste is collected from building sites by a jointly organised container

collection system. The waste is either transported directly to one of the two recycling facilities or first to one of the service points in the neighbourhood and then to a recycling plant. The collection frequency is variable and is dependent of the disposing need of the sources. FKS estimates that about 70% of the total quantity of pipes, which becomes free are collected and processed. It is further estimated that the pipes waste is made available from the different sources according to the following split:

- 30% FKS service points
- 40% directly from disposing locations to processing facilities
- 30% sorting plants

The collection costs are about 110 euro/ton.

The first stage in the recycling facility involves manual sorting the PE, PP and PVC pipes and removal of the gross contaminating fractions. The sorted PVC fraction is then fed to a shredder and the shredded material is de-ironed by a magnet. Non-ferrous metals are separated with the help of detection equipment and sand and other fine materials are removed by sieving. Following the upgraded PVC is finely ground to approximately 0.5 mm (micronised) and homogenised. This (compound) material is then used for the foamed inner layer of a three layer sewer pipe by means of a co-extrusion process. With two outer layers of virgin material and the inner layer of recycled material such a three layer pipe can contain up to 60% by weight of secondary PVC. The PE and other fractions are dealt with in other (parts of the) recycling plants.

As for the contamination rate it can be stated that up to 8% is accepted by the recyclers. However when the contamination rate is lower the process is both technically and environmentally more feasible and a better quality of the recycled material can be reached. With a virgin PVC price level of at least 585 euro/ton the recycling activity then becomes self-supporting.

11.3 Economic aspects

With the relatively good quality of the recycled PVC in The Netherlands no problems are encountered with the application of the recycled PVC in new products. The total quantity can be used in the production of new sewer pipes with a “KOMO” quality certificate (closed loop system).
FKS has organised the whole recycling structure and takes care of financing the chain deficit of 110 euro/ton (≅ collection costs). The disposers have to take care of the correct selective collection of the discarded pipes and have to pay a small contribution for disposal of their waste. No additional external funding is needed.

In 1998 3,000 tons of PVC pipes were recycled in The Netherlands and the yearly amount will increase to 5,000 tons within short time. With a capacity of the two recycling facilities of 15,000 tons/year there is both the potential and the ambition to

collect and process larger amounts. A better exploitation of the built capacity will result in a decrease of the recycling costs. The objective of FKS is that the recycling scheme will become self-financing, that is without chain-deficit.

As for the European perspective it can be stated that currently about 20,000 tons of discarded PVC pipes are becoming available in Western Europe per year and the forecast is that that this amount will increase to about 50,000 tons/year in 2010 and about 105,000 tons/year in 2020. These increasing amounts make it possible to realise more recycling schemes in the future, both in terms of number and relative efficiency.

11.4 Legal, governmental aspects

In several European countries there is a threat of legislation for PVC or PVC containing products. Furthermore in some countries the landfill of recyclable or incinerable wastes will be forbidden. These aspects encouraged the industry to react by setting up of a recycling system. In The Netherlands the producing industry and the government have an agreement that used pipes will be recycled and that diversion from landfill/incineration is encouraged. A blocking factor is the phenomenon that in several western European countries different regulations exist concerning PVC or PVC containing products. Another blocking factor is caused by the local authorities, which do not control the source collection and transport of discarded pipes. Also there is no obligation for the discharge of underground pipes upon demolition.
The aspects mentioned stimulated the chain of PVC pipes producers and disposers to realise a recycling scheme.

11.5 Social aspects

Due to strong anti-PVC lobbies in the past, especially by environmental action groups, and the threat of legislation to discourage the application of PVC containing products, the PVC industry (with The Netherlands and Germany taking the lead) has taken the initiative to realise recycling schemes for specific product groups with the objective to close the loop. This has resulted in a decrease of the pressure by the society and even in a change of that pressure into a positive attitude of the general public. In The Netherlands the producers have organised the institutional and administrative structure and the chain of all involved parties has realised a feasible, pragmatic closed loop system.

11.6 Organisational aspects

The reversed logistics and recycling structure has been well organised and there is sufficient processing capacity available. In the current situation the still rather small collected quantities are co-processed with other PVC pipe fractions from off-cuts and production or process waste. The future prospect is that sufficient quantities of post use pipe waste will become available to match the available recycling capacity. This will result in a higher efficiency of the whole recycling process with lower costs.
In starting up new recycling activities in other countries it might be an option to collect different end of life PVC products together, such as pipes, windows, cables, trays and shutters. Co-collecting the pipes with other components out of the demolition waste might also contribute to a lower level of collection costs. But it must be recognised that the different component fractions need different processing and recycling activities.

11.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of PVC pipes combined with a selection of relevant remarks made in the interviews or in the questionnaires results a listing of the relevant progress and blocking factors. (See table A11.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for PVC pipes have been identified and weighted according to the procedure described in the main report. (See table A11.2.)

11.8 Eco-profile considerations

Generally speaking, the recycling of PVC pipes strongly contributes to closing a product loop. The application of secondary resources into new products results in a decrease of new resources and energy as well as of the amounts of emissions and waste. The well-organised reverse logistics system, feasible contamination levels and good outlets for the recycled material, they all together contribute to a neutral to slightly positive (depending on the specific situation) environmental profile of the recycling scheme of PVC pipes.

11.9 Conclusions

The overall picture of the progress/blocking factors (see table A11.1) and the overall score of the decisive criteria (see table A11.2, especially with regard to the chain and sector co-operation) is positive for this recycling scheme. The disposers and the producing industry have to financially support the collection and recycling activities. The quality of the recyclate is good and the demand for the recyclate is much higher than the available quantity. The results of the ecoprofile considerations show that also from an environmental point of view the recycling of PVC pipes is a favourable option.

11.10 References

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Table A11.1 Progress / blocking factors for PVC pipes recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Levy on PVC products for financing collection and recycling • Regional subsidies • Availability of market outlets for recyclates	• Low prices and fluctuations in prices of virgin plastics and recyclates • Export to low wages countries determines the price for recyclates
Legal, governmental	• Threat of legislation • Active support from the government (in the framework of PVC policy) • Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates) • Policy on landfill; raising the prices of disposal (landfill and/or incineration)	• Lack of harmonization of regulations between the different EU member states on PVC • No active role of local authorities in ensuring that pipes are being collected and transported to the dedicated organizations • No obligation to remove underground pipes on demolition (NL) • Possibly in future legislation on lead content
Social	• High pressure on recycling of PVC wastes; anti-PVC lobby stimulates recycling initiatives • Existence of institutional and administrative structure (as guarantor and link between legislation and actual waste problems), mainly for collection and recycling, and organisation of fee for demolitioners (suppliers). • Pro-active producers; involvement of producers in collection and recycling organisation. • Communication with suppliers and authorities • Positive attitude of general public	• Difficulties with acceptance due to mentality in construction area (low educational level staff is difficult to convince to properly handle the waste)
Organisational	• Good quality recyclate • Existence of reversed logistics system • Intensifying the collection aimed at enhancing the amount of post-use pipes, thus enhancing the economy of scale of the recycling process • Availability of sufficient recycling capacity • Initiatives / existing structure for collection of demolition waste • Infrastructure for specific collection already available due to delivery system for new products	• Uncontrolled leakage of part of the discarded pipes out of the loop • Small quantity of post-use pipes in spite of large potentials (partly due to no obligation of removal, see above, and long lifetime) • Degradation of PVC (reduced UV-stabilisation) • Presence of contaminants (like soil particles, rubbers and non-PVC polymers) • Complicated infrastructure needed for full coverage (including low quantity waste locations)

Table A11.2 Decisive criteria and scores for recycling scheme PVC pipes

Decisive Criteria	Recycling scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	0	
1.2 Quantity	-	
1.3 Number of disposers	0	**0**
1.4 Contamination level	-	
1.5 Markets	+	
1.6 Substitution threat	+	
1.7 Recycling costs	0	
2 Legal		
2.1 Laws / directives	0	
2.2 Governmental agreement	+	**0/+**
2.3 Trade obstacles	+	
2.4 Application norms	0	
3 Social		
3.1 Chain co-operation	+ +	
3.2 Sector co-operation	+	**+**
3.3 Participation disposers	0	
3.4 Society pressure	+	
3.5 Successful recycling stories	0	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	+	**+**
4.3 Processing capacity	+	
4.4 Certification secondary products	0	

+ + very positive
+ positive
o neutral
- negative
- - very negative

12. Appendix: Scheme Analysis Automotive bumpers

12.1 Introduction

Dismantling of End of Life Vehicles (ELVs) is a common activity in several European countries with the aim of recycling of different materials. The related activities are in line with the European Directive of ELVs, which favours an increasing recycling of the materials of discarded vehicles. Plastics are among the targeted materials with bumpers as an example of larger, more easily recyclable parts.
In The Netherlands the organisation Auto Recycling Nederland (ARN) supports the dismantling of a wide variety of specific parts with the aim of material recovery. One of the prerequisites for this selective dismantling is that markets for the secondary materials have to exist, with a minimal need for further application development. This also holds for the PP and PC bumpers, which are removed from ELV cars. After grinding, the secondary plastic is used for direct injection moulding as such or after regranulation.
In Germany Targor GmbH, a joint-venture of BASF and Hoechst, uses secondary PP regranulate for the production of quite a range of products including some applications in the automotive sector.

The organisation CARE (Consortium for Automotive Recycling) in the United Kingdom was established in 1995 by a group of vehicle producers. In close co-operation several pilot projects have been carried out to investigate all different aspects of vehicle disposal and the related recycling. In the first two years of operation (1996 and 1997) CARE has expanded its network of affiliated dismantlers to 30 companies. The main aim is to achieve a steady growth in the reuse and recycling of vehicle components and materials. One of the pilot projects undertaken by the Consortium concerned the investigation into the recycling process of polypropylene bumpers with an evaluation of all different aspects such as collection, regrinding and recycling.

12.2 Description of the recycling scheme

At the dismantling facility the old cars are dismantled and also the bumpers are removed. Upon dismantling the bumpers are sorted according to their raw materials because bumpers of different brands may be made of different material compositions.
In The Netherlands only the PP and PC bumpers are sorted and shredded at two locations. Transportation of shredded bumpers to the recycling companies increases the transport efficiency. At the recycling company granulation, separation of plastic

impurities and remaining metals, washing and drying takes place. Regranulating and compounding is done either at the recycling company or at a special compounder, e.g. Targor. At this company the flakes of 10 mm in size are compounded and extruded i.e. they are blended with any required additives/virgin material, then melted and extruded through a die and chopped into pellets. These pellets can be sold to a wide range of end use industries.

As for an indication of the costs involved CARE gives the following economic balance of all the activities:

	£/ton	Euro/ton (at a rate 1 £ ≅ 1.6 euro)
Dismantling/segregation	100-150	160-240
Transportation	50	80
Granulation, separation, etc	130	210
Extrusion/compounding	185	295
Additional delivery/packaging	50	80
In total	**515-565**	**825-905**

The costs are relatively high, which implies that a rather high price of the secondary material is required to compensate these costs.

12.3 Economic aspects

With a rather high quality of the secondary material no problems are met in finding outlets. Potential markets are for example the shoe industry for producing shoe heels and in the automotive sector for producing components like wheelarch liners and underbonnet applications. It can also be used in blends with virgin polypropylene to produce grades that meet automotive requirements. A general purpose grade of polypropylene copolymer generally commands a price of around £ 580-610/ton (end 1997, equals 930-975 euro/ton at a rate of 1 £ ≅ 1.6 euro). This means that in such a situation costs and price are close together.
In The Netherlands a levy is paid by the consumers (≈ 70 euro in 1999 for each first registration in The Netherlands of cars with a maximum weight of car + loading of 3,500 kg) to establish a fund to support recycling activities which do not take place without this support. From this point of view also the recycling of PP and PC bumpers was started; the following bumper recycling amounts are realised:

- in 1996 2.1 kg/car (436 ton/year)
- in 1997 3.1 kg/car (1232 ton/year)
- in 1998 4.4 kg/car (1424 ton/year)

The figures show a steady increase over the years and this implies a positive outlook for improvement of the recycling scheme economy. From the aforementioned fund a fee can be paid for the different recycling activities (dismantling, grinding,

transports and extrusion). Dismantling is getting more and more efficient, thus costs are reduced. Pre-shredding of bumpers was implemented in 1999, which means a reduction of transportation costs and the ability to supply more recycling companies (larger transport distances are possible to recyclers which can handle only shredded material). Recycling revenues depend on market prices, but when more recyclers can be supplied competition will be stimulated. When the recycling costs are lowered and the benefits increase the required fee can decrease as well: this is the case when better quality regranulate can be marketed for advanced applications.
It can be concluded that the expected growth in recycled amounts will positively contribute to the realisation of a more optimal recycling scheme in the future.

12.4 Legal, governmental aspects

In The Netherlands the government and the car recycling chain have an agreement to recycle 86% of all materials in wrecks in the year 2000 and to increase the recycling level even more in the following years. ARN will increase recycling targets to 95% in 2015 (with a minimum of 85% mechanical recycling and 10% thermal recycling). Bumpers are big parts that are easy to dismantle and recycle. Therefore they can contribute to the targets for mechanical recycling. In order to support several recycling activities, like the recycling of plastic bumpers, and to achieve increasing recycling amounts in the future the organisation ARN was established by the whole chain of car producers/importers and car recyclers.
The European Directive for ELVs , which took the Dutch agreement as a lead, also contains a recycling target of 95% in 2015. In consequence of this a further increase of bumper amounts to be processed is expected also on European scale. The automotive industry will support the extension of the bumper recycling activities.
A further support for the extension of recycling is that in several European countries landfill of combustible fractions will no longer be allowed in the future.

12.5 Social aspects

The original automotive recycling scheme was based on dismantling of wrecks and metal recycling. The sale of reusable parts has become through the years an increasingly important pillar for a more feasible economic structure of that business and both for economic (lowering of the amount of residual waste which only costs money) as well as legislative reasons the recycling of other materials has been added to the existing activities. This also holds for the mechanical recycling of specific plastic parts that became available upon the establishment of the required organisational structure.
In The Netherlands the actors in the automotive chain have organised the required institutional and administrative structure by the establishment of ARN. ARN was able to structure the whole practical system that can comply easily with the initial (2006) requirements of the European Directive, including the recycling of specific

plastic parts such as PP and PC bumpers. The ARN system is broadly accepted by the society.
The recycling of such plastic automotive parts is widely supported by the plastics production and recycling sector which may be illustrated by for example the joint-venture of BASF and Hoechst among others to set up a bumper recycling scheme in Germany.

12.6 Organisational aspects

With an optimised dismantling network the collection and sorting of the bumpers do not pose any problem. Also the grinding of the sorted bumper fractions is no problem as grinding of a wide variety of plastic products is common practice. Due to the relatively low current amounts of this higher grade plastic the extrusion capacity is concentrated at only some locations in Europe, which results in higher costs. When the amounts to be processed increase, the recycling costs will decrease. This might also be the case when different other end of life products (also from other sectors) made of a similar grade PP are processed together.
The presence of paint layers and the fact that different PP grades and compounds (for example PP+EPDM) are used for the production of bumpers can have a negative influence on the success of the recycling scheme (blocking factor). Removal of paint will become more important and also more cost effective when bigger quantities of painted material will be available in the coming years. Technologically these problems can be dealt with but as a result the process becomes more expensive.

12.7 Matrices progress/blocking factors and decisive criteria

An analysis of the different aspects (economic, legal, social and organisational) of the collection and recycling of automotive bumpers combined with a selection of relevant remarks made in the interviews or in the questionnaires results in a listing of the relevant progress and blocking factors. (See table A12.1.)

On basis of the information in the preceding paragraphs and the summary of the progress/blocking factors, the decisive criteria to set up a recycling scheme for automotive bumpers have been identified and weighted according to the procedure described in the main report. (See table A12.2.)

12.8 Eco-profile considerations

Generally speaking, the recycling of automotive bumpers can be regarded positively from an environmental point of view. Especially when high quality recycling takes place (substitution of virgin materials for instance in the automotive sector) and even

better when the product loop is closed by use of the recyclate in bumpers again. The application of secondary resources into new products results in a decrease of new resources and energy as well as of the amounts of emissions and waste. A well-organised collection system, feasible contamination levels and good outlets for the recycled material, they all together contribute to a positive environmental profile of the recycling scheme of automotive bumpers.
The results of a number of studies support this conclusion.

12.9 Conclusions

The overall picture of the progress/blocking factors (see table A12.1) and the overall score of the decisive criteria (see table A12.2, especially with regard to chain co-operation, participation of the disposers and available markets) is positive for this recycling scheme. A good co-operation between the automotive chain and the plastic sector organisation was established. The automotive chain has to financially support the collection and recycling activities.
The quality of the recyclate is good and there is a growing demand for the recyclate. The results of the eco-profile considerations show that also from an environmental point of view the recycling of automotive bumpers is a favourable option.

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Table A12.1 Progress / blocking factors for automotive bumpers recycling

Theme (aspects)	Progress factors	Blocking factors
Economic	• Levy (from consumers) to establish fund for fee to stimulate recycling and creation of new recycling routes • Supportive financing of the bumper recycling • With a fee recycling is less dependent of the market price of virgin plastics; however trading of the recyclates takes place on the basis of market prices	• High costs of the PP-recycling • High costs of dismantling • High costs for disposal of residues of plastic recycling
Legal, governmental	• EU directive for End of Life Vehicles (in prep.) as basis for national policy • Standards for application of recyclates and definitions of waste (to guarantee consistent qualities and to improve the image of recyclates) • Recycling targets in new products	• Incineration with energy recovery and gasification are stimulated as final disposal; landfill disposal is reduced
Social	• All parties of the “car-chain” are present in the End Of Life scheme of cars • Involvement of the automotive manufacturers based on the idea “service to our consumers” • Certification of all actor activities • (Dutch) recycling system is accepted by public	• Initiatives of automotive manufacturers are mainly “window dressing” • Essential differences between some countries, like UK, F and NL
Organisational	• Availability of dismantling capacity and technology • Availability of sufficient recycling capacity • Availability of market outlets for recyclates • Good quality control	• Many different plastic types (development towards less different types) • Painted bumpers • Availability of alternative disposal options • Recycling capacity is concentrated at only some locations in Europe

Table A12.2 Decisive criteria and scores for recycling scheme automotive bumpers

Decisive Criteria	Recycling Scheme specific scores	Overall score
1 Economic		
1.1 Price virgin plastics	+	
1.2 Quantity	+	
1.3 Number of disposers	o	**0 / +**
1.4 Contamination level	o / +	
1.5 Markets	+	
1.6 Substitution threat	+	
1.7 Recycling costs (incl. collection costs)	- / o	
2 Legal		
2.1 Laws / directives	+	
2.2 Governmental agreement	+	**+**
2.3 Trade obstacles	+	
2.4 Application norms	?	
3 Social		
3.1 Chain co-operation	o?	
3.2 Sector co-operation	+	**0 / +**
3.3 Participation disposers	+	
3.4 Society pressure	o	
3.5 Successful recycling stories	o / +	
4 Organisational		
4.1 Disposal system	+	
4.2 Take back logistics	+	**+**
4.3 Processing capacity	+	
4.4 Certification secondary products	o	

+ +	very positive
+	positive
o	neutral
-	negative
- -	very negative

13. Appendix: Catering plastics

13.1 Introduction

Catering plastics are only dealt with on a limited scale (both in the main report as well as in this appendices report) due to the heterogeneous character in composition: it includes both distribution films (covered by DCF collection schemes) and a highly contaminated mixture of small plastic items like PS cups and small trays, plastic cutlery and e.g. EPS take-away boxes. Further, the plastic waste mixture has a low share in the total catering waste stream (with a high paper and food content). If this plastic waste mixture could be separately collected it should be best compared with the mixed plastics fraction due to the fact that the contamination level is higher than for PS coffee cups. As for catering activities one should differentiate between catering services (canteens, party service) and fast-food shops; in the former category less and less disposable crockery and cutlery are used resulting in even lower quantities of plastic waste.

In The Netherlands the Association Environmental Management of Plastic Packaging (VMK) promotes the source collection of distribution films, coffee cups and pails/trays in the catering sector with the aim of mechanical recycling of these used products. The recycling of distribution films and coffee cups are running accepted schemes: see Appendices 3 and 7.
In The Netherlands McDonalds only recycles commercial/distribution films and Van Hecke (the largest industrial/institutional caterer) only recycles commercial and distribution films and coffee cups. There is no indication that other polystyrene products than cups are recycled nowadays.

In the UK the PS catering cups might be included in the Save-a-Cup scheme.

13.2 References

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14. Appendix: Table with key progress and blocking factors for mechanical recycling from TNO/Sofres study

Plastic waste segment	Main factors of progress	Main blocking factors
Films and pipes for agriculture	• Optimise the collection schemes and the location of recycling plants. Promote the development of « short circuits » including one or several collectors, one or several recyclers and a plastic manufacturer. • In general good quality material even though high contamination rate. • Communicate intake specifications to specific people involved in agri- and horticulture. • Find new outlets (or extend existing outlets) for the excess waste.	• Greenhouse film is frequently damaged by rain, acidity, sun (UV radiation). • PE films are thinner and thinner. Stronger influence of high contamination. • Geographical dispersion of waste: most farmers are far from existing municipal collection schemes. • Even if farmers collect plastic waste they prefer to burn it rather than sort it.
LDPE / LLDPE films and bags from the distribution and industry sector	• Develop technologies for the mechanical recycling of stretch film waste. • Outlets: – Carrier bags with recycled resin. Solve quality problems of colour, touch and image. Communicate that carrier bags are not in direct contact with food so recycling content is allowed. – Moulded products: geoblock, plaswood, recycled envelopes (alternative to paper), pallets for food distribution: high potential, drainage of used water and rain water, eco composters, stabilisation matrix for waste residues of class 1. – Focus on higher range of product quality wood or concrete instead replacement.	• Continuous decrease of film thickness. • Continuous decrease of the ratio shrink / stretch film.

Plastic waste segment	Main factors of progress	Main blocking factors
Distribution HDPE / PP crates, drums and boxes	• UN norms in 1999 will allow for recycling content of large containers. • High quality collection system for crates. • Promote wider usage of plastic pallets, every % market share stands for 50 ktonnes recycled or blended material. • Co-injection of recyclate in pails and co-extrusion in blow moulded containers to a certain extend possible.	• Impossible to make large drums (high molecular weight) with recycled resin. • Dedicated collection systems for industrial pails missing. • Cadmium content of old crates may hamper recycling. • Large share of secondary use of crates and boxes (in households, garden or garage) extends usage time and « prevents » availability for recycling
MSW trays, pails and cups (PS, PP, PE)	• PS and PP from dairy products can be recycled in high quality regranulates. • Wider application of use of recycled in middle layer of coffee cups.	• Closed loop outlets are extremely limited because of constraints due to hygiene, safety, norms. Mechanical properties: no blocking factor.
MSW / PET bottles	• Develop new outlets to absorb coloured PET waste streams: films/sheets for thermoformed products, deep moulding applications (flower and agriculture pots, blisters, trays, protection sheets, ...). • Promote wider acceptance of coloured PET in out of sight fibre applications. • Bottle to bottle recycling schemes. • Huge markets for compounds foreseen. • Adapt the selective collection systems in order to sort PET and PVC bottles directly at the collection strip. • Promote the development of identification systems for compressed PET and PVC bottles.	• Emergence of coloured PET bottles, particularly in Southern Europe (total share of coloured PET in European market 25 - 50%). There is currently no market for recycled coloured PET (except blue PET). • The decision to use recycled PET in beverage bottles is a political one. Technically it is possible.