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REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

ON THE TARGETS CONTAINED IN ARTICLE 7(2)(b) OF DIRECTIVE 2000/53/EC ON END-OF-LIFE VEHICLE

IMPACT ASSESSMENT

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TABLE OF CONTENTS

1. Procedural Issues and Consultation of Interested Parties 5
1.1 Legislative Requirements 5
1.2 Impact Assessment 6
1.3 Consultation and expertise 6
1.3.1 Stakeholder Working Group 6
1.3.2 Research Study on Benefits and Costs of 2015 Targets 6
1.3.3 Additional Consultation 6
2. Problem Definition 7
2.1 Background to the Problem Definition 7
2.1.1 Characteristics of the Waste Stream 7
2.1.2 Overview of Current Waste Management Practice 9
2.1.3 Existing Treatment and Disposal Routes of ASR 10
2.2 Definition of Problem Issue the Targets are set to Tackle 11
2.2.1 Barriers to Innovation in Treatment of ELVs 12
2.2.2 Potential Lack of Economic Efficiency of Existing Targets for 2015 14
2.3 Parties Affected 14
3. Objectives 15
3.1 EU Sustainable Development 15
3.2 Lisbon Strategy 16
3.3 European Union Resources and Waste Objectives 16
4. Policy Options 17
4.1. Differences between Policy Options due to Definitions 17
4.2 Other Options not Described in Detail Here 17
4.3 Linkage to Other Policy Measures 19
5. Analysis of Impacts 19
5.1 Discussion of Stakeholders Views 19
5.2 Analysis of Impacts in the Future 20
5.3 Scenarios for Future Technological Development 23

5.4 Innovation and Competitiveness - Other Policy Measures 24
5.5 Estimation of the Economic Effects of Different Targets 25
5.6 No Policy Change (85% recycling, 95% recovery) 26
5.6.1 Environmental Impacts 26
5.6.1.1 High Technology Development Scenario 26
5.6.1.2 Low Technology Development Scenario 27
5.6.2 Economic Impacts 28
5.6.2.1 Impacts on Costs in the Economy 28
5.6.2.2 Impacts on the Technology Export Potential of the EU 29
5.6.2.3 Economic Impacts on EU Vehicle Manufacturers 29
5.7 Reduced Recycling Targets (illustrated by 80% recycling and 95% recovery targets) 29
5.7.1 Environmental Impacts 30
5.7.2 Economic Impacts 31
5.7.2.1 Impacts on Direct Costs of ELV Treatment 31
5.7.2.2 Impacts on Competitiveness 31
5.8 Reduced Recovery (scenario 85% recycling and modified recovery target) 32
5.8.1 Environmental Impacts 32
5.8.2 Economic Impacts 33
5.9 Combinations of Different Reductions in Reuse/Recycling and Reuse/Recovery Targets (illustrated by 80% recycling and 85% recovery target) 33
5.9.1 Environmental Impacts 33
5.9.2 Economic Impacts 34
5.10 Administrative Burden of all Considered Policy Options 34
5.11 Social Impacts of all Considered Policy Options 34
6. Comparing the options 34
6.1 Environmental Impacts 34
6.2 Economic Impacts 35
6.3 Sensitivity Analysis 36
6.3.1 Factors Affecting Environmental Impacts 36
6.3.2 Factors Affecting Economic Impacts 37

7. Monitoring and Evaluation 38
8. Conclusions 39
8. ANNEXES 41

This Impact Assessment report describes the estimated effects of different targets for re-use, recycling and recovery of end-of-life vehicles from 2015. It describes why the Commission is considering these targets, the procedures that it has followed to inform assessment of impacts and the rationale behind the assessment.

The report compares different options, looking at the impacts that targets are likely to have on commercial practices in, and outside, the European Union and the environmental and economic effects that would result.

The assessment finds that policy which promotes innovation is most likely to lead to both significant environmental and economic benefits – with net benefits to all affected parties.

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1 Legislative Requirements

Article 7 of Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles[1] ("ELV Directive") contains a set of reuse, recycling and recovery targets[2]. According to Article 7(2), Member States shall take the necessary measures to ensure that the following targets are attained by economic operators for all end-of-life vehicles by an average weight per vehicle and year:

- 85% of reuse and recovery and 80% of reuse and recycling by 1 January 2006 ("2006 targets"),
- 95% of reuse and recovery and 85% of reuse and recycling by 1 January 2015 ("2015 targets").

The Directive states that by 31 December 2005 at the latest[3] the European Parliament and the Council shall re-examine the 2015 targets on the basis of a report of the Commission, accompanied by a proposal. In its report the Commission shall take into account the development of the material composition of vehicles and any other relevant environmental aspects related to vehicles.

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1 Directive 2000/53/EC, OJ L 269, 21.10.2000, p. 34.

2 Directive 2000/53/EC provides for the following definitions: Article 2(6) "***reuse***" means any operation by which components of end-of-life vehicles are used for the same purpose for which they were conceived; Article 2(7) "***recycling***" means the reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery. Energy recovery means the use of combustible waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat. Article 2(8) specifies that "***recovery***" means any of the applicable operations provided for in Annex IIB to Directive 75/442/EEC. Directive 75/442/EEC, currently under revision, defines recovery as "operations that result in waste serving a useful purpose in replacing, whether in the plant or in the wider economy, other resources which would have been used to fulfil that function, or in waste being prepared for such a use". Article 2(9) of the ELV Directive states that "***disposal***" means any of the applicable operations provided for in Annex IIA to Directive 75/442/EEC.

3 This date has been postponed by the Commission in order to gather more information on the subject and a better understanding of the possible impacts.

1.2 Impact Assessment

In line with the Commission's Better Regulation approach[4], the consideration of policy options has been developed through an impact assessment of alternatives. The information that has informed this assessment has been gathered from extensive and detailed formal and informal consultation of all interested stakeholders and a study by independent consultants. The decision on the appropriate targets has been based on this consideration of economic and environmental impacts. Environmental impacts are not monetised as, in this case, both economic and environmental impacts point in the same positive direction and monetisation would not help in examining the relative strength of different options. Social impacts were considered, but are broadly similar for each option.

The impact assessment has followed the Commission's guidelines.

1.3 Consultation and expertise

1.3.1 Stakeholder Working Group

The Commission established a Stakeholder Working Group composed of representatives of the vehicle industry (manufacturers, recyclers, materials and components producers), non-governmental organisations, representatives of governments and academia[5]. The Group worked for nine months, held three plenary meetings hosted by the Commission and several additional meetings on specific sub-topics. On the 4th November 2005, it produced a report containing its conclusions[6]. This impact assessment builds on the information provided, with the conclusions and assumptions of the stakeholders discussed in Section 5.1.

1.3.2 Research Study on Benefits and Costs of 2015 Targets

The Commission launched a study in the third quarter 2005 to gather information on the costs and benefits of 2015 ELV Directive targets for recycling, re-use and recovery. The final report was delivered to the Commission in May 2006[7]. The Commission invited all the interested parties to comment on the study to check or challenge its findings and to fill data gaps, receiving informative and helpful responses.

1.3.3 Additional Consultation

In addition, the Commission has directly consulted members of the waste and automobile industry, together with experts from Member States governments. A potential revision of the 2015 targets was initially discussed in the meeting of the Technical Adaptation Committee held on 16 November 2005, subsequently to which Member States' experts were invited to send their position to the Commission. The final detailed discussion of

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4 Communication from the European Commission to the European Parliament and the Council "Better Regulation for Growth and Jobs in the European Union", COM(2005) 97 final.

5 See Annex XX: List of Contributing Stakeholders.

6 The report of the Stakeholder Working Group is available at: http://ec.europa.eu/environment/waste/pdf/elv_final_report_051104.pdf

7 The GHK/BIOIS report is available at: http://ec.europa.eu/environment/waste/elv_study.htm

the targets took place in the meeting of 5 July 2006[8]. Prior to an official Inter Service Consultation, a draft of this Impact Assessment was subject to consultation between Commission's services.

2. PROBLEM DEFINITION

Summary The ELV Directive contains a set of targets for re-use, recycling and recovery of end-of-life vehicles for 2015 established to reduce the environmental impact from the expected 14 million tonnes of ELV waste generated per year at that time. These targets need to be set at an appropriate level to promote the best environmental, economic, and social outcome given blocks to innovation in treatment technology.

2.1 Background to the Problem Definition

2.1.1 Characteristics of the Waste Stream

The end-of-life vehicles (ELVs) from 2015 will mostly be vehicles produced around 2002-2003, which are on the road at the moment, together with more modern ELVs scrapped as a result of accidents. The typical life of a vehicle varies with the type of vehicle and the country in which it is being used. Based on information from GHK/BIOIS here we assume an average vehicle lifespan of 13 years, so that the largest proportion of ELVs in 2015 will be those cars sold in 2002.

The number of all cars in the EU15 increased by 17% between 1995 and 2002 and the number of light commercial vehicles by 28%, equivalent to combined compound annual growth of 2.4% over this period.

The average weight of vehicles covered by the ELV Directive is increasing, and the data as to the actual ELV weight differ. According to GHK/BIOIS, an average end-of-life vehicle weighs approx. 964 kg[9] and this weight is likely to increase to over 1,025 kg[10] by 2015. This weight was used in this Impact Assessment. However, weighted averages for all car manufacturers show higher weight of ELVs of approximately 1,280 kg by 2019[11], being an average weight of a vehicle put on the market in 2006 as reported in the certificates of conformity (i.e. 1,391 kg) minus the weight of a driver, tools and fuel. Using these figures for weight increases the magnitude of impacts in this assessment; for instance, there would be 17.6 m tonnes of arisings/year by 2019.

Based on the ELV weight of 1,025 kg, it is estimated that almost 14 million tonnes of ELV waste will have to be treated annually by 2015, compared to an estimated 10

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8 Summary Records from the meetings are available under the rules of access to documents specified in Regulation 1049/2001, OJ L 145, 31.05.2001, p. 43.

9 Source: GHK/BIOIS, p. 3, based on the consultants' estimates using average weight and material composition of newly built cars in Germany between 1981 and 2000.

10 The numbers depend on the model of a vehicle; hence some differences may occur.

11 Member States' reports for the monitoring of the average specific emissions of carbon dioxide from new passenger cars, based on figures provided by JAMA, KAMA, ACEA for 2006 vehicles. An average annual increase in car weight is assumed at 1.5% See: http://ec.europa.eu/environment/co2/co2_monitoring.htm.

million tonnes of EU25 ELV waste in 2005[12]. The increase of the waste volumes is due to the increase of the average weight of a vehicle and growth in ELV numbers. A quarter of this waste is currently classified as hazardous in some Member States.

Year	No ELVs Treated (000)	Average Weight (kg)	Weight ELVs Treated (000t)
2005	10,864	955	10,375
2006	11,124	964	10,724
2015	13,771	1,025	14,116

Table 1. Estimated weight of ELVs requiring treatment in the EU, GHK/BIOIS 2006.

Material/Component	**2003 ELV (% by weight)**	**2015 ELV (% by weight)**
Ferrous Metal	68%	66%
Non Ferrous Metal	8%	9%
Plastics and Process Polymers	10%	12%
Tyres	3%	3%
Glass	3%	2%
Batteries	1%	1%
Fluids	2%	2%
Textiles	1%	1%
Rubber	2%	2%
Other	2%	2%
Total	**100%**	**100%**

Table 2 Typical Composition of a 2003 ELV and a 2003 new vehicle (and therefore a 2015 ELV), by weight, UK, Source: TRL (2003) and stakeholder consultation.

Since 2015 ELVs are on the roads today, the material composition of 2015 ELV waste can be estimated from the information on the material composition of current vehicles[13].

Understanding of the composition of the plastics fraction is crucial for an assessment of treatment options and assessment of impacts. Many different polymers are used in cars which will become end-of-life vehicles in 2015. Out of all plastics used in cars, PP (polypropylene) has the greatest share of around 40%. Many parts are composites of different polymers, whilst within a class of a polymer (like polypropylene (PP)) parts may have different physical properties. Vehicle design is increasingly moving towards use of fewer polymers in vehicles, less use of PVC, greater use of PP and greater use of composite parts.

Impacts have been estimated by looking at impacts from treatment of a polypropylene part (an example of a PP/EPDM bumper was used), chosen because polypropylene is likely to be the polymer most recycled, and which has environmental impacts broadly representative of the impacts of most of the other polymers likely to be recycled.

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12 GHK estimate based on 2.4% growth in vehicle stock per year (see GHK/BIOIS 2006, Annex.2 p.9).This estimate would be influenced by increases in the significant flows of vehicles exported out of the Community as second hand vehicles before they reach their end-of-life phase.

13 Detailed analysis of changes in material composition can be found in Annex I, section 2.

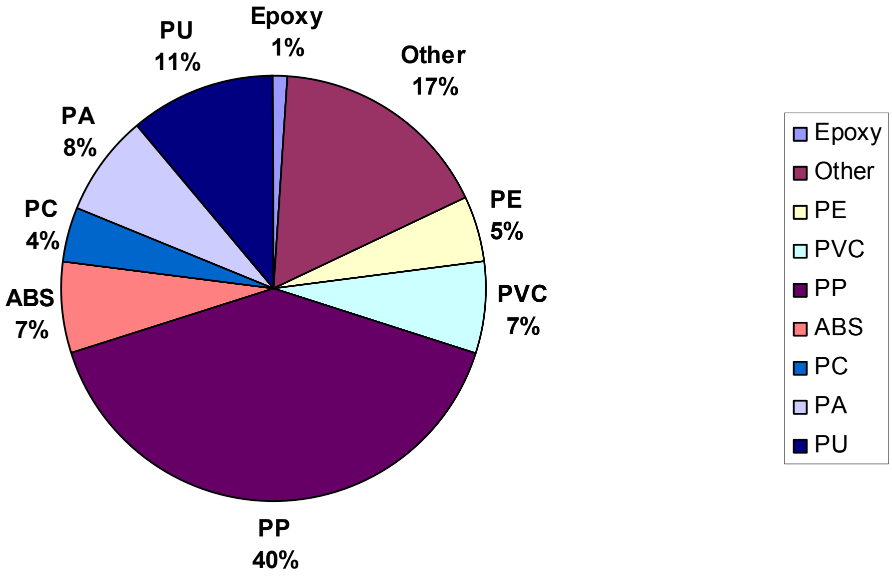

Diagram 1. Average content of plastics in a new vehicle (2001). Source: ACORD, CEP

2.1.2 Overview of Current Waste Management Practice

Directive 2000/53/EC requires that all end-of-life vehicles[14] in the EU are collected by authorised treatment facilities following a prescribed procedure[15] and are subsequently depolluted, dismantled, and treated.

After depollution (removal of hazardous parts and substances) and dismantling (removal of large parts for reuse and recycling), ELVs are shredded in order to recover the majority of the valuable metal. The material resulting from shredding contains heavy and light fractions which are further separated by their magnetic or density properties. The heavy fraction is mainly composed of ferrous metals. The light fraction contains non-ferrous metals and a combination of other residues such as plastics, foam, glass, textile fibres, and rubber. Non-ferrous metals are often separated from the rest of the light fraction, which is then typically landfilled[16].

Shredding is a capital intensive process undertaken by a limited number of companies in the EU. ELVs are shredded together with waste from electrical equipment (such as fridges and washing machines), because the use of an input of mixed materials is more

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[14] Vehicles reach their end-of-life phase either due to their age and wear or because they become waste prematurely as a result of an accident.

[15] Authorised treatment facilities need to obtain permits in order to start operation. They should be obliged to collect all ELVs free of charge from the last holder / owner and issue a certificate of destruction on the basis of which a vehicle can be deregistered.

[16] For detailed composition of ASR, see Annex XVII.

efficient for operators both technically and economically. The proportion of the light fraction coming from ELVs is approximately 50% by weight. For convenience, this is referred to in this assessment as auto shredder residue ("ASR"), but it is important to remember that residue coming from shredders is a mix of ELVs and waste from other goods, both of which are dealt with together[17].

2.1.3 Existing Treatment and Disposal Routes of ASR

According to PR Newswire, the waste market today is witnessing a shift in focus from direct disposal, which has typically relied on the use of low-cost methods such as landfill, to higher value pre-treatment methods. The enforcement of the Landfill Directive[18], which limits the use of landfill for the disposal of municipal solid waste, has resulted in greater demand for pre-treatment methods[19.] The implementation of the Directive has influenced national landfill policies which are now aiming to discourage landfilling as the environmentally and economically worst option of waste management, placed on the very bottom of the Community waste hierarchy. This can be done either through landfill bans (Germany) or through increasing landfill taxes (the Netherlands, Austria, Italy, Denmark, the UK) and result in an increase of landfill prices across the EU. Such trends are likely to occur in the new Member states as well.

ASR, which is a mix of pieces of plastics, fibre, rubber and some metals, can be treated in various ways. Today, ASR is mainly disposed of in landfills. There is very little use of incineration as a means of disposal, partly because of high gate fees and a limited capacity in countries like the UK or Germany[20]. Depending on the proportion of materials separated out, ASR accounts for around 25% of an ELV weight[21]. Thus, in 2005 between 1.5 and 2.5 million tonnes of ASR required disposal in EU25. This amount is estimated to be 3.5 million tonnes in 2015.

Recently, due to the development of treatment techniques triggered by the recovery and recycling requirements of the ELV Directive and national landfill policies, an increasing amount of ASR is being recovered. There are several potential routes of ASR recovery, including energy recovery in municipal waste incineration plants, energy recovery in cement kilns, and feedstock recovery (in blast furnace or during syngas production)[22].

The development of technologies to separate plastics from shredder residue is essential to the development of recycling of plastics from ELVs. Recently, several technologies - called post-shredder technologies (PSTs) as they treat waste after shredding - have also been developed in order to recycle and recover ASR.

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17 White goods can contain more copper than ELVs. They also contain PCBs which ELVs do not. Source: GHK/BIOIS 2006, Annex 3.

18 Council Directive 1999/31/EC, OJ L 182, 16.7.1999, p.1.

19 Strategic Analysis of the Western European Municipal Waste Management Services Market, PR Newswire, press release of 6 November 2006.

20 See GHK/BIOIS 2006, p. 10.

21 In this Impact Assessment, we take 25% to be the fraction based on the composition of vehicles, although the light shredder fraction (with mixed inputs) varies between 15 and 25%.

22 For more information see Annex I, section 3.

There are two main categories of PSTs. The first one is based on mechanical sorting of different waste fractions which can subsequently be recycled or recovered. The most advanced technique in this category is a density separation based on floating different materials in liquids of various density and their subsequent separation. The second option is based on thermal treatment of a waste stream to generate feedstock for energy generation.

Most of PSTs are still in their development phase, with some that operate on an industrial scale already today[23]. Some of these technologies are licensed to operators[24], others are developed and operated by the companies which own them[25]. Numerous technological institutes and progressive companies are experimenting with combinations of different techniques to produce purer plastics input streams. The potential to produce plastic recyclates from greater proportions of shredder waste depends on the success of efforts to improve waste separation, something itself dependent on the magnitude of those efforts. To date, technological progress in separation has been substantial, although investment in separation of material from shredder residue has been hindered by lack of certainty about demand and outputs.

A summary of current and developing plastics sorting technologies forms part of an ongoing Gaiker study[26].

2.2 Definition of Problem Issue the Targets are set to Tackle

It is estimated here that 14 million tonnes of ELV waste in 2015 will generate approx. 3.5 million tonnes of ASR per year[27]. It is necessary to appraise the environmental and economic impacts of the recovery and recycling of this ASR at the levels currently set for year 2015 and for lower levels. The 2015 targets should be confirmed or amended accordingly to the results of this analysis.

In order to meet the existing 2015 targets, recycling and recovery of plastics contained in shredder residue will be needed. The environmental performance of recycling and recovery of different plastics from ASR is also the key determinant of the environmental impacts of recycling and recovery targets.

Recycling and recovery of different polymers found in ASR has very different environmental effects and consideration of different present and potential treatment routes is necessary to determine impacts of different targets. Not all recycling of plastics

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23 These include Galloo, Sult, R-Plus, and Twin-Rec. For more information see GHK/BIOS report in Annex 3.

24 For instance VW-Sicon, TwinRec, Reshment. More details on these technologies can be found in GHK/BIOIS Annex 3 and in Annex I, section 3 to this IA.

25 For instance Citron, Galloo, Sult, R-Plus. More details on these technologies can be found in GHK/BIOIS Annex 3 and in Annex I, section 3 to this IA.

26 Annex 2 to the "Assessment of the environmental advantages and drawbacks of existing and emerging polymers recovery process", Project contracted with European Commission – Joint Research Center, Institute for Prospective Technology Studies to GAIKER, ongoing study to be published in 2007.

27 Around 6 million tonnes of shredder residue, including residue not derived from ELVs.

is environmentally beneficial, but becomes so only where the post-shredding sorting and recycling process creates less environmental impacts than are created by the process of making plastic from raw material. According to stakeholders, in order to meet the 2015 recycling target of 85%, as much as 50% of the non-metallic shredder residue fraction would need to find profitable new markets as recycled products28. This may well not be all plastics recycling.

This assessment is based on the assumptions on plastics recycling described in detail in Annex I, section 6.2. Current waste management practice in the disposal of ASR and development of technologies show that existing market forces on the waste industry will not lead to the best treatment of ELV waste for two reasons:

- The prices for treatment and disposal of shredder residue do not usually reflect the costs to society of treatment and disposal since businesses do not take into account environmental impacts of those methods. When firms choose treatment or disposal methods on the basis of what is financially best for them individually, it is often not the option that would bring greatest economic and environmental benefits to the EU. For example, ASR disposal to landfill can be financially the cheapest option at present.

- There are low levels of investment in new treatment technologies caused by uncertainties about the future market for products (in particular recyclates) and knowledge of existing techniques. Lack of knowledge of the most cost-efficient technologies slows diffusion of technology, in the same way that many firms do not adopt cost-efficient energy efficiency measures. These problems, detailed below, will lead to a lack of R&D in innovative techniques and diffusion of good techniques in ELV treatment.

If current practice continued, shredder residue would mostly go to landfill which would create **significant environmental problems** – approximately 3 million tonnes of landfilled shredder residue from ELVs per year in 2015 leading to increased emissions of 280,000 tonnes of CO_2 equivalent, significant energy losses, increased air acidification, photochemical oxidation, waster pollution and eutrophication, and increase of waste volumes disposed of in landfills. Landfilling of this waste would also represent a **loss to the EU economy** of approx. 2.5 million tonnes of high-calorific waste per year (including streams of recyclable materials) which could replace imports of energy and raw materials.

2.2.1 Barriers to Innovation in Treatment of ELVs

Innovation in technological development of processing shredder residues is held back by several market failures, some common to industrial innovation as a whole, some relating

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[28] This statement is made with the assumption that 75% by weight of ELVs are metals, 5% by weight of ELVs can be disposed of in landfills, 20% of the ELV is the non-metallic rest waste fraction. Stakeholder Working Group, Final Report, p. 13, http://ec.europa.eu/environment/waste/elv_index.htm

to eco-innovation, and some specific to the post-shredder and plastics recyclate markets. These lead to a lack of investment and diffusion of advantageous technologies in the EU.

- Diffusion of latest technologies is slow, despite being economically advantageous for all parties (this is comparable to similar problems to uptake of energy efficiency improvements). In some cases, this is due to the lack of information exchange, restricted knowledge of opportunities, or lack of incentives at firm level for individuals to push for innovation.

- In many firms, there is unwillingness to take-up known innovative technology until it has been widely proved to be commercial. This leaves few market opportunities for technology to be proved commercially and, as a result, it may never be proved. Here, rational behaviour by individual firms (each looking after their individual risk) does not lead to the best outcome for the market as a whole (a market failure).

In a related problem, new technologies can create new markets by producing new products that have market value. However, as no proven market will exist until the products have been produced, firms are often unwilling to invest until others have done so and proved the market (so the potential market may never be realised). This circularity also hinders uptake of technology by individual firms. This cause of reduced demand is one of the problems which holds back investment in research and development for post-shredder technologies for sorting and recycling of ELV waste. The others, one of these is a knock on effect:

- Knowledge of the threat of lack of demand for technology (from the above market failures in the technology market) greatly reduces the potential returns on R&D investment whilst at the same time increases the risks. This has lead to sub-optimal investment levels in R&D for post-shredder technologies.

- The risks for individual technological R&D are higher than the risks to society from developing technologies in a particular direction. Firms face the risk both of their individual technology failing and of their technology succeeding but being less competitive than competing technologies. Society as a whole faces a much lower risk that all potential technologies fail. Firms, facing higher risk, invest in R&D at lower levels than society as a whole would invest – a market failure affecting development of post-shredder technologies.

- One of the most likely sources of capital investment in post-shredder technologies are the existing shredder operators. Yet, many of the shredder operators do not include plastics recycling in their main business. Faced with an unknown area of business, they have less incentive to research the market opportunities and therefore little incentive to innovate to sell products into a market they don't know. This restricts capital investment. The same is true of current institutional investment funds.

- Levels of R&D and investment in eco-technologies, like recycling technologies, are particularly likely to be at sub-optimal levels. The environmental benefits that the technology brings benefit society as a whole, but are unlikely to bring additional financial returns to the developers and users of the eco-technologies. Even in a perfect market, firms would only invest at a level that reflected their own financial returns – a level of investment below the appropriate level for society.

2.2.2 Potential Lack of Economic Efficiency of Existing Targets for 2015

Stakeholders have expressed concerns that changes in vehicle composition create challenges for the currently specified 2015 recycling and recovery rates[29]. If technological progress were to halt, current commercial practices do not allow for profitable recycling and recovery at the 85%, 95% levels stated in the ELV Directive.

2.3 Parties Affected

It is estimated that in 2004 there were on average 472 passenger cars per 1,000 inhabitants in EU25, with a span ranging from 659 cars in Luxembourg to 280 cars in Hungary[30]. 74% of all vehicles put on the EU25 market were marketed in 5 Member States: 20% on the German market, Italy (16%), France (15%), UK (13%) and Spain (10%). ELV waste in 2015 is likely to be greatest in these Member States, although a growing trade in second-hand vehicles will divert some of the need for ELV treatment to new Member States (also Bulgaria and Romania as of 1 January 2007). This will bring about a large % increases in ELV arisings in the eastern EU Member States[31]. Overall, it is expected that because of an average old age of the car fleet in the new Member States, these countries will face a challenge of an increased amount of ELV deregistrations and their treatment. In 2004, 74% of all passenger cars registered in the Czech Republic were over 10 years old[32], while in Ireland it was only 13.8%. These trends are already reflected in investments made in new Member States to tackle the increase of ELV waste: for example Recycling Technologies, a subsidiary of Spanish engineering firm Equip Tecnic Santandreu, is building a €4.5m car shredding site in Hungary. The site, which will open in 2007, is claimed as the largest in central Europe. It will have a capacity of up to 30,000 cars a year, and recycle 20-30,000 tonnes of scrap metal[33].

The practice of ELV treatment in connection with the legal requirements has lead to the establishment of a system of economic operators involved in the management of this waste stream. The parties which are involved in this policy area and affected by the ELV Directive include stakeholders involved in vehicle manufacturing, sales, collection, depollution and dismantling, recycling and recovery, in particular:

– Consumers,

– ELV collectors, dismantlers, shredders, recyclers, and other businesses involved in waste management,

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29 Auto-Recycling Netherlands, Dutch ELV recycling scheme which currently achieves the highest recovery and recycling rates in the EU estimates that rates of recycling and recovery will fall after 2006 due to increased proportion of plastics and other non-metallic materials in cars, unless new methods of recycling and recovery are found. Source: GHK/BIOS.

30 Source: EUROSTAT at: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NZ-06-009/EN/KS-NZ-06-009-EN.PDF.

31 GHK/BIOIS 2006, Annex 2 and case studies.

32 Source from EUROSTAT at: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NZ-06-009/EN/KS-NZ-06-009-EN.PDF.

33 Source: ENDS Daily 2189 of 20.10.2006.

– Users of raw materials that can be substituted, e.g. steel and cement makers,

– Waste and recycling technology firms, mainly SMEs,

– Vehicle Manufacturers and producers of raw materials used in vehicle manufacture (metals, aluminium, plastics, rubber, textiles etc.),

– National or regional authorities.

3. OBJECTIVES

Summary To set appropriate reuse, recycling and recovery targets for ELVs from 2015 onwards that will maximise the net environmental and economic benefits of treatment of ELV waste, making best use of the EU's potential for innovation.

The 2015 targets should be set to meet the ELV policy objectives below. In this way, specific objectives for 2015 ELV Directive targets should:

- **reduce the disposal of ELV waste,**
- **improve the environmental performance of the treatment of ELV waste,**
- **promote innovation in waste management technologies**

in ways which balance positive economic, environmental and social impacts against negative impacts.

3.1 EU Sustainable Development

The **EU Sustainable Development Strategy**[34], aims at meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. The Strategy identifies 7 key ways to ensure sustainable development, including an increase of the EU's global market share in the field of environmental technologies and eco-innovations. To this end, the Commission and the Member States are engaged in a dialogue with business and relevant stakeholders aiming at setting environmental and social performance targets for products and processes and to promote and disseminate eco-innovations and environmental technologies.

The Strategy calls for improving resource efficiency to reduce the overall use of non renewable natural resources and the related environmental impacts of raw materials use, thereby using renewable natural resources at a rate that does not exceed their regeneration capacity. In particular, it aims at avoiding the generation of waste and enhancing efficient use of natural resources by applying the concept of life-cycle thinking and promoting reuse and recycling.

[34] Review of the EU Sustainable Development Strategy (EU SDS) - Renewed Strategy. Version as agreed by the Heads of State on 15/16 June 2006.

3.2 Lisbon Strategy

The Lisbon strategy (or the **Strategy for Growth and Jobs**) is one of the European Union's top political goals. The "Integrated Guidelines for Growth and Jobs for 2005 – 2008"[35] addressed to Member States and the European Commission recommend actions aiming to raise the welfare of European citizens, notably through addressing growth performance and insufficient job creation. The micro-economic guidelines place particular importance on policies to boost Research and Development and to promote diffusion of innovation. Guideline 11 focuses on encouraging the sustainable use of resources and strengthening the synergies between environmental protection and growth, particularly through the spread of eco-efficient technologies.

3.3 European Union Resources and Waste Objectives

The key environmental objectives for the European Community are laid down in the Sixth Community Environment Action Programme (6EAP) which sets out a framework of goals and actions for ten years starting from 22 July 2002[36]. The objectives of the 6EAP in the field of the sustainable use and management of natural resources and wastes include *"increasing drastically resource and energy efficiency; a significant reduction in the quantity of waste going to disposal and the volumes of hazardous waste produced, while avoiding an increase of emissions to air, water and soil; encouraging re-use for wastes that are still generated (...); preference (...) to recovery and especially recycling",* and minimisation of the quantity of waste going to disposal. This programme forms one of the underlying drivers for the revision of the 2015 targets of the ELV Directive.

According to the Thematic Strategy on the sustainable use of natural resources[37], European economies depend on natural resources, including raw materials. These resources are crucial to the functioning of the economy and to our quality of life, and their efficient use contributes to growth and is a key of long-term prosperity. Although Europe has improved its material efficiency over the past 20 years, the need to reduce the negative environmental impacts generated by the use of natural resources and, at the same time, improve resource productivity across the EU economy, remain a major challenge. This challenge is also addressed by this policy measure.

Waste treatment in the EU is governed by a concept known as waste hierarchy, according to which preference should be given to waste prevention, followed by reuse, recycling, energy recovery, and - if none of these options can be used - disposal. Recently adopted Thematic Strategy on waste prevention and recycling[38] reiterates this hierarchy and states that waste policy should have a purpose of contributing to reducing the environmental impacts associated to resource use. It underlines that landfill is the worst waste management option which should be avoided because it accounts for lost resources and potential environmental liability in the future. The Strategy points out that the goal

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[35] Integrated Guidelines for growth and jobs (2005 – 2008), COM(2005) 141 final.
[36] OJ L 242, 10.9.2002, p. 1.
[37] Thematic Strategy on the sustainable use of natural resources, COM(2005) 670 final.
[38] COM(2005) 666 final.

should always be to move up the hierarchy if environmentally and economically feasible with an objective to make Europe *a recycling society*. In order to achieve these aims, the Strategy calls for encouraging recycling.

The Waste Strategy introduces life-cycle thinking in waste policies, which allows defining environmental impacts on all levels of resource use: "from cradle to grave", which has strong implications also for this impact assessment.

4. POLICY OPTIONS

This IA report evaluates a range of options for the 2015 targets, using examples of targets as illustrations:

Policy Option	Illustration	
	Recycling	Recovery
No Policy Change **(baseline scenario)**	85%	95%
Reduced Recycling Target	80%	95%
Reduced Recovery Target	85%	90%*
Combination of different reductions in reduced Recycling and Recovery Targets	80%*	85%*

* an example of a possible target

The analysis shows that the impacts of reductions in the two targets are additive, so that combined targets of e.g. 80% reuse/recycling and 85% reuse/recovery can be considered by combining the analysis of a reduction to 80% reuse/recycling with the impact of a reduction in the reuse/recovery target to 85%.

The targets have been chosen at 5% intervals, which serves to illustrate the direction of changes in impacts resulting from changes in the targets.

4.1. Differences between Policy Options due to Definitions

The difference between the policy options is the need for diversion of fractions of the ASR between various treatment and disposal routes. Recycling is defined in the ELV Directive (Article 2) as "the reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery. Energy recovery means the use of combustible waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat".

Certain treatment processes for ASR clearly fall under either recycling or recovery, whilst others are less obviously described. For the purposes of this IA report, use of shredder fibres in treatment of sewage sludge is classed as recycling, whilst use of treated ASR in blast furnaces is classed as recovery.

4.2 Other Options not Described in Detail Here

Different ways in which the targets contained in the ELV Directive could be approached have been identified by stakeholders. These ways ranged from the complete removal of any targets, a removal of one of the targets, adopting a combination of material based targets, moving to a landfill ban (allowing 5% of ASR to go to landfills), introduction of a set of process standards for recovery and recycling of ASR or a combination of options. Not all these options have been discussed in detail in this impact assessment report for several reasons.

Firstly, the impacts of removal of one or both of the targets can be seen from the assessment presented here – as reductions in targets to levels below what would be achieved anyway by existing market practice. The Commission has based its assessment on life-cycle analyses of various treatment options for plastic parts of vehicles conducted by the Fraunhofer Institute (2002)[39] and APME[40]. These analyses show significant environmental benefits from plastics recycling and recovery, particularly obvious when ELV materials are sorted and treated appropriately by fraction. The assessment of reductions in targets is sufficient to indicate that removal of the targets or an introduction of a landfill ban (allowing 5% of ASR to go to landfills) would be significantly worse than the reductions considered. Landfill bans and landfill reduction targets have a similar effect as recycling targets in redirecting waste streams. However, they need to be seen in relation to which waste management option could possibly be used subsequently to achieve the greatest environmental benefit. Recycling targets cannot be simply replaced by landfill bans and landfill reduction targets if this would result in an increase of incineration at the detriment of recycling and the overall environmental benefits of the Directive.

Secondly, as regards an introduction of a combination of material based targets or of a set of process standards for recovery and recycling, these options were indicated by the stakeholders but have not been considered by them in detail. Introduction of material based target would need to be considered in a much broader scope of all product specific directives, including in particular waste electric equipment which is treated together with ELV waste, but also other waste streams. This would extend the impact assessment to questions of approach to treatment of waste in general. As regards the process standards to be introduced instead of the targets, this option suggested by the stakeholders was too vague and undefined to make it suitable for consideration here, raising in particular such questions as who would carry out the assessment, under which criteria, and how to guarantee transparency of the process and avoid hindering of innovativeness.

Finally**,** changes to the form of the policy instrument in the ELV Directive such as complete removal of targets or introducing process standards are outside the scope of the assessment as the discussion on the type of instrument was finalised with the adoption of the ELV Directive that selected binding recycling and recovery targets as appropriate instruments. Significant change to the ELV Directive that is currently being implemented by the Member States and industry would also reduce regulatory stability, potentially damaging legislative credibility after industry has made investments towards meeting 2006 targets.

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[39] *Verwertung von Kunststoffbauteilen aus Altautos – Analyse des Umwelteffekte nach dem LCA-Prinzip und ökonomische Analyse*, Fraunhofer Institut für Verfahrenstechnik und Verpackung (Till Nurrenbach, Dr. Gertraud Godhan, Alexandra Woköck, May 2002.

[40] Recovery Options for Plastic Parts from End-of-Life Vehicles: and Eco-Efficiency Assessment. Öko-Institut e.V. Darmstadt, 2003.

4.3 Linkage to Other Policy Measures

The selection of targets does not stand alone as a policy instrument to tackle the blocks to innovation affecting development of ELV treatment technology. In analysing the impacts of targets, consideration is given to the strong linkage between the results of the targets and other complementary policy instruments, particularly in those that promote investment into R&D for innovation in waste treatment, including those mentioned below in section 5.4.

5. ANALYSIS OF IMPACTS

Summary

- Assessment of the impacts of different policy options indicates a wide range of substantial impacts on both the environment and the EU economy, with an indicative maximum economic difference in processing costs between options of €16bn over a 10 year period from 2015.
- The stakeholders directly affected by difference in the options are the EU waste management industry, suppliers of waste technology and, potentially, consumers. Impacts on the automotive industry are estimated to be insignificant.
- Differences in impacts between options are significant, but relatively small in the general waste context:
  - waste generated by ELVs constitutes less than 0.7% of the total amount of waste generated in the EU annually[41], with ASR representing between 3 and 4% of all hazardous waste generated in the EU;
  - changes in costs per vehicle represent around 0.3% of the life cycle economic cost of a vehicle;
  - even extreme assumptions show ELV treatment accounts for a maximum of 3% of the environmental life cycle impacts of a vehicle[42].

5.1 Discussion of Stakeholders Views

The Commission has welcomed the views of stakeholders on the impacts of target levels, many of which have been crucial to building the analysis of impacts. Stakeholder

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41 Waste generation in the EU is estimated at more than 1.3 billion tones per year. This includes waste from manufacturing (427 million tonnes), from energy production and water supply (127 million tonnes), from the construction sector (510 million tonnes), and municipal waste (241 million tonnes). In addition significant amounts of waste for which good estimate are not available are produced by agriculture, forestry, fishery, mining, quarrying, and the service and public sectors. .Source: Waste Generation and Treatment in Europe, Eurostat, 2005.

42 LIRECAR 2003, p. 3.

conclusions about the impacts of the targets differ and the reasons for this are discussed in Annex 2. Three important views are taken here:

View 1: Achievement of 85% recycling 95% recovery targets makes an insignificant difference in terms of the life-cycle impact of a vehicle. The Commission agrees that the impact is a small proportion of the life cycle impact of a vehicle. Yet, when applied across the EU ELV waste arisings, the environmental benefits are substantial, whilst still small in proportion to the total impact of vehicles. The economic benefits are similarly substantial, but small in relation to the total lifetime expenditure on personal road transport in the EU.

View 2: Achievement of 85% recycling targets will be environmentally disadvantageous as changes to vehicle design to achieve recycling reduce the lifetime environmental performance of vehicles. To date, the targets for treatment of ELVs have not led to design changes in vehicles which affect the weight or environmental performance of vehicles, and with 2015 ELVs having been mainly designed before 2001, no changes to future car design arising from a 2015+ 85% target can be expected. Recent increases in designed weight of vehicles are mainly due to consumer preferences and resulting market incentives for auto-manufacturers as well as safety requirements.

View 3: Achievement of 85% recycling will negatively affect the competitiveness of EU industry, in particular auto-manufactures. Since the targets apply equally to all ELVs in the EU, the EU manufacturers could not in any event be disadvantaged by recycling and recovery target levels in ways that non-EU competitors were not, even where targets imposed costs, which will not be the case. In fact, the economic benefits of slightly reduced material prices in the EU market could be available to firms manufacturing in the EU, where EU vehicle manufacturers are dominant.

5.2 Analysis of Impacts in the Future

It would be misleading to analyse the achievement of the 2015 targets on the basis of current practices and technology because there are clear tendencies towards a larger deployment of new waste treatment technologies in the future (see Annex XVIII). Therefore, the question asked here is not what the impacts of targets would be if they were applied now, but what the impacts will be if the targets are set now and apply in 9 years time. This affects the analysis in two ways:

A) practices, markets, technology in use will all have changed by 2015,

B) choice of options will – and is intended to – bring about changes in practices and technology by 2015.

This analysis must necessarily make predictions of practices and technology in 2015 and for the years afterwards. Views on practices and technology during that period must be based on the situation in 2006 and in the analysis these practices are the starting points for predictions.

This summary of effects and impacts is described in more detail in Annex I, together with the reasoning and assumptions behind the assessment. In summary, it is expected that by 2015 and under different targets (scenarios) the following shares of materials will go for different treatment routes:

Materials and Treatment Options	% for each scenario				
	No Policy Change (High Tech)	No Policy Change (Low Tech)	80% recycling, 95% recovery	85% recycling, 90% recovery	80% recycling, 85% recovery
Recycling					
Ferrous metals	**66%**	**66%**	**66%**	**66%**	**66%**
Non-ferrous metals	**9%**	**9%**	**9%**	**9%**	**9%**
Fluids	**1%**	**1%**	**1%**	**1%**	**1%**
Tyres	**2%**	**2%**	**1%**	**1%**	**1%**
Batteries	**1%**	**1%**	**1%**	**1%**	**1%**
Plastics	**7%**	**2%**	**2%**	**7%**	**2%**
Shredder sand (glass, road dust, rust, etc)	**4%**	**4%**	**0%**	**4%**	**0%**
Recovery					
Fluids	**1%**	**1%**	**1%**	**1%**	**1%**
Tyres	**1%**	**1%**	**2%**	**2%**	**1-2%**
Plastics	**5%**	**10%**	**10%**	**0-5%**	**0-10%**
Other residues (textiles, rubber)	**2%**	**2%**	**2%**	**2%**	**2%**
Landfill					
Other residues from shredder sand (glass, road dust, rust, etc)	**1%**	**1%**	**5%**	**1%**	**5%**
Plastics	**0%**	**0%**	**0%**	**0-5%**	**0-5%**

Table 3 Shares of materials going for different treatment routes under different targets and scenarios.

For each of the options considered, recycling possibilities of plastics will play a key role. Technology exists and is being used commercially to produce plastics recyclates from waste to a standard that meets some market demands. In order to recycle plastics for more than the most basic uses, it is necessary to have pure inputs of waste. In this respect, the development of technology to separate plastics from shredder residue is essential to the development of recycling of plastics from ELVs.

At the moment, with the most advanced post-shredder separation techniques used in industrial operations, 15-25% of shredder residue will go to a plastics mix fraction that is sent for recycling, depending on the specification of the plastics mix. Thus, plastics representing 7% of the ELV by weight would go to recycling operators.

From this fraction, currently only parts of the PE and PP and ABS/HIPS fractions are sometimes used for recycling, with up to 2% of the ELV by weight becoming recyclates. Where the current maximum of polymers (PE, PP and ABS/HIPS) is used this proportion might reach 4%, though this is not currently done.

Developments in separation technology in the period up to 2015 would allow greater extraction of a greater range of polymers and in turn lead to a greater proportion of ELV plastics made into recyclates. The increase in the proportion depends on technological developments and is not possible to predict with any certainty.

The market demand for recycled polymer material depends on the properties of this material. Today, demand exists for any plastic recyclates that can be used to substitute for virgin plastic in a way that allows the resulting plastic part to meet the properties required, as recyclates are typically cheaper than virgin material. The recyclate price lies below the price of virgin material and is an incentive for manufacturers to use the recyclate.

Closed-loop recycling for vehicle applications is not easy and is often done in parts that are not seen by the car-user. Today, an increasing number of car manufacturers incorporate recycled components into their vehicles, however the use of recycled plastics is hindered by plastics manufacturers who are unwilling to undermine their virgin plastic market by developing use of recyclates. The specifications of plastics used in modern cars means that closed-loop recycling of ELV plastics is unlikely to reach more than a low percentage of plastics recycled from ELVs.

5.3 Scenarios for Future Technological Development

R&D investment is very likely to result in further commercial development of the existing technologies or the development of new treatment technologies. To reflect the possible range of resulting effects, the Commission has assessed the impacts in a scenario of the High Technological Development and of the Low Technological Development, based on information described in section 4 of Annex I. These scenarios show the ends of the range of impacts, with the actual impact lying somewhere in between

Under the **High Technological Development Scenario**, around half the plastics in ELVs would be able to by recycled from 2015 onwards (a large proportion of PP, some PE, ABS/HIPS and some PA), a greater proportion of tyres would be recycled and much of the shredder sand fraction could be made inert and used in construction (see table on p. 20).

This scenario is based on an assumption that between 2006 and 2015 technological progress allows greater separation of material fractions (in particular, a polymer recyclate of a high degree of purity from part of some major groups of ELV plastics: PP, PS, PE and PA) within ASR and greater use of the material and energy contained in ASR. This would allow 70kg of plastics (out of 130kg) to be recycled. To bring about this additional technological change would require policies that stimulate both R&D in new technologies and an uptake of technologies.

This scenario would achieve reuse and recycling of 90% of ELVs, with the potential (not shown in the table above) of higher recycling if the use of shredder fibre as a dewatering agent for sewage sludge takes places and is included as recycling. This may provide a use for around 7% of the ELV, comprising plastics, remaining tyres, textiles and rubber. However, under an 85% target, recovery may be a more financially attractive option for this fraction.

Under the **Low Technological Development Scenario**, a significantly smaller proportion of ELV plastics would be recycled, a proportion of tyres, and either the majority of shredder sand or the fibrous fraction of ASR would be recycled (see table on p. 20).

It is possible that the fibrous fraction of ASR, which would be made up of around 5% of plastics with textiles and rubber, is recycled to meet the 85% target instead of shredder sand.

5.4 Innovation and Competitiveness - Other Policy Measures

Whilst the level of targets has an impact on the incentives for innovation in waste treatment, it will not affect all the blocks to innovation. Other existing and planned policy instruments can tackle some of those blocks. The impacts from setting the levels of particular targets will be influenced by the effect of these other policy measures.

Many of these solutions could be addressed and further developed with European projects and initiatives under the Competitiveness and Innovation Framework programme, a flexible programme which could be partly directed to tackle the issues of shredder residue treatment. Moreover, Members States should be encouraged to implement the Community strategic guidelines on cohesion by using funding earmarked for eco-innovation under the European Regional Development Fund, the Cohesion Fund to further the promotion and uptake of advanced shredder technologies. However, financial assistance from these funds is only possible provided it is given according to the objectives, rules and procedures applicable to these funds respects the *polluter pays* principle. Moreover, the upcoming 7th Research Framework Programme has a clear priority research in the area of life strategies for vehicles, vessels and infrastructures.

To support the diffusion of high technology shredder residue solutions, efforts could be made to raise awareness and support the uptake of technologies among the shredder industry, to educate all players involved (businesses, procurers, investors, national and regional authorities, etc.) about the possibilities that these new technologies offer as well as create incentives for the use of high technology recycling and recovery by shredders. The measures could include:

– Pro-active promotion of innovative shredder technologies and plastic recycling,

– Programmes that professionally accompany the technology transfer process (patenting, licensing, market analysis, market introduction, financing, etc.),

– Promotional and educational activities towards public and private procurers (shredder and recycling technologies) encouraging the uptake of innovative technologies.

At the same time, it would be necessary to facilitate access to finance by, for instance, addressing investors which are specialising in the area of eco-innovation / environmental technologies in a special financing programme and informing them about the opportunities that new technologies offer, thus facilitating investment decisions in this area. Moreover, the Competitiveness and Innovation Programmes (CIP) of the European Commission foresees considerable funds for investments in eco-innovative technologies and businesses. This funding could be used to set up a special fund focusing, for example, on recycling industries and technologies.

5.5 Estimation of the Economic Effects of Different Targets

This Impact Assessment has examined the economic impacts by looking at the total value and cost generated across the ELV disposal chain in 2015 from deregistration to disposal, identifying which parties gain or bear cost.

The value of an ELV is made up of the value of ferrous metal for recycling (a % of the value of the recycled metal), the value of non-ferrous metals for recycling (a % of the value of the recycled metal), the value of the recycled plastics, the value/cost of the final use/disposal of the mineral fraction, and the value/cost of use/disposal of the fibrous shredder light fraction and un-recycled plastics.

Out of this net value, there are certain costs of the processes steps, including the cost of shredding, of advanced post-shredder sorting and separation, of processing high plastic fractions into plastic recyclates, transport costs (of an ELV going to shredder and of shredder fractions going to next use/disposal), depollution costs, and – possibly - dismantling costs.

The difference between the values and the costs is shared between the price paid to the last owner/supplier of the ELV, and the profit taken by the dismantler, shredder, plastics recycler, and the receiver of fractions for final disposal (e.g. landfill owner or cement kiln operator). In a market economy, the net value of the ELV would be expected to be spread between these parties, though market pressure may give one of the parties/firms a strong position to be able to extract most of the benefits.

It is clear that the net economic benefit of the treatment of ELVs will depend on the price of metals, the costs of processing, and the value of recycled plastics. Note that there will be no costs for automobile manufacturers, whose liability depends on the legislative regime in the Member State, but who in many Member States currently have no legal financial liability for the costs of ELV treatment, even if those are negative.

The details of the calculations based on the above value and costs chain are described in section 8.2 of Annex I.

5.6 No Policy Change (85% recycling, 95% recovery)

Effects

The 85% and 95% targets will reduce some of the existing blocks to research and development in waste treatment technologies, and in diffusion of those technologies. An 85% recycling target creates certain markets for both advanced post-shredder technologies and advanced polymer recycling technologies. This will substantially increase R&D investment in new technologies by reducing the risks that lead to sub-optimal investment in R&D. Keeping the current 2015 targets gives seven years for R&D and two years for commercial installation of the technologies to meet the targets.

The result will be technological development that is higher than the low technological development scenario, but how much higher depends on the success of increased R&D in promoting innovation. Where complementary policy measures – of the kind suggested in section 5.4 above – are applied, the impacts of targets are more likely to be close to the High Technological Development Scenario, which forms the upper bound of likely progress.

Even if there was no further technology development, 85% recycling target would boost the diffusion of the existing most efficient technologies.

The assessment of impacts below looks at the impacts at the two ends of the ranges.

5.6.1 Environmental Impacts

5.6.1.1 High Technology Development Scenario

- Recycling of Plastics

The environmental benefits of plastics recycling depend on the balance between the negative environmental impact of the plastics recycling process and the avoided impacts from production of the material replaced by the recycled plastics. If the recycled plastic product has significantly different physical performance characteristics, it might have additional environmental impacts. Negative environmental impacts may also come from the additional activities required to separate plastics from other materials and any difference in the transport of plastics to recycling facilities compared to transport to recovery or landfill facilities.

The different polymers in ELVs have different characteristics which affect the impacts from the recycling process. Numerous studies on the treatment of ELV plastics indicate that the benefits of plastics recycling as compared to recovery are not always environmentally clear. The evidence on individual polymers is clearer. The use of a recyclate depends on its physical characteristics and therefore on its purity. When the impacts of recycling into granulates are discussed in this impact assessment, it refers to the recycling of sorted polymers into recyclate. Only part of the plastics in an ELV would be able to be treated in this way, even under the highest technological scenario considered.

Key environmental benefits come from the recycling of the plastic fraction representing 7% of ELV by weight. For the EU, this would represent recycling of around 988,000 tonnes[43] of plastics per year and:

– estimated environmental benefit of saving 980,000 tonnes of CO_2 equivalent a year[44], or approx. 10 m tonnes of CO_2 equivalent over 10 years[45], compared with manufacturing of virgin plastic.

– substantial environmental benefits from reductions in photochemical oxidation, air acidification, water pollution, water eutrophication and reductions in waste generated[46.]

It should be noted that these figures relate to polyolefins (example of a PP/EPDM bumper) and can change for other resins.

- Recycling of shredder sand and tyres

This option would neither generate significant environmental benefit nor significant environmental costs, indicating that it would result in a small increase in CO_2 emissions.

- Recovery

Increased recovery could bring about a reduction of over 200,000 tonnes of CO_2 equivalent[47] per year mainly from the substitution of other fuels[48].

5.6.1.2 Low Technology Development Scenario

- Plastics Recycling

Significant environmental benefits are generated by the recycling of 2% of the plastics:

– savings of 280,000 tonnes of CO_2 equivalent[49] per year or approx. 3 m tonnes[50] over 10 years,

– correspondingly smaller, but still substantial environmental benefits from reductions in photochemical oxidation, air acidification, water pollution, water eutrophication and reductions in waste generated.

- Recycling of Shredder Sand and Tyres

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43 1,234,000 tonnes for 1,280 kg ELVs.
44 1,220,000 tonnes for 1,280 kg ELVs.
45 12 million tonnes for 1,280 kg ELVs.
46 For details, see Annex XIII.
47 280,000 tonnes for 1,280 kg ELVs.
48 Details underlying the calculation of this impact are presented in Annex I, section 9.1.2.
49 350,000 tonnes for 1,280 kg ELVs.
50 3.5 million tonnes for 1,280 kg ELVs.

This recycling process would have small negative impacts on greenhouse gas emissions.

- Recovery of 95% of ELVs

High recovery level could generate important environmental benefits, in particular CO_2 emissions reduction of 450,000 tonnes of CO_2 equivalent/year[51], but which is not large enough to offset the lost benefits from reduced recycling[52].

5.6.2 Economic Impacts

In **the low technology development scenario**, the net added value of the ELV treatment process with the 2015 targets would be between **€80 and €55[53] per ELV**. Therefore, the minimum net added value of the ELV treatment process in this scenario for the estimated number of ELVs arising in 2015 would be €760million per year. With the ELV targets assumed to operate over10 years and the economics taken to remain similar, the added value of the process under this set of targets would be **€7.6bn[54]**. This value would be shared in profit between the operators involved in the ELV process, with, most likely, some payment to the last owner.

In the **high technology development scenario**, a greater share of plastics could be recycled at a higher value, while some disposal costs and the costs of the separation process would be smaller. Based on the assumptions presented in table on p.20, the net added value from the treatment of an ELV would be between **€120 and €90**. Therefore, the total maximum value of the ELV treatment process in this case for the estimated number of ELVs arising in 2015 would approximate €1.6 bn per year, giving the maximum value of the process of **€16bn** over the 10 year period under this set of targets.

Thus, with the future impacts estimated to lie within the range of these scenarios, the ELV treatment process under the 85% recycling and 95% recovery targets has substantial net economic benefits on reasonable assumptions, with the benefit being greater with greater technological development.

5.6.2.1 Impacts on Costs in the Economy

New technologies would provide greater resource efficiency by facilitating the recycling of increased shares of plastics in ELV and WEEE waste, production of better quality secondary materials, and providing those at lower prices than the existing materials that are substituted. This will reduce the costs of the EU economy in terms of energy costs (plastics are substituted for fuels or electricity generation) and of plastics processing feedstock. Even with low technological development, the best technologies currently available offer cost advantages over the use of current practices. In the future, it is likely

51 560,000 tonnes for 1,280 kg ELVs.

52 Details underlying the calculation of this impact are presented in Annex I, section 9.1.2..

53 The value if all values are at their minimum range and the costs at the maximum.

54 These estimates are based on figures for per tonne costs of various processes and disposal options. A fuller description of the assumptions behind these values is set out in section 8.2 of Annex I.

that these costs substantially decrease following a typical decrease pattern of the costs of new technologies.

5.6.2.2 Impacts on the Technology Export Potential of the EU

Stimulation of R&D in this area may make the EU the world leader in a technology market with great potential. The resource from ELV and WEEE waste is growing across the world and many countries in the world are developing recycling policies for ELVs as the number of cars increases globally. Technologies that offer products from these waste streams that can substitute currently used virgin materials at lower prices have a large global potential.

5.6.2.3 Economic Impacts on EU Vehicle Manufacturers

There will be small savings to the EU vehicle industry from the promotion of high-quality plastics recycling, a decrease in any potential liability from increased value in the ELV treatment chain, whilst other costs to vehicle manufacturers will not be affected by 2015 targets. Very little impact on the design of vehicles is expected, as changes to design started now for new cars will only change the composition of the typical end-of life vehicle in 2021 onwards.

5.7 Reduced Recycling Targets (illustrated by 80% recycling and 95% recovery targets)

Effects

The 80% recycling target can be met without the use of new technologies, with some efforts to increase dismantling of large plastics, glass, or tyres. In fact, several Member States have already achieved the 80% or higher target for recycling[55], or are close to its attainment.

The change in the target from 85% will significantly slow down development of new technologies, removing incentives for technological development and increasing the risks to companies planning any R&D investments. Moreover, the 80% recycling target will slow diffusion of current most eco-efficient technologies.

Technology for recycling of plastics out of ASR will cease development. Recycling of plastics will continue to take place through dismantling.

This policy option would lead to the recycling of 75% of metals, 3% of tyres, fluids and batteries, and 2% of plastics. The majority of ELV plastics (10%) would be recovered, together with 5% of other materials including the remaining tyres, fluids, textiles and

[55] Sweden reached 84% recycling and 85% recovery target in 2004, Austria estimates that 80% can be achieved in 2006, Denmark reached 83% recycling and 85% recovery in 2004, Belgium reached 80% recycling and 81% recovery in 2005, the Netherlands attained 82.5% recycling and 85.3% recovery in 2005. Source: Member States information presented in the Technical Adaptation Committee meeting of 5 July 2006.

rubber. The remaining 5% of shredder residue mainly composed of glass, road dust, rust etc. would be landfilled.

The impacts of the option are described as changes against the baseline scenario.

5.7.1 Environmental Impacts

- Recycling of metals

Economic incentives continue to remain for the separation of all metals from ASR and by 2015 this can be expected in well-run shredding operations[56]. However, lower targets for recycling will discourage the spread of advanced post shredder sorting technology to shredding yards across the EU. This would lead to the situation where less progressive shredding firms continue with their existing practices, leaving a proportion of ferrous and non-ferrous metals in the shredder residue which eventually goes to landfill.

The reduction in metals recycling against baseline can have substantial environmental costs which, however, are not quantified.

- Recycling of plastics

Compared to the 85% high technology development scenario, plastics constituting 5% of the ELV by weight will go to recovery rather than to mechanical recycling which amounts to around 700,000 tonnes[57] per year in 2015 onwards. A key environmental impact of this 80% recycling target will be the difference between the environmental impacts of plastics going to recovery compared to the estimated impacts of their recycling in 2015. As a result, depending on the type of plastic considered, significant environmental harm could occur, for example 500,000 tonnes[58] of additional CO_2 emissions would be produced per year, or an indicative 5 million tonnes[59] over a 10 year period. It should be noted that these figures relate to polyolefins (example of a PP/EPDM bumper) and can change for other resins.

Compared to the 85% lowest technological development scenario (in which there is very low technological development by 2015), there would be no environmental impacts from the treatment of plastics.

The environmental benefits foregone from this option depend on the technological development that would be achieved by R&D stimulated by 85% targets.

- Recovery of the remainder of the shredder light fraction not mechanically recycled and landfill or reuse of the mineral fraction

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56 VW-Sicon Post Shredder Technology is currently capable of extracting additional 5% of ferrous metals and 3% of non-ferrous metals worth €7.5 and €24 respectively out of each tonne of shredder residue. Source: GHK/BIOS, Annex 3, p.7.

57 881,000 tonnes for 1,280 kg ELVs.

58 560,000 tonnes for 1,280 kg ELVs.

59 5.6 million tonnes for 1,280 kg ELVs.

The parts of the shredder light fraction that went to recovery in the baseline scenario will continue to be recovered. With consistent assumptions on the recovery used and the environmental impacts of those routes, the environmental impacts of this part of ELV waste will be unchanged from the baseline. There will be no significant change compared to the baseline scenario as regards the disposal route of the mineral fraction of shredder residue.

5.7.2 Economic Impacts

5.7.2.1 Impacts on Direct Costs of ELV Treatment

The direct economic impacts on costs of this option depend on the cost advantages foregone from technological innovation not becoming available to be used in 2015 onwards.

Again, the range of economic impacts depends on the assumptions of innovation under the no policy change option. If no additional innovation would have taken place under an 85% recycling target, there would be no cost difference under this policy option. If, however, the high technological development scenario under the 85% recycling and 95% recovery target is predicted, the estimated maximum lost *direct* benefits will be the difference between the high technological development scenario under the 85% recycling target and the lowest technological development scenario without the targets. This is the situation where lower targets undermine existing technological development and the level of technology remains as it does in 2006, with the use of the techniques available now[60].

If high technological development is assumed under 85% recycling targets and a pessimistic view is taken of technological development under an 80% target (zero technological development), dismantling might remain the route to attain the 80% target. In this case, the value from the ELV chain would be between +€35 and -€15. The maximum negative economic impact of this option would then be **€1.1bn a year** (€85 times 13.8m), as explained in Annex I, p.50

If low technological development was predicted under 85% recycling targets and an optimistic view is taken of development under an 80% recycling target (the line that setting of targets will make no difference to innovation development and dissemination), there would consequently be no difference in economic value between the treatment – this option would have neither economic costs nor benefits.

5.7.2.2 Impacts on Competitiveness

Apart from the loss of direct costs savings, the negative impacts on innovation mentioned above will have further negative impacts on EU competitiveness from the increased costs to the economy, reduced resource efficiency in Europe, greater imports of raw materials, and the loss of export markets for waste technologies. These costs are hard to quantify and monetise, but nevertheless significant.

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[60] For details of the assumptions leading to this estimate, see section 8.2 of Annex I.

5.8 Reduced Recovery (scenario 85% recycling and modified recovery target)

Effects

Under this policy option, the impacts of high recycling will remain unchanged. The major change compared to the baseline scenario includes a diversion to landfill of some of the plastics that were previously going to recovery.

With lower targets for recovery, the percentage of ELVs that go to recovery or landfill will be determined by the relative prices of landfill and recovery options available in each Member State. If in one Member State landfill costs €150/tonne including gate fee and tax, while at the same time a cement kiln accepts processed shredder residue at a cost of €120/tonne (including processing costs), then the maximum feasible percentage of shredder residue would go to cement kilns whatever the recovery target. There may be limited capacity in several recovery options in many Member States, in which case not only the price, but also the availability will determine the proportions of ELV going to either recovery or landfill. Because of these variables, it is not possible to precisely estimate the possible impacts of decreased recovery without relying on probable assumptions on the situation in each Member State.

In Member States where landfill in 2015 remained more economic than recovery, the maximum diversion from recovery to landfill from lowering recovery targets (with an 85% recycling target in place) would be the diversion of 9% of the ELV by weight (made up of 6% plastics, 1% tyres, 2% other rubber and textiles.)

Whilst this assessment considers the impacts of the 85% recycling and 90% recovery targets, other targets for recovery below 95% would have similar impacts for each % target reduction.

5.8.1 Environmental Impacts

Under the assumptions used, diversion of plastics from recovery to landfill would be the key environmental impact. A 90% recovery target allows for landfilling of 10% of ASR, which would most likely result in the maximum of a diversion of plastics making up 5% of the ELV. This could result in production of a maximum of 480,000 extra tonnes of CO_2 equivalent/year with substantial increases in air acidification, water pollution and eutrophication, and photochemical oxidation.

This diversion would also lead to detrimental environmental impacts including the loss of resources, occupied space, and potential problems linked to landfill of shredder residue (pollutant discharge via leachates from plastics). Moreover, a cross contamination of the material in the shredding process due to its contact with pollutants from other waste streams such as PCBs may occur[61], which has led some Member States to classify ASR as hazardous waste and to ban its landfilling completely. Finally, higher landfill rates bring about various disamenity effects including visual disturbance, noise and odours.

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[61] Landfill operators maintain that the contamination of ASR is typically very low (below 50 ppm), and thus the classification of ASR as hazardous waste is misleading. Source: GHK/BIOIS, p. 82.

The environmental impacts of a decreased recovery target compared to the baseline are estimated as a difference in environmental impact per tonne between landfill and recovery, multiplied by the number of tonnes estimated to go to landfill instead of recovery. Again, the key environmental impact will be the change in high-calorific plastics and rubber that go to landfill instead of going to recovery options. The result will depend on the policy and mix of recovery options in each Member State.

For any change in the percentage other than 10%, similar calculations can be made. These calculations assume that changes in recovery targets bring about changes in the treatment of the shredder light fraction, with use or disposal of the inert fraction remaining the same.

5.8.2 Economic Impacts

The change in direct costs to the economy from changes in the recovery targets will depend to a large extent on the costs of landfill[62] relative to other disposal options. With the costs of recovery options estimated at between €80 and €100 per tonne, depending on the level of innovation expected under the baseline scenario of 85% recycling / 95% recovery, only landfill prices below €80 and €100 per tonne would have any impact on the economic costs as the amount recovered would not change. If landfill prices were above those figures, a reduction in the recovery target would not make any difference. Note that permitted trade in shredder residue might allow landfill outside the boundaries of the Member States with high landfill costs.

If we illustrate these costs by comparing the likely €80 recovery cost with a landfill cost of €65[63], the impact will be an decrease in costs of €15 for each tonne landfilled. With 5% extra of each ELV going to landfill, being 708,000 tonnes, this would amount to around €11m per year, or €110m over 10 years.

5.9 Combinations of Different Reductions in Reuse/Recycling and Reuse/Recovery Targets (illustrated by 80% recycling and 85% recovery target)

The effects of this option can be estimated as the sum of the effects from separate reductions in either the reuse/recycling or the reuse/recovery targets. For 80% recycling and 85% recovery targets these will be the impacts from a reduction of 5% in recycling and 10% in recovery, with the main impact being the continuation in blocks to innovation to waste treatment technologies.

5.9.1 Environmental Impacts

The environmental impacts of this option are the sum of the impacts from lowering recycling targets from 85% to 80% plus the impacts of lowering the recovery targets from 95% to 85%.

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62 For typical average costs of landfill in the EU see Annex XVIII. More details on landfill costs in different EU Member States can be found in Annex 2 to GHK/BIOIS 2006.

63 The figure of €65 for landfill costs is taken from the GHK report as a mid range for landfill costs.

Compared to the high technological development scenario, this will result in substantial environmental harm, including the release of 0.8 million tonnes of CO_2 equivalent a year.

5.9.2 Economic Impacts

Similarly, the economic impacts are the sum of the impacts from lowering recycling targets from 85% to 80% plus the impacts of lowering the recovery targets from 95% to 85%. Using the calculations of these impacts from consideration of the two options above, there are costs from the lowering of recycling targets with either costs or benefits from lowering the recovery target depending on the relative price of recovery and landfill options in each Member State.

The change in recycling target would lead to costs of up to €1.1bn per year, or €11bn over a ten year period where technological development is foregone with no saving if no technological development under an 85% recycling target is foreseen.

The negative impacts on cost and competitiveness for the EU economy from lowering recycling targets remain as described above in Section 5.7.2

5.10 Administrative Burden of all Considered Policy Options

Under each option, the requirements on organisations to provide information appear likely to remain unchanged. In each case, the monitoring and reporting requirements of the targets will need to remain in place. As there appears to be no significant difference between the options on administrative burden, this has not been mentioned above under economic impacts.

5.11 Social Impacts of all Considered Policy Options

Changes in targets are not likely to produce any significant social changes. Further discussion of impacts on employment is contained in section 9.5 of Annex I.

6. COMPARING THE OPTIONS

Summary The determining parameter in comparing the options is the environmental and economic performance of plastics recycling. Targets are technology forcing and lead to the development of the most eco-efficient ELV treatment technologies. The targets set today will shape treatment paths of ELVs beyond 2015.

6.1 Environmental Impacts

The costs and benefits of different recycling and recovery targets will differ due to the various levels of plastics recycling, recovery or landfill. Since the change of the targets is unlikely to significantly affect the recycling of metals or other material fractions contained in ELVs, it was not considered here.

The relative environmental impacts of plastics recovery largely depend on various factors such as the recovery method used, the type of plastic resin used to replace fuels, and the type of substituted resources. The environmental performance of all plastic fractions contained in ELVs is not certain and differs from one resin to another. The most representative type of plastic used in vehicles – polypropylene (PP) – served as a basis for this assessment.

The table below illustrates the environmental impacts of different sets of targets considered above for all the impact categories considered. Note that the results are simplified, taking mid points of ranges. Particularly for the recovery target, changes in assumptions about the proportion of the ELV waste going to landfill rather than recovery would make a significant difference to the figures. Negative figures indicate environmental benefits from the treatment process.

	85% recycling / 95% recovery	80% recycling / 95% recovery	80% recycling / 85% recovery	85% recycling / 90 % recovery	*unit*
Energy savings / losses	-79.539.040	-62.745.280	-39.041.440	-67.687.120	GJ
Greenhouse gas emissions	-1.205.240	-728.048	-362.366	-1.022.399	t CO2 eq
Air acidification	-17.886	-6.770	-5.248	-17.125	t SO_2 eq
Photochemical oxidation	-709.590	-198.060	-150.270	-685.695	kg ethylene
Water pollution	1.329.560	2.625.200	18.342.800	9.188.360	m3
Eutrophication	-784.800	-246.720	75.420	-623.730	kg PO_4
Municipal waste	-81.413	-196.746	612.427	323.173	t
Hazardous waste	11.196	8.824	5.532	9.550	t

Table 4. Environmental impacts of different sets of targets.

The results illustrate that the environmental performance of the targets is not necessarily clear and depends on many variables.

As regards recycling and based on the assumptions made, the 85% level seems to be currently optimal as it allows for the recycling of all metals with clear environmental and economic benefits and increased recycling of non-metallic fractions (in particular plastics). **The maintenance of the recycling target at 85% brings about the greatest net environmental benefit.**

6.2 Economic Impacts

The estimated economic impacts of different options must be described as ranges, with the eventual impact dependent on the technological development that would come about under the baseline scenario.

In addition, the indirect costs of options (lost competitiveness benefits to the economy from lost export opportunities and reduced resource costs) have not been estimated. These are significant costs, despite not being given monetary value. The table below therefore only represents estimates of direct costs, under the assumptions described in section 8.2 of Annex I. Costs are given per year, and could be multiplied by 10 to give an indication of the costs over the likely lifetime of the policy.

Direct Costs (billion euros)	85% recycling / 95% recovery	80% recycling / 95% recovery	85% recycling / 90 % recovery	80% recycling / 85% recovery
Maximum	**Baseline**	**1.1**	**0**	**1.1***
Minimum		**0**	**-0.11***	**-0.11***

*The impacts of reduced recovery targets are likely to reduce this cost in Member States where landfill remains cheaper than recovery. However, the value depends on Member State policy and relative landfill costs.

Table 5. Economic impacts of different sets of targets.

In the calculations assumed in this economic analysis, for clarity of understanding, ELVs from 2015 onwards are assumed to weigh approximately 1,000kg. Estimations of ELV weight based on the weights of new manufactured cars indicate that the weights will be around 1,280kg by 2019 and on an increasing trend. This increased weight increases the total value of the materials in the ELV, but also increases the costs of processing, which are typically estimated per tonne. These increases offset each other, but do not balance out exactly.

The effect of changing the assumption about the weight would be an increase of the net costs in the low and zero technological development scenario by around €4/ELV and an increase of the net value in the high technological scenario by around €4/ELV. As weights get higher from 2015 onwards this effect would increase, e.g. with the increase in value being €5 towards 2020.

This increase in weight therefore accentuates the difference between the value from scenarios by around €8 to €10/ELV, with the high technological development bringing €10 greater net value than the low technological scenario.

This sensitivity should be borne in mind when considering the estimates of value above.

6.3 Sensitivity Analysis

6.3.1 Factors Affecting Environmental Impacts

Various factors will affect the assumptions about environmental performance of treatment of ASR. Increases or decreases in any of the factors below will lead to corresponding increases or decreases in environmental impacts from recycling and recovery. Where they lead to increases, this will increase the environmental harm from reduction in recycling targets and, similarly, where they decrease, the environmental harm will become smaller:

- Efficiency of recycling process
- Development of sorting technology/purity of recycling inputs
- Diffusion of advanced technology
- Environmental performance of recovery options available in Member States

- Greater than expected use of plastics in vehicles

- Use of plastic and tyre fraction of ASR in sewage sludge dewatering (rather than other forms of tyre recycling).

6.3.2 Factors Affecting Economic Impacts

Increases or decreases in the factors below will lead to corresponding increases or decreases in the economic impacts of options:

- Price of oil – and so the price of virgin plastics

- Wage costs of dismantling

- The costs of plastic composition to be recycled

Also note that changes in the prices of metals, although showing an upward trend, are subject to fluctuations. Moreover, metal content of each vehicle is different: in some Member States the ELV park is composed of cars which contain less metals since more expensive vehicles with higher metal content tend to be exported at a certain age to other countries (where they become ELVs). Higher technological development will allow for greater separation of fractions and the reduction of processing costs. Therefore, it appears that if the higher targets improve treatment technologies, it will stabilise incomes of the treatment sector. On the contrary, lower targets bring about risks of additional costs for vehicle manufacturers if metal prices drop. According to the ELV Directive, manufacturers shall meet all or a significant part of the costs of free take-back. This means that they would need to pay collection and treatment facilities for dealing with negative value ELVs. It is therefore in the interest of producers to guarantee that the treatment of ELVs brings about a positive value for the treatment sector.

The assessment here assumes full compliance by 2015. If there is incomplete compliance, the environmental and economic benefits will be proportionately lower. However, a degree of incomplete compliance in some countries is unlikely to change the impacts of different targets for promoting innovation. Geographic pockets of non-compliance would reduce the demand for innovations, but not stop that demand.

Summary table comparing impacts of different illustrative options

OPTION	**Baseline scenario** *85% recycling* *95% recovery*	**Reduced recycling** 80% recycling 95% recovery	**Reduced recovery** 85% recycling 85 or 90% recovery	**Combination** 80% recycling 85% recovery
Environmental				
Recycling	full metals recycling recycling of PP, PS and PA plastics, greater resource	(-) significant lost benefits from decreased plastics recycling	(=) no change	(-) Significant lost benefits from decreased plastics recycling

	efficiency			
Recovery	substitution of other resources' recovery	(=) no change	(-) lost benefits from reduced recovery	(-) lost benefits from reduced recovery
Landfill	low levels of landfill	(=) no change	(-) moderate to high detriments due to increased landfill	(-) high detriments due to increased landfill
Economic				
Costs for businesses (treatment sector)	high net added value per ELV treated	(+ to =) loss of net added value per ELV treated (depending on innovation level)	(?)costs dependent on relative costs of landfill and innovation level	(- to =) low net added value per ELV treated, high costs of treatment
Costs for businesses (vehicle manufacturers)	(=) neutral or positive	(=) neutral	(=) neutral	(=) neutral to negative (if needed to compensate for negative value ELVs)
Innovation and research	high potential for R&D leading to most eco-efficient treatment of ELVs, boost on diffusion of most efficient technologies	(-) foregone technological innovation because no clear signal is given, innovation is not encouraged	(=) neutral impact on innovation (boost from high recycling but limited by low recovery)	(-)foregone technological innovation because no clear signal is given, innovation is not encouraged
Social	(=) No direct impact identified apart from a potential shifts of employment within the treatment sector.			

Table 6. Qualitative summary of environmental, economic and social impacts of different targets.

7. MONITORING AND EVALUATION

At Community level, the policy will be implemented by Article 7(2)(b) of Directive 2000/53/EC on end-of-life vehicles, which the Member States will need to implement in their national territories.

Developing tools to monitor and report progress in reducing the negative impacts of resource use in the EU, Member States and economic operators is one of the actions which need to be undertaken according to Thematic Strategy on the sustainable use of natural resources[64].

The Commission established the principles necessary to control compliance of Member States with the reuse, recovery and recycling targets in Commission Decision 2005/293/EC laying down detailed rules on the monitoring of the reuse/recovery and reuse/recycling targets[65]. Based on this decision, MS are obliged to collect data for the rates of reuse, recycling and recovery starting from 2006. Therefore, monitoring systems should already exist[66]. If not already in place, monitoring systems will need to be set up by the Member States. The results of the reports sent by the Member States will be assembled by the Commission and published on the website.

In particular, Commission Decision 2005/293/EC lays down in what way the calculation of the attainability of the targets should be made, which assumptions can be made in the absence of precise data, how to determine shredder output streams, and under which conditions exported ELVs can be calculated for the achieved targets of the exporting country. It also contains tables with material breakdowns and explanations on how to use them.

In addition, the Commission will encourage an exchange of best practices between the Member States within the framework of the Technical Adaptation Committee established on the basis of Article 18 of Directive 2006/12/EC on waste[67].

8. CONCLUSIONS

Setting levels of targets will affect not only the end point of fractions of ELV waste, but also the development of the technology to treat it. The environmental and economic impacts of treatment and disposal of ELV waste depend on the commercial availability and diffusion of technology.

Analysis of the state of innovation and progress to date indicates that confirmation of the current 2015 targets would reduce current blocks to innovation. This is likely, though not certain to bring significant environmental and economic benefits in the period from 2015.

The ELV Directive has triggered technological development in the area of ELV treatment, but new techniques have not yet diffused across the European recycling market. Continued development of treatment technologies to recycle some types of plastics would bring substantial the environmental benefits from recycling those plastics .Further support for the technological development is still necessary to overcome market failures, and changing the instruments, or lowering the targets of the ELV Directive is very likely to slow down or even stop this development, also endangering planning reliability. The observed lack of investment in PSTs has not been helped by the reduced

64 COM(2005) 670 final, p. 5.
65 OJ L 94, 13.4.2005, p. 30.
66 Efficient monitoring systems already function in the Netherlands and in Belgium.
67 OJ L 114, 27.4.2006, p. 9.

regulatory stability caused by the clause of the ELV Directive requiring the review of the 2015 targets.

Comparison of different target levels demonstrates that no convincing arguments exist that could justify a modification of these targets: lowering of either set of the targets is most likely to increase both economic and environmental costs. At the same time, higher targets for recycling or recovery remove flexibility with no corresponding gain to innovation.

Whilst all estimations of future impacts for a period of 9 years in the future contain uncertainty and required assumptions, the Commission concludes that the 85% reuse/recycling and 95% reuse/recovery targets are currently optimal both in terms of environmental and economic performance and should remain stable in order to guarantee investment security into more cost-efficient technologies.

In addition, Annex I of the ELV Directive contains a set of mandatory requirements for treatment operations aimed to promote recycling, including an obligation to remove glass. If high targets for recycling and recovery are promoted, technological development is likely to allow the separation of glass fraction after the shredding process. This operation will be much less expensive than manual removal of glass, as confirmed by both stakeholders and Member States. Therefore, a possible amendment of Annex I in accordance with the procedure provided for in Article 11 of the ELV Directive should be considered in order to adopt it to scientific and technical progress and make the removal of glass optional if it is possible to segregate it in further treatment processes.

ANNEXES

TABLE OF CONTENTS

Annex I The Basis for assessment of environmental and economic impacts of different sets of the targets 44

Annex II Comments on Stakeholder views 102

Annex III The GHK/BIO Intelligence Service Report 109

Annex IV Environmental impacts of recyling PP/EPDM (per tonne) 111

Annex V Environmental impacts of recovery PP/EPDM (per tonne) 112

Annex VI Environmental impacts of landfilling PP/EPDM (per tonne) 113

Annex VII Qualitative Summary of Comparative Environmental Impact Assessment – All plastic resins (per kg) 114

Annex VIII (a) Environmental benefits of plastics treatment per resin and treatment option (per kg) *Source: GHK/BIOIS 2006, p. 128.* 119

Annex VIII (B) Environmental costs of plastics treatment per resin and treatment option (per kg) *Source: GHK/BIOIS 2006, p. 129.* 120

Annex IX Current practice per material – overview 121

Annex X Impact Categories 123

Annex XI Ranges of impacts per treatment option for all plastic resins (per kg) 127

Annex XII Global warming potential for different ELV materials and treatment options 128

Annex XIII Environmental impacts of different sets of recycling and recovery targets 129

Annex XIV Numbers of deregistered vehicles in the EU 135

Annex XV ELV Treatment sector in Europe 136

Annex XVI Typical landfill costs for ASR in the EU 137

Annex XVII Estimated composition of ASR in Germany, 1998 138

Annex XVIII List of Contributing Stakeholders 139

Annex XIX List of Abbreviations 142

Annex I
The Basis for assessment of environmental and economic impacts of different sets of the targets

1. GENERAL APPROACH TAKEN IN THIS IMPACT ASSESSMENT

This Annex explains the background of the impact assessment and details the assumptions and analysis made to evaluate the targets. It necessarily contains some overlaps with the text of the impact assessment, as it develops the various points addressed there.

The main question raised in this analysis is not what the impacts of the different targets would be if they were applied now, but what the impacts will be if they are set now and apply in 9 years time and afterwards, which affects the analysis in two ways:

- practices, markets, technology in use will all have changed by 2015,
- the choice of options will bring about changes in practices and technology by 2015.

There is a significant scope of uncertainties as regards the possible future scenarios, which made it necessary to develop certain assumptions and make predictions of practices and technology in 2015 and afterwards explained in detail in this Annex.

Views on practices and technology between today and 2015 are based on the situation in 2006, which is the starting point for developing future scenarios. This analysis is not set out as the costs and benefits of moving from the 2006 situation to 2015 situation. The policy choice is between different alternatives in 2015 and afterwards.

This Annex contains the evidence and rationale behind the assessment of impacts. It explains the assumptions on which predictions of the future must rest and the consequences of those assumptions. The impact assessment is proportionate; it can not and does not attempt to answer every question or see how every change in assumptions affects impacts, but should serve as a framework for consideration of the issue and provide guidance as to the direction of impacts under different targets.

The analysis rests on a set of building blocks:

- Analysis of Future ELV Waste Streams
- Analysis of Potential Waste Treatment Options
- Innovation and Technological Development

From this basis, the Annex describes the method for estimation of environmental and economic impacts, before describing the likely treatment of ELVs under different options, and then estimating the impacts of those options.

It clarifies further assumptions and looks at how those assumptions and analysis build on or differ from stakeholders and the information provided to the Commission.

2. ANALYSIS OF FUTURE ELV WASTE STREAMS

ELVs may enter the waste stream from a variety of sources, including private individuals, garages, local authorities (in the case of abandoned vehicles) and insurance companies (in the case of accident damaged vehicles). In the UK, it is estimated that 10-15% of ELVs are accident damaged vehicles and that the remaining 85-90% have reached the end of their life naturally.

The average age of ELVs has been variously estimated at 15.3 years (Netherlands, 2004), 12.1 years (UK) and more than 11 years (Hungary). In the UK, TRL (2003) estimated the average age of ELVs as a whole at 12.1 years, with the average age of natural end-of-life vehicles at 12.8 years and that of premature end-of-life vehicles at 6.7 years (the average age of the vehicle park). The average used in the impact assessment is of 13 years.

ELVs from 2015 onwards will therefore mainly be vehicles already in use, being vehicles that were produced between 2001 and 2004. The weight and composition of these vehicles is known and an average can be taken[68]. According to GHK/BIOIS, an average end-of-life vehicle weighs approx. 964 kg and this weight is likely to increase to over 1,025 kg by 2015. Weighted averages for all car manufacturers show higher weights of ELVs e.g. of approximately 1,280 kg by 2019, being an average weight of a vehicle put on the market in 2006 as reported in the certificates of conformity (i.e. 1,391 kg) minus the weight of a driver, tools and extra fuel[69]. If this higher weight was used in the Impact Assessment, the direction of impacts would be the same, but they would be greater. The differences resulting from changed weight estimations are described in the relevant sections below.

GHK/BIOIS estimate the following volumes of ELV arisings:

Year	**No ELVs Treated (000)**	**Average Weight (kg)**	**Weight of ELVs Treated (000t)**
2005	10,864	955	10,375
2006	11,124	964	10,724
2015	13,771	1,025	14,116

Table 1. Estimated weight of ELVs requiring treatment in the EU, GHK/BIOIS.

These figures are used in this analysis. If average ELVs weigh 1,280kg in 2019, there will be 17.6m tonnes or waste arising.

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68 Details of the estimated arisings of ELVs in 2015 can be found in Annex 2 of the GHK/BIOIS report produced for the European Commission.

69 Source: Member States' reports for the monitoring of the average specific emissions of carbon dioxide from new passenger cars, based on figures provided by JAMA, KAMA, ACEA for 2006 vehicles. An average annual increase in car weight is assumed at 1.5% See also: http://ec.europa.eu/environment/co2/co2_monitoring.htm.

The composition of a 2015 ELV can also be estimated. In 2003, an ELV in the UK had the following composition:

Material/Component	**% by weight**
Ferrous Metal	68%
Non Ferrous Metal	8%
Plastics and Process Polymers	10%
Tyres	3%
Glass	3%
Batteries	1%
Fluids	2%
Textiles	1%
Rubber	2%
Other	2%
Total	**100%**

Table 2. Typical Composition of an ELV, by Weight, UK, Source: TRL (2003)

Due to changes in the composition of vehicles, a 2015 ELV is estimated to have a smaller percentage of ferrous metal, and greater percentages of non-ferrous metal and plastic:

Material/Component	**% by weight**
Ferrous Metal	66%
Non Ferrous Metal	9%
Plastics and Process Polymers	12%
Tyres	3%
Glass	2%
Batteries	1%
Fluids	2%
Textiles	1%
Rubber	1%
Other	3%
Total	**100%**

Table 3. Typical Composition of a 2015 ELV, by weigh. Source: GHK/BIOIS and information from stakeholder consultation.

2.1 Composition of the Plastics Fraction of an ELV

Understanding of the composition of the plastics fraction is important for an assessment of treatment options and assessment of impacts. Many different polymers are used in vehicles, with the 2001 composition of a vehicle described below.

Many parts are composites of different polymers, whilst within a class of polymer (like polypropylene (PP)) parts may have different physical properties. Vehicle design is increasingly moving towards use of fewer polymers in vehicles, less use of PVC, greater use of PP and greater use of composite parts.

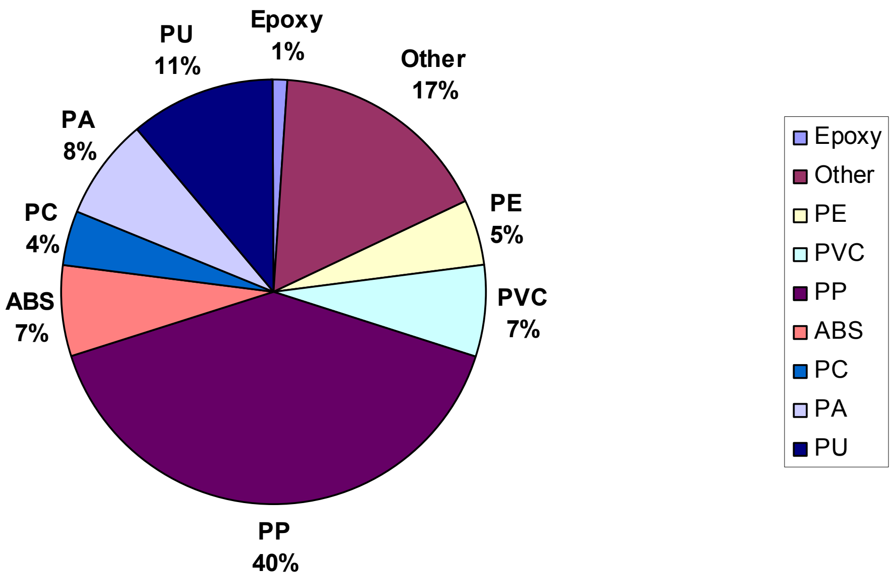

Diagram 1. Average content of plastics in a vehicle (2001). Source: ACORD, CEP.

2.2 Location of Plastic Parts in ELVs

PART	MAIN PLASTICS TYPE	WEIGHT IN AVERAGE CAR (kg)
BUMPERS	PP	**10.4**
SEATS	PUR, PP, PA, PVC, ABS	**18.4**
COCKPIT	PP, SMA, ABS, PC, PVC, PUR	**21.3**
FUEL SYSTEMS	PE, POM, PA	**8.6**
BODY (including body panels)	PP, PPE, UP	**10.8**
UNDER THE BONNET COMPONENTS	PA, PP, PBT	**13.8**
INTERIOR TRIM	PP, ABS, POM, PVC, PUR	**31**
ELECTRICAL COMPONENTS	PP, PVC, PA, PBT, PE	**10.3**
EXTERIOR TRIM	ABS, PA, PP, PBT,ASA	**5.1**
LIGHTING	PP,PC, ABS, PMMA, UP	**5.6**
UPHOLSTERY	PUR, PP, PVC	**6.8**
OTHER RESERVOIRS	PP, PE, PA	**1.5**
TOTAL		**143.4**

Table 4. Location of plastic parts in end-of-life vehicles. Source: PlasticsEurope, 2005.

3. ANALYSIS OF POTENTIAL ELV TREATMENT ROUTES

The disposal route for ELVs is influenced by several factors such as material prices, legislative requirements and available treatment technologies. Before treatment, some valuable parts are dismantled and reused. Afterwards, the metal fraction of a car wreck is recycled, while the remaining residues undergo recovery, incineration, or are disposed in landfills. Typical treatment process of an ELV comprises several stages.

Initial processes of **depollution and dismantling** are obligatory and subject to the requirements outlined in Annex I to the Directive. In fact, not all ELVs are dismantled prior to being shredded[70], and not all the parts are removed. Depollution may take place either at the dismantling phase or prior to shredding.

Depollution of an ELV, which accounts for 3% of vehicle materials by weight, is the first step in its treatment and involves the removal of batteries and liquefied tanks, removal and neutralisation of potentially explosive components (e.g. air bags), removal and separate collection or storage of liquids (fuel, oils, cooling liquids, antifreeze, brake fluids, air-conditioning system fluids etc., unless such fluids are necessary for the re-use of the concerned parts), removal of vehicle components which contain heavy metals. Batteries are either reused or reprocessed, depending on their condition. Fluids are

70 In the UK, two thirds of vehicles are dismantled while the remaining one third is sent directly for shredding (Defra, 2005).

generally reprocessed or sold for use as fuels. This initial process is heavily labour intensive[71].

This process is followed by **dismantling** – an operation aimed to promote recycling - which accounts for the removal of valuable parts and materials that can be reused or easily recycled (e.g. catalysts, glass, metal components containing copper, aluminium and magnesium, tyres, large plastic parts such as bumpers, dashboards, fluid containers). Metal components, tyres and plastic parts need to be removed only if they are not segregated in the shredding process in such a way that they can be effectively recycled as materials. The most commonly reused parts include wheels, engines, gearboxes, carburettors, alternators, starter motors, distributors, headlamps, brake discs and callipers, tyres, radiators, and batteries. If not reused, larger metals parts are usually sent for metal recovery to specialist reprocessors. The percentage by weight of parts removed depends on the age and condition of a vehicle as well as on the method of operation of a dismantler and ranges from 47% for PELVs to only 9% for NELVs. In addition, those removed parts which could not have been sold are eventually shredded (approx. 32% of parts removed)[72]. German Car Manufacturer Association estimates that depollution and dismantling of ELVs before shredding reduces their weight by 25-30%[73], while in Austria the estimates are lower (12.5%)[74].

Removal of glass and plastics involve high costs which are greater than the revenues received. Current practice shows that only in few Member States removal of glass is obligatory[75], since this action is not economically viable. Glass removed from ELVs is very hard to recycle because the use of recyclate depends on where glass was situated in a vehicle. It is impossible to recycle vehicle glass with packaging glass due to specific chemical composition of the former. In some Member States, glass is shredded with the rest of ELVs and disposed with ASR in landfills.

Further to depollution and dismantling, all ELV shells are eventually sent to shredders in order to be mechanically cut into small pieces. **Shredding** is a capital intensive process undertaken by a limited number of companies in the EU. The resulting material contains heavy and light fractions which are further separated by a mechanical process. The heavy fraction is mainly composed of metals (currently 74% ferrous metals, 3% non-ferrous metals, 6% heavy shredder fraction)[76], most of which can be recycled after separation by its magnetic or density properties done by shredders. Shredder light fraction is a

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71 According to ADEME (2003), depollution costs approx. 30 €/ELV. The Stakeholder Working Group report estimates the costs of depollution at 40 to 80 €/ELV, including administration costs.

72 TRL's study of dismantlers, check source with GHK/BIOIS 2006.

73 Reinhardt T & Richers U (2004), Entsorgung von Schredderrueckstanden – Ein aktueller Uberblick, Wissenschafliche Berichte, Forschungszentrum Karlsruhe.

74 Neubacher 2005, *Evaluation of the Measures and Targets of teh Austrian End-of-Life Vehicles Ordinance with regards to the Implementation of the Directive 2000/53/EC*, UV&P, 2005.

75 In Denmark and in Poland removal is obligatory, in Sweden and the Netherlands incentives are offered to promote this process. In AT, glass is removed sporadically.

76 Tecpol study (see GHK/BIOIS 2006).

combination of other residues such as plastics, foam, glass, textile fibres, rubber and is mainly disposed of in landfills (17%)[77].

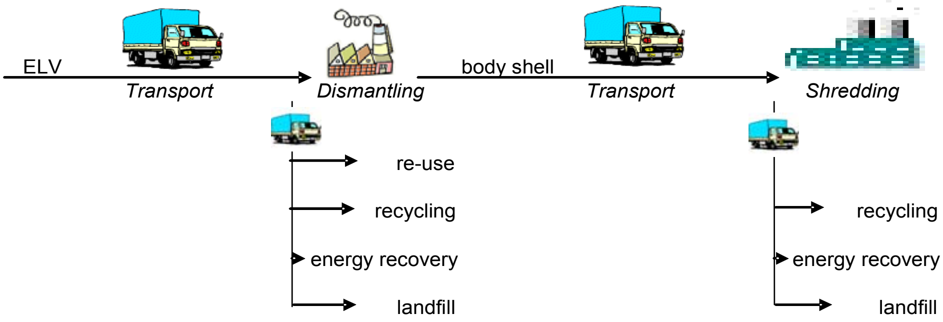

Diagram 2. Overview of the ELV treatment process.

With the vast majority of metals already extracted from ELV waste and recycled, it is the treatment and disposal of the shredder residue that is of central importance to the impact of different recycling and recovery targets.

ELVs are typically shredded together with waste from electrical equipment such as fridges and washing machines, as the use of an input of mixed materials is more efficient for operators both technically and economically. The proportion of the residue coming from ELVs is approximately 50% by weight, though this differs with inputs. For convenience this is referred to in this assessment as '**ASR**', but it is important to remember that residue coming from shredders is a mix of ELV and waste from other goods, both of which are dealt with together[78]. It is a mix of the heavy shredder fraction and the shredder light fraction – those parts of the ELV (and waste equipment) which are not extracted for re-use or for metal recycling during the shredder process.

Potential routes for shredder residue

Shredder Residue can move through several alternative routes to several alternative solutions for final treatment or disposal. Where fractions of the shredder residue are separated from each other, these can end up in different treatment or disposal solutions. The proportions of the residue which end up in the solutions shown below will depend both on the economics and the technology used. The treatment routes are explained in more detail below. Each has different environmental and economic impacts. This describes the technical possibilities, and then discusses the availability of the routes.

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77 Tecpol study (see GHK/BIOIS 2006).

78 White goods can contain more copper than ELVs. They also currently contain PCBs which ELVs do not. Source: GHK/BIOIS 2006, Annex 3.

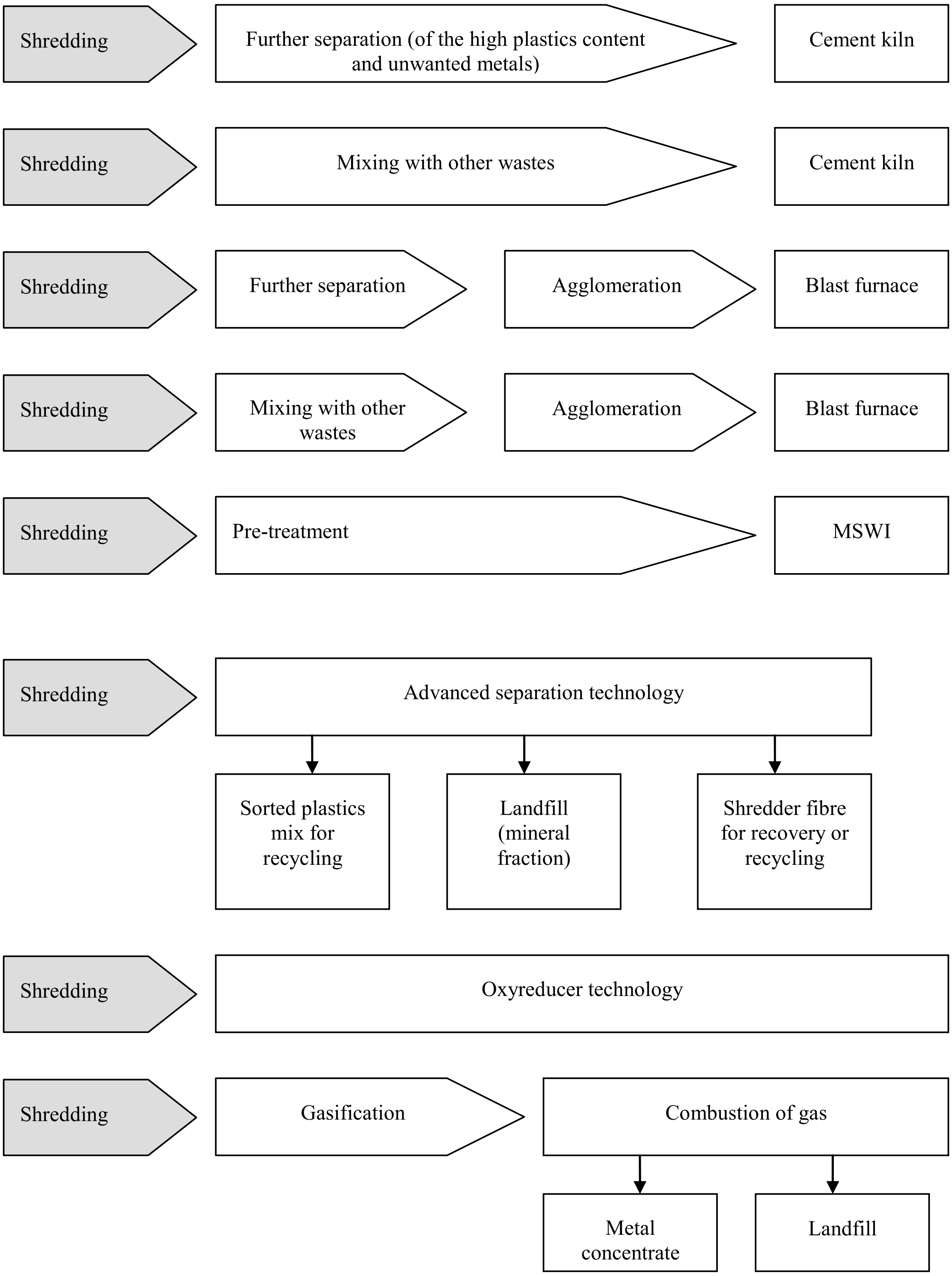

Diagram 3. Potential routes for shredder residue.

Where dismantling takes place, a fraction of the weight of an ELV will not end up in the shredder residue, which would reduce its plastics content, but the residue would still follow one of the routes above. However, it is extremely unlikely that where advanced separation was used to obtain a mix of sorted plastics for recycling that more expensive dismantling of plastic parts would also take place.

- **Separation of ferrous and non-ferrous metals from shredder residue**

Most of the current shredders do not separate out all of the metals from the shredder residue. Small pieces of metal, frequently attached to other materials remain, with a particularly high proportion of non-ferrous metals not being separated. With great commercial interest in separating out the highly valuable ferrous and non-ferrous metals, additional post-shredder technologies are now available to further separate out metals from residue at shredding plants.

It is generally assumed here that by 2015 (even in the absence of any ELV policy) many shredding plants will have some system to further separate out metals and that shredder residue at that time will not contain a significant proportion of metals, but that many less entrepreneurial plants would not invest in the new technology but continue their usual practices.

- **Residue to cement kilns**

Waste going to cement kilns can arrive through three routes. Cement kilns can take high plastic content waste as a substitute for fuel, either coal or heavy oil, essentially because it is cheaper. To meet their technical and environmental operating conditions, cement kilns require a mix which is high in calorific value, low in PVC and low in heavy metal compounds. The high calorific value is needed to provide the necessary heat for the cement process, PVC reacts to form the acid HCl in the kiln which in significant quantities can damage the kiln, whilst heavy metals, such as Mb and Mg would be emitted from the stack and can lead to breach of emissions standards.

Chlorine levels between 1% and 5% appear tolerable, dependent on the applied technology. The HCl is neutralized within the process and does not contribute to flue gas emissions. Research work is being undertaken to exploit the limitation PVC may impose on some of these processes.

To avoid these problems, cement kilns only take waste which is suitable for their operations. This requires either separation of metals and concentration of high plastic fractions or mixing of waste with other waste streams prior to introduction to the cement kiln.

The plastic or fibrous fraction produced by advanced post-shredder separation techniques can also be suitable for use as a fuel substitute in cement kilns.

Where the mineral fraction of shredder residue has not been separated out before going to the kiln, this will form part of the kiln's slag, which will typically go to landfill.

It is assumed that cement kiln technology will not change significantly with respect to the use of shredder residue in the period up to 2015 and shortly afterwards.

- **Residue to blast furnaces**

Suitably pre-treated shredder residue can be burnt in blast furnaces where it substitutes for coal or heavy oil. At the same time, it also serves as a reducing agent in the steel making process (substituting for coke's role). To be suitable for this use, shredder residue must be pre-treated to separate out impurities which would reduce the performance of the steel (like copper) and to remove the unnecessary and unreactive mineral fraction. The residue must also then be agglomerated to make it suitable for input. Slag from blast furnaces can be landfilled or used as inert material in construction processes.

It is assumed that blast furnace technology will not change significantly with respect to the use of shredder residue in the period up to 2015 and shortly afterwards.

- **Advanced separation technologies**

Advanced separation technologies exist which can separate out polymer pieces from shredder residue. The output of the process depends on the sophistication of the technology. In 2006, commercially operating plants have demonstrated the ability to separate out approximately half the plastics within an ELV to produce a polymer rich mix. These are mainly in the form of the small, broken up parts of the ELV, mostly black plastic. The ability of technology to increase the separation of different polymers is very likely to increase by 2015, although the rate of increase is dependent on the regulatory environments and the success of R&D.

The current technology will typically separate shredder residue into three fractions: a plastics rich mix, an inert mineral fraction and another fibrous fraction containing other plastics, textiles and rubber. All of these fractions contain significant mixtures of materials and impurities.

Advanced separation is a relatively new technology that has proved itself. Commercial advanced separation plants are in operation in the USA, China, Austria, France/Belgium, Germany, Poland, Finland, and Norway and under construction in the Netherlands and Sweden.

There are a large number of technologies in development which might increase the efficiency and degree of separation of shredder residue by 2015. Whilst a large proportion of these are unlikely to become commercially available, taken as a whole technological development is likely to increase the range of fractions of plastics and other materials being able to be separated out and improve the purity of those mixes.

Post-shredder technology is also currently able to separate out a fibrous fraction from ELV waste, which is made up of shredder plastic, rubber and textiles. This may find uses as a dewatering agent for sewage sludge. Trials have taken place in Germany to establish its suitability. Otherwise, the high calorific fibrous fraction can be suitable for recovery operations[79].

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[79] For more details of sorting technologies refer to the GHK/BIOIS Report, Annex 3.

- **Municipal solid waste incineration**

If the inert fraction of shredder residue is separated out, the remainder can be burnt in some municipal waste incinerators under certain conditions. For many municipal waste incinerators, the high-calorific value of the plastics creates too much heat for the incinerator. To be burnt in incinerators, shredder residue must be mixed with other lower-calorific wastes.

Significant levels of PVC in the incinerator will interfere with the incineration process. Studies done in France, the Netherlands, Germany and Switzerland have indicated that within the tested limits of 10-15%, co-combustion of ASR with MSW in modern incinerators is perfectly acceptable and does neither interfere with the combustion process nor the composition of the slag and flue gases. As demonstrated with MSWI, the presence of PVC in shredder residue has no effect on dioxin emissions.

Where the incinerators recover energy from waste either by generating electricity or using the heat in the steam produced, the burning of shredder residue substitutes for other sources of energy for heat and electricity generation. The amount of substitution that takes place depends on the efficiency of the incinerator. The average efficiency of energy recovery of a municipal incinerator in Europe is estimated at 40% (12% electricity generation and 28% heat recovery)[80].

Flue gases from the incineration process are further treated and then may be used in construction or landfilled.

By 2015, with pressure for innovation coming from other waste and emissions legislation, it is expected that the efficiency and environmental performance of municipal waste incinerators will have increased significantly, which is likely to produce average performance across the EU closer to the best performing current incinerators.

- **Gasification**

Several technologies of gasification have been developed able to treat waste, including ELV streams. The *Twin-Rec* process, a thermal technology developed by the Japanese company Ebara, does not yet operate in Europe. There are however 17 operational plants in Japan linked to several shredders and other operators. The Twin-Rec gasifier combines material recycling of metals, mineral components, and ashes with energy recovery. At the same time, materials are decontaminated. Combustible gas and fine char are used here to vitrify ashes and fine particles turning these into a recyclates – an inert construction material – with the recovery of excess energy.

Another high-temperature gasification process was developed in Germany. The *Schwarze-Pumpe* process is based on gasification of waste materials, including ASR, to produce synthetic gas (syngas) and vitrified slag which can then be used in road

80 Recovery Options for Plastic Parts from End-of-Life Vehicles: and Eco-Efficiency Assessment. Öko-Institut e.V. Darmstadt, 2003.

construction and mine filing. Syngas resulting from the process is a valuable resource used for large scale production of base chemicals (methanol, ammonia, formic acid)[81].

- **Mechanical recycling of plastics into granulate recyclates**

There are two routes by which plastics from ELVs can be recycled into granulates:

(i) Manual dismantling of parts before shredding followed by recycling

Before shredding, to gather plastics for recycling from ELVs, some of the plastic parts can be removed from the ELV with manual work, using suitable tools. Dismantling has been the main way to meet the 2006 recycling targets in the ELV Directive with dismantling of certain parts (e.g. bumpers) also required as part of the treatment of the ELV (see requirements of Annex I to the ELV Directive[82]). Auto-Recycling Netherlands, the Dutch ELV recycling scheme which currently achieves the highest recovery and recycling rates in the EU estimates that rates of recycling and recovery will fall after 2006 due to increased proportion of plastics and other non-metallic materials in cars, unless new methods of recycling and recovery are found.

The time taken to dismantle plastic parts from vehicles are highly variable, with some large parts which can be removed relatively cost-effectively and a steep increase in costs for the removal of larger quantities of smaller parts[83]. The curve below demonstrates how the time and the costs of dismantling increase after the dismantling of approx. 70 kg of plastics (7% of ELV by weight).

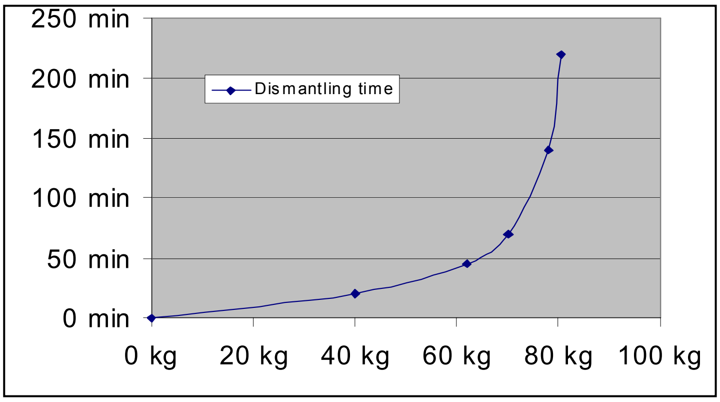

Diagram 4. Dismantling time for a car (total plastics 160kg). Source: GHK/BIOIS 2006.

Stakeholders indicate that the time taken to dismantle parts for a car depends significantly on the skills of the worker, in addition to the design and familiarity of the

81 More details about these and other processes can be found in GHK/BIOIS 2006, Annex 3.

82 The ELV Directive requires removal of catalysts, glass, metal components containing copper, aluminium and magnesium, tyres, large plastic parts such as bumpers, dashboards, fluid containers.

83 Today, total dismantling costs per ELV related to the requirements of the Directive range between 250-350 € in Germany to 330 € in France. These costs are covered by the revenues from the sale of parts and materials (over 490 E/ELV in France, plus over 20 E/sold ELV shell). Source: GHK/BIOIS 2006.

vehicle. ACEA estimates that dismantling costs can only be taken as constant for the first 40kg of dismantled plastic parts and that this dismantling will take 60 minutes rather than the 20 minutes estimated by GHK/BIOIS. This has implications for dismantling costs, considered later.

(ii) Separation of plastics from the shredder residue by advanced sorting technologies followed by recycling.

Advances in technology now allow certain plastic pieces to be separated from shredder residue. These form part of a high-polymer mix which can then be sent to plastics recyclers (also called converters).

Plastics recyclers can, where the purity allows, turn this mix into granulate recyclate. The value of the plastics mix to plastics recyclers depends on the polymers it contains and the purity of the mix. Various technologies exist or are under development which could increase the purity of mixes coming from shredder residue. These separation technologies can be undertaken by the shredding operation or the plastics recycler, or some by both.

If the rate of technological progress in this area remains the same for the next ten years, it would be expected that by 2015 greater proportions of plastics will be recovered from the polymer mix going into recyclers with greater purity of outputs.

4. Innovation and Technological Development

4.1 Current market failures in innovation for ELV waste treatment

Existing market forces will not lead to the best treatment of ELV waste, because they do not take into account the environmental benefits of different treatment options and because there are blocks to innovation. This has been shown by the current treatment practice. More specifically:

- The prices for treatment and disposal of shredder residue usually do not include the environmental costs or benefits of those methods. This means that, when firms choose treatment or disposal methods on the basis of what is financially best for them, it is often not the choice that would bring greatest benefits to the EU, if all impacts are considered. This difference in pricing between private costs and society's costs for treatment distorts the incentives to private firms to innovate.

- Investment in new treatment technologies is constrained by uncertainties about the future market for products and knowledge of existing techniques. Lack of knowledge of the most cost-efficient technologies slows down diffusion of technology, in the same way that many firms do not adopt cost-efficient energy efficiency measures. This will lead to a lack of R&D in innovative techniques and affect diffusion of good techniques in ELV treatment.

4.2 Blocks to innovation in treatment of ELVs

Innovation in technological development of processing shredder residues is held back by several market failures, some common to industrial innovation as a whole, some relating to eco-innovation, and some specific to the post-shredder and plastics recyclate markets. These lead to a lack of investment and diffusion of advantageous technologies in the EU.

- Diffusion of latest technology is slow, despite being economically advantageous for all parties (this is comparable to similar problems to uptake of energy efficiency improvements). In some cases, this is due to the lack of information exchange, restricted knowledge of opportunities, or lack of incentives at firm level for individuals to push for innovation.

- In many firms, there is unwillingness to take-up known innovative technology until it has been widely proved to be commercial. This leaves few market opportunities for technology to be proved commercially and, as a result, it may never be proved. Here, rational behaviour by individual firms (each looking after their individual risk) does not lead to the best outcome for the market as a whole (in economic terms, a market failure).

- In a related problem, new technologies can create new markets by producing new products that have market value. But as no proven market will exist until the products have been produced, firms are often unwilling to invest until others have done so and proven a potential market, so the potential market may never be realised. This circularity also hinders uptake of technology by individual firms.

These are all problems which have hindered, and continue to hinder, the demand for post-shredder technologies for sorting and recycling of ELV waste. One of these is a knock on effect:

- Knowledge of the threat of lack of demand for technology (from these market failures in the technology market) greatly reduces the potential returns on R&D investment whilst at the same time increasing the risks. This has lead to sub-optimal investment levels in R&D for post-shredder technologies.

- The risks for individual technological R&D are higher than the risks to society from developing technologies in a particular direction. Firms face the risk both of their individual technology failing and of their technology succeeding but being less competitive than competing technologies. Society as a whole faces a much lower risk that all potential technologies fail. Firms, facing higher risk, invest in R&D at lower levels than the society as a whole would invest – a market failure affecting development of post-shredder technologies.

- The most likely source of capital investment in post-shredder technologies is the existing shredder operators. Yet, many of the shredder operators do not include plastics recycling in their main business. Faced with an unknown area of business, they have less incentive to research the market opportunities and therefore little incentive to innovate to sell products into a market they do not know. This restricts capital investment.

- Levels of R&D and investment in eco-technologies, like recycling technologies, are particularly likely to be at sub-optimal levels. The environmental benefits that the technology brings benefit society as a whole, but are unlikely to bring additional financial returns to the developers and users of the eco-technologies. Even in a perfect market, firms would only invest at a level that reflected their own financial returns – a level of investment below the appropriate level for the society.

4.3 Current best technology, development pathways and the potential for innovation

4.3.1 Technology for producing recyclates from plastic waste

Technology exists and is being used commercially to produce plastics recyclates from waste to a standard that meets some market demands. There is a very large number of plastics recycling companies operating in the EU, with thousands of small companies recycling some polymers (e.g. PP). Technology for recycling from waste is waste-stream specific. Whilst many companies are recycling plastic from PET bottles and packaging, far fewer are recycling plastics from shredder waste. This, again, relates to the purity of plastic waste coming from shredder residue.

These recyclers differ in the inputs that they use for their recycling process. Different input streams both require different machinery and produce very different outputs. For example, it is relatively easy to produce a pure polymer from waste plastic left over from production processes, where the input stream is both clean and of pure type of polymer.

Technological processes and the possibilities for recycling are different for different polymers. Thermosetting plastics are very difficult to recycle, whilst thermoplastics are easier, with different thermoplastics requiring some different processes and energy inputs to allow recycling. Polypropylene and polyethylene (both polyoleofins) are relatively easy to recycle.

A small but growing number of plastics recyclers are using recently developed technology to use high-polymer mixes from shredder residue as inputs. Typically, these use dense-media separation, possible with mid-infra red detection and some wet and dry separation techniques to separate out the plastics which they want to recycle from the plastics mix. Plastics are washed at the start of the process.

The commercial operations running in the USA and Europe separate out some of the polyolefins – polypropylene (PP) and polyethylene (PE) and then convert these into plastic granulates which meet sets of specifications and can be used in different applications either in the EU or overseas. The conversion rate of the plastics into granulates is slightly less than one, with an estimated 10% or less being lost in the conversion process. The technology employed can also be used to separate out polysterenics (ABS/HIPS). This application is not yet being carried out commercially, but is now being investigated, as is the potential to use the technology to separate out polyamides/nylon.

Plastic recyclates from shredder residue are produced by Galloo plastics in France and by Mueller Gotterbraun in a 40,000t/year plant in Austria using a technology developed by MBA Polymers used commercially in the US and China. The Mueller Gotterbraun plant has been operating since 2005.

The recycling process faces some technological difficulties depending on the level of impurities in the material being recycled. Where waste plastics are mostly free of impurities, the recycling process itself can be relatively simple. At one extreme, the recycling of production waste – virgin plastic off-cuts from manufacturing processes – is relatively simple, similar to the end of the process of producing virgin plastics. As impurities increase, greater changes need to be made to the process and plant used in the reforming of the plastic. For example, changes are likely to be needed to prevent extrusion nozzles blocking. Purity also links to the efficiency of the recycling process: for instance, fibrous impurities in the input will lead to greater blocking of nozzles and greater percentage of waste plastics in the process.

Galloo and MBA have made suitable adjustments of their plants to operate commercially viable recycling processes. MBA deals mainly with plastics from WEEE – a purer stream of plastics than is offered by shredders from shredder light fraction.

To date, techniques have been developed to operational processes for PP. There is scope for technological development to extend these techniques to other plastics. MBA and ARN state that they are experimenting with recycling of nylon. One of the factors holding back development of these technologies is lack of supply of suitably pure input streams.

4.3.2 Technology for separation of plastics from shredder residue

The development of technology to separate plastics from shredder residue is essential to the development of recycling of plastics from ELVs. The shredder light fraction is a mix of mangled pieces of plastics, fibre, rubber and some attached metal.

The most advanced current techniques to separate out different plastic fractions include density separation – placing waste in liquid of differing densities. Material denser than the liquid falls to the bottom, material lighter than the liquid rises to the top. By a series of successive separations using liquids of differing densities, various materials can be separated out. The process does not create pure outputs – the same polymer part (e.g. a piece of vehicle dashboard) may contain a filler which changes its density, or may still be attached to a part of another material, whilst some polymer pieces (e.g. polypropylene and polyethylene) have similar densities. Other separation steps can be carried out, e.g. the use of centrifuges.

Numerous technological institutes and progressive companies are experimenting with combinations of different techniques to produce purer plastics input streams. The potential to produce plastic recyclates from greater proportions of shredder waste depends on the success of efforts to improve waste separation, something itself dependent on the magnitude of those efforts. There are substantial efforts into research into separation of materials from other waste streams, for example packaging waste. Some of these involve sensing technology: e.g. use of infra-red or diffraction to identify different polymers, coupled with sorting techniques. Technologies can rarely be transferred directly to shredder residue, where pieces of polymers are smaller and further research is necessary to adopt appropriate techniques for shredder residue. Some technologies that sort shredder waste are in development. These include sorting technologies which use near-infra red, or mid-infra red to sort black plastics. The costs of many of the technologies are currently uneconomic at the current level of their development and the development of markets for their outputs.

To date, technological progress in separation has been substantial, although investment in separation of material from shredder residue has been hindered by lack of certainty about demand and outputs. With recycling targets in place that remove blocks to innovation, technological progress could be considered likely to increase.

4.3.3 Proportion of plastics from shredder residue forming recyclates

At the moment, with the most advanced post-shredder separation techniques used in industrial operations, 15-25% of shredder residue will go to a plastics mix fraction that is sent for recycling, depending on the specification of the plastics mix. It is necessary to assume the proportion of the plastics mix that comes from ELVs rather than from the other inputs into the shredder (e.g. WEEE) - and this is around 50%. Thus, plastics representing 7% of the ELV by weight would go to recycling operators.

From this fraction, currently only parts of the PE and PP and ABS/HIPS fractions are sometimes used for recycling, with up to 2% of the ELV by weight becoming recyclates. Where the current maximum of polymers (PE, PP and ABS/HIPS) is used this proportion might reach 4%, though this is not currently done.

The possibilities of extracting and using polyamides (PA/nylon) are now being investigated.

The Galloo process takes inputs of around 63% of shredder residue – the shredder light fraction including some non-ferrous metal, producing a plastics concentration including 12% of the ELV so that plastics accounting for around 6% of the ELV by weight are recycled.

Developments in separation technology in the period up to 2015 would allow greater extraction of a greater range of polymers and in turn lead to a greater proportion of ELV plastics made into recyclates. The increase in the proportion depends on technological developments and is not possible to predict with any certainty. Past trends on improvements in technology would indicate increasing proportions, but advances of technology depend on many factors, both engineering and investment[84].

4.3.4 Financial viability of recycling - use and demand for recycled polymers

The market demand for recycled polymer material depends on the properties of this material. Plastic parts used in products are rarely made of simple materials, they are usually composed of a base polymer (e.g. polypropylene) which is mixed with other substances to give the plastic the properties required for its purpose. Common additives include plasticisers, stabilizers, or fillers (e.g. talc). For instance, there are at least 83 different types of un-reinforced polypropylene (itself just one of several polymer types), each one having different physical properties.

Often – e.g. in automotive components' production – very precise properties are required from plastics, requiring exact mixes of pure plastic and other substances. In other plastic

[84] Sources: personal communication with ARN, MBA Polymers, Galloo plastics.

uses, where less specific properties are required, there is more flexibility in the composition of the plastic used.

Demand exists for any plastic recyclates that can be used to substitute for virgin plastic in a way that allows the resulting plastic part to meet the properties required, as recyclates are typically cheaper than virgin material.

Often plastic recyclate containing low levels of impurities can substitute for a proportion of virgin material to obtain a resulting mix with the required properties. For example, if a computer keyboard requires PP with 2.5% impurities, this could be created using a batch of recycled PP containing 5% impurities and recyclate with an equal amount of virgin PP. Note here that the amount of recyclate used will replace an equal amount of virgin material.

The price the market is willing to pay for recyclates is determined by the price of virgin material, as when recyclates can be substituted for virgin material (even if in only a proportion of a plastic), they tend to be substituted 1:1. The recyclate price lies below the price of virgin material and is an incentive for manufacturers to use the recyclate.

The virgin material price for plastics depends on the oil price. With oil prices now at levels around three times their prices at the end of the 1990s, prices for recyclates are high. The process to produce recycled plastics is comparably costly to the process to produce virgin material, though not subject to great returns to scale. The input for recycling can be cost free, although with transport costs.

The availability of mixed plastics recyclates may also create markets for these materials, as manufacturers identify opportunities to change their material sourcing to the cheaper recyclates. This both takes time and is not certain. It has, however, been seen in other recyclate markets, for example, the growth of markets for PET recyclate from bottles, where new commercial uses – such as use in plastic sheeting - have been found.

4.3.5 Closed-loop recycling – recycling polymers back into vehicle parts

Closed-loop recycling is not easy. The polymers used in ELVs typically date from around 12-15 years earlier than new cars. In that period, the polymers used in parts have changed substantially: even if the polymer recyclates were pure, the recyclate would not necessarily be suitable for use in the same part in a new vehicle. For many vehicle part applications, even small pieces of impurities can make the recyclate unsuitable.

However, many auto-manufacturers have been carrying out closed loop recycling, using recycled polymers in parts that are not seen by the car-user. General Motors used its first recycled part in 1989. Renault has had a policy of designing vehicles with recycled content since the late 1990s, with 16kg of recycled polymers in the 2002 Meganne and 20kg in the smaller Modus. It is committed to use 50kg of recycled plastics in its cars by 2015 and is on track to achieve that target. These figures include pre-consumer and post-consumer plastic waste, but do not take into account the use of production waste that is then re-used in the same production process. This 50kg is currently more WEEE than ELV derived waste, with some recyclate being derived directly from WEEE, rather than shredder residue. Other manufacturers are also heavily involved in use of recycled parts (e.g. Volvo has a target of 30kg per vehicle).

100% recyclate parts are also used in vehicles. The properties of recyclate polymers are different but not necessarily worse than those of virgin materials, while a careful design of vehicles can incorporate such recycled parts.

Use of recycled plastics is hindered by plastics manufacturers who are unwilling to undermine their virgin plastic market by developing use of recyclates through incorporation of recyclates into virgin plastics. With volumes of recyclates available from recyclers currently at a low level, auto manufacturers wanting to use these materials find it difficult to source sufficient volumes.

4.3.6 Increasing market uptake for recyclates

Market demand for recycled plastic has been hindered in the past by lack of certainty about the properties of recyclates. With the properties of recyclate depending on the inputs into the process, potential users of these materials were uncertain about using recyclates where there are no guarantees of their properties.

By setting agreed standards for the properties of different recyclates – essentially creating a set of different polymer recyclate 'products' - this uncertainty can be reduced. Work to agree such standards is already well progressed in some areas, for example CEN TC249 WG11.

4.3.7 Potential for investment in new technologies by 2015

Installation of an advanced post-shredder treatment plant is stated to take a minimum of 4 months[85] and to be operational after testing and optimisation after 1.5 years. This allows 7 years for development of technology before it is necessary to install it to meet the targets in 2015.

5. ASSESSMENT OF UNCERTAINTY OVER TECHNOLOGICAL DEVELOPMENT: USE OF SCENARIOS

In this assessment of different options for 2015 onwards, the Commission must consider the technology available at that time. This requires prediction of future technological development, which necessarily involves uncertainty and simplification. A range of potential outcomes from stimulation of innovation are considered. The analysis considers the results from two different scenarios – one where technological progress is significant and one where increased R&D in the EU does not lead to significantly commercially usable results. Both these scenarios are then used to assess impacts from policy options, showing the end points of a range, with some policy results expected to fall within that range as described later.

5.1 Low Technological Development Scenario

Low technological development could arise in two ways:

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[85] Source: ARN/VW-SiCon.

- High recycling and recovery targets stimulate greater research and development in recycling and dismantling technologies, but little successful progress is made in finding commercialised technologies.

- Policy does not remove current blocks to R&D, but other market and policy stimuli bring about development of technology in some areas.

In both these cases, there will still be some innovation in some of the technologies, particularly in extraction of a greater proportion of metals from shredder residue, some developments in plastics recycling and sorting technology, particularly in other areas of plastics recycling (like packaging) and improvement in the efficiency of municipal waste incinerators. These will lead to a change in the technology available in 2015 compared to today, but a very significantly smaller change, with progress in post-shredder technologies below the rate of technological development that has been seen in recent years when an 85% recycling and 95% recovery targets have been part of the ELV Directive.

In this scenario, we assume that post shredder technologies for mechanical recycling do not develop beyond their current costs and potential, but that existing pilot technologies do become commercially available by 2015. Greater volumes of installation of the technologies may lead to changes in the price of the technologies.

We assume that technology for the various options for processing for feedstock recycling (including some PSTs) develop only incrementally, but that the technologies for incineration of waste, driven by other incentives from other waste streams[86] and the potential to sell energy arising, do develop to a significant extent. These assumptions will have impacts on the environmental and economic costs and benefits.

Reviews of current PSTs describe several different processes with varied economic and environmental performance[87]. Under this scenario, technologies exist which would allow several alternative treatments:

- The production of ASR containing less metal than current ASR.

- The separation of high-calorific plastic fraction from ASR to produce a fibrous fraction, shredder sand and a residue.

- The production of feedstock gas.

- The recycling of a small proportion of plastics from ELVs from a small proportion of polymer pieces that can be sorted from ASR or obtained from dismantling. This allows 20kg of plastics recycling.

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86 Diversion from landfills required by Directive 1999/31/EC on the landfill of waste (OJ L 182, 16.7.1999, p. 1), requirements of Directive 2000/76/EC on the incineration of waste (OJ L 332, 28.12.2000, p. 91.

87 GHK/BIOIS and stakeholder consultation.

- Thermal recovery in municipal waste incinerators with a high degree of efficiency.

5.2 High Technological Development Scenario

This scenario is based on an assumption that between 2006 and 2015 technological progress allows greater separation of material fractions within ASR and greater use of the material and energy contained in ASR. To bring about this additional technological change would require policies that stimulate both R&D in new technologies and an uptake of technologies.

In this scenario, we extrapolate progress with the existing technologies and research to predict that in 2015 technology exists to produce:

- ASR containing less metal than current ASR.

- A polymer recyclate of a high degree of purity from part of some major groups of polymers found in ELVs (PP, PS (ABS/HIPS), PE and PA). This would allow 70kg of plastics (out of 130kg) to be recycled.

- The separation of a high-calorific mixed plastic fraction from other ASR (shredder sand made mostly of concrete and glass passing through the shredders).

- The production of feedstock gas.

- Thermal recovery in municipal waste incinerators with a high degree of efficiency.

The environmental and economic impacts still depend on the use to which the outputs are put. These uses are equally sensitive to the definition of recycling and recovery, markets and the substituted fuel in energy production.

The 2015 targets are likely to lead to the high innovation scenario and costs and benefits are assessed against technology in that scenario.

5.3 Zero Technological Development

The two scenarios described above illustrate potential outcomes from stimulation of innovation through baseline maintenance of recycling and recovery targets.

Where recycling and recovery targets are reduced, it is very likely that even a small further technological development will not take place. Again, a range of potential impacts on innovation can be considered. It is possible that existing market incentives would support current technologies, so that the technological outcome would be similar to the low tech scenario described above.

More pessimistically, it is possible that removal of policy support for innovation will lead to a lack of development of current technologies and their failure to commercialise. This would lead to no change in the techniques used widely to treat ELVs across the EU between 2006 and 2015, with the impacts of that able to be judged from current practices.

6. ENVIRONMENTAL IMPACTS FROM DIFFERENT TREATMENT ROUTES FOR ELVS

Treatments or disposal for the materials that come from ELVs have a range of environmental impacts which vary significantly. Treatment of each material within the ELV will have a different environmental impact, depending on its characteristics. These impacts come from either:

- Environmental impacts caused by the treatment or disposal process; and
- Opportunities to substitute ELV materials for other materials in the economy (for example shredder plastic instead of oil for fuel) that reduce the environmental impacts of production and consumption of those substituted materials.

6.1 Recycling of metals

The various impacts of ELV waste depend on how the different materials in that waste are processed or disposed of. The following analysis is based on the assumption that an average ELV weighs 1,025 kg and comprises[88]:

• Ferrous metals	66%
• Non-ferrous metals	9%
• Fluids	2% (fuels 1%, waste oils and water based fluids – 1%)
• Tyres	3%
• Glass	2%
• Batteries	1%
• Plastics[89]	12%
• Other residues	5% (fibres, road dust, rust etc)

Existing processes and technologies already used commercially at shredding plants allow separation of the materials within ELVs into the following fractions[90] which can be sent to different treatment routes:

88 Assumption based on: RTL 2003, GHK/BIOIS 2006, Neubacher 2005, Stakeholder Working Group report 2005, interviews with other stakeholders.

89 For detailed composition of plastics see Annex VI. In summary, PP accounts for 40% of all vehicle plastics, followed by PU (11%), PA (8%) and PVC (7%). Other resins constitute less than 5% of vehicle plastics. Source: Gaiker.

90 Assumption based on: RTL 2003, GHK/BIOIS 2006, Neubacher 2005, Stakeholder Working Group report 2005, interviews with other stakeholders.

• Ferrous metals	66%
• Non-ferrous metals	9%
• Fluids	2% (fuels 1%, waste oils 0.5% and water based fluids – 0.5%)
• Tyres	3%
• Glass	2%
• Batteries	1%
• Plastics	8%
• Other residues	9% (remaining plastics 4%, shredder sand, shredder fibres, rubber, road dust, rust, etc)

In order to meet the 85% recycling target, some of the non-metallic fractions would need to be recycled. These could include fluids, tyres, glass, and plastics.

Currently, metals represent approximately 75% of materials used in cars. Available studies[91] and the stakeholders[92] confirm that the recycling route for metal scrap is already well established in the EU, both technologically and institutionally.

Primary production of metals is the source of approximately 10% of global CO_2 emissions; hence, reuse of metal parts and the use of recycled metals in vehicle production instead of virgin material contribute to the reduction of greenhouse gas emissions. The recycling of metals from ELVs has clear environmental benefits as compared to landfill, mainly due to reduced energy use in virgin metal production and reduced pollution related to mining of the virgin resource.

ELVs contain several different metals. The environmental benefits of metal recycling differ between the metals, but they all bring substantial environmental benefits[93]. It has been estimated that, compared to manufacture from virgin materials, recycled steel uses

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91 GHK/BIOIS compared the possible environmental benefits of different ELV treatment options, such as landfill, recycling, and different types of recovery. This study is limited in scope due to the lack of data on all plastic resins present in cars and a limited amount of information on recycling of other materials such as glass or fibres. As a result, it covered only 80% of materials present in vehicles, including ferrous and non-ferrous metals, 20% of plastics, and tyres.

92 Stakeholder Working Group, Final Report, p. 12, http://ec.europa.eu/environment/waste/pdf/elv_final_report_051104.pdf

93 For other metals, the energy savings are: aluminium - 95%; copper - 85%; lead - 65%; zinc - 60%. Source: *The Environmental Impacts of Motor Manufacturing and Disposal of End of Life Vehicles*, Cleaner Vehicles Task Force (Department of the Environment, Trade and the Regions), UK, March 2000 and; *Shredding and Media Separation*, Bureau of International Recycling, Brussels, www.bir.org/biruk/eolv.htm, 2000.

74% less energy, 40% less water, reduces air pollution by 86% and water pollution by 76%[94].

6.2 Plastics

There are about 15 different plastic resins involved in vehicles[95]. Plastics are the main material that would be involved in reaching higher recycling and recovery targets. They account for around 10% of today's ELVs and will account for 12% of ELVs generated in 2015. Plastics from ASR can be recycled, recovered or landfilled.

6.2.1 Recycling of plastics

Numerous studies on the treatment of plastics indicate that the environmental benefits of plastics recycling depend on the balance between the negative environmental impact of the plastics recycling process and the avoided impacts from production of the material replaced by the recycled plastics. If the recycled plastic product has significantly different physical performance characteristics, it might have additional environmental impacts.

Negative environmental impacts may also come from the additional activities required to separate plastics from other materials and any difference in the transport of plastics to recycling facilities compared to transport to recovery or landfill facilities.

The different polymers in ELVs have different characteristics which affect the impacts from the recycling process. Numerous studies on the treatment of ELV plastics - taken as a mixed whole - indicate that the benefits of plastics recycling as compared to recovery are not always environmentally clear. The evidence on individual polymers is clearer.

The use of a recyclate depends on its physical characteristics and therefore on its purity. Shredder residue is a mix of many polymers and other materials and the environmental benefits of recycling depend on the extent to which relatively pure plastic streams can be sorted from the shredder residue and processed so that they replace virgin material.

Not all recycling of polymers brings environmental benefits. For example, if polyurethane foam (PUF), which is used in auto seats, is recycled and used again in auto seats, the physical properties of the recycled material are not as good as those of the virgin material. Therefore, an extra amount of PUF must be used to provide the required performance of the seat. For example, to make one seat cushion from PU, 1.5 times the amount of recycled PU must be used compared to virgin material, which means that the use of the recycled PU will cause negative environmental impacts compared to the use of virgin material. However, if recycled PUF was used where its physical properties were

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94 The Environmental Impacts of Motor Manufacturing and Disposal of End of Life Vehicles, Cleaner Vehicles Task Force (Department of the Environment, Trade and the Regions), UK, March 2000 and; Shredding and Media Separation, Bureau of International Recycling, Brussels, www.bir.org/biruk/eolv.htm, 2000.

95 See Diagram 1, page 5.

more suitable and it replaced an equal amount of virgin PU, its use would bring environmental benefits. This is the case in its use in carpet underlay.

As an example of differentiated environmental impacts from plastics recycling (subject to conditions described above), GHK/BIOIS made an analysis of the plastic parts of ELVs for which Life Cycle Analysis data existed. Across all the parts that they looked at, the following range of environmental benefits and harms were produced from recycling (on a life cycle basis):

RECYCLING	Max. Harm (per tonne plastics)	Max. Benefit (per tonne plastics)
Energy consumption	12,700 MJ	105,200 MJ
Greenhouse gas emissions	6000 kg CO_2	4000 kg CO_2
Air acidification	45.5 kg SO2 equivalent	to 3.1 kg SO2 equivalent
Photochemical oxidation	-360 kg ethylene equivalent	100 kg ethylene equivalent
Water pollution	1,075,000 litres	10,800 litres
Eutrophication	530 kg PO4 equivalent	75 kg PO4 equivalent
Municipal waste	272 kg	70 kg
Hazardous waste	30 kg	11 kg

Table 5. Ranges of environmental impacts from plastics recycling – all plastic resins[96].

6.2.2 *Mixed plastics recycling*

Recycled plastics mix containing many different polymers has few uses since its physical properties are very rarely suitable for replacement of virgin plastic material for any application. Production of substantially mixed plastic recyclates usually brings environmental detriments because they can only be used to replace low impact materials (such as wood).

Without separation of plastics before their conversion into recyclates, this would be the result of increased recycling. This is one of the factors that lead GHK/BIOIS to form the view that "above a certain threshold, which is not possible to determine but which is higher than 78% (…), the higher the recycling target, the lower the environmental benefits".[97]

GHK/BIOIS carried out an assessment in which the recycling of each material fraction of an ELV is evaluated for its potential to save greenhouse gas emissions[98]. The results for material fractions were then assembled into an overall result for the recycling of all ELV materials. The following diagram demonstrates the environmental benefits of different recycling targets for ELV waste in general (all materials) in terms of CO_2 equivalent savings.

96 Source: GHK/BIOIS 2006, p. 126. See also Annex XIII.
97 GHK/BIOIS 2006, p. 181.
98 See tables in Annex VIII A and B.

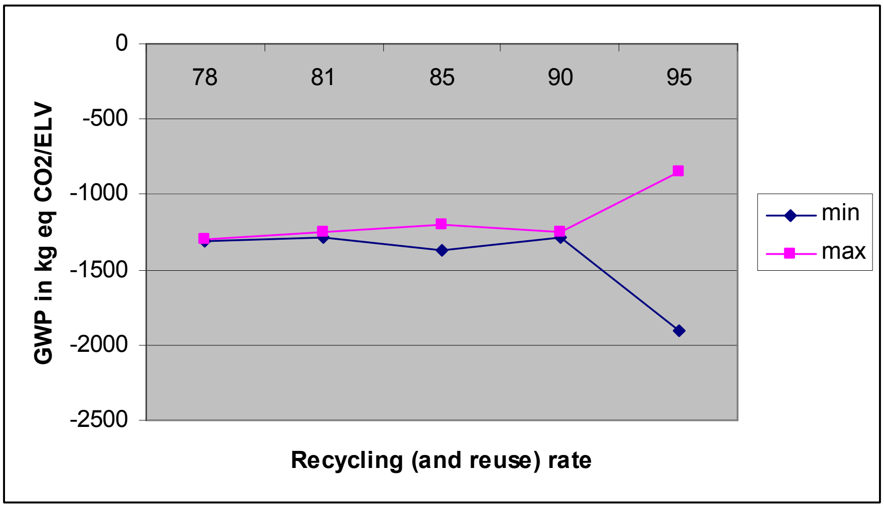

Diagram 5. Environmental benefits for different recycling (and re-use) targets.

It can be seen that the environmental benefits of increasing recycling targets are not linear. Even with future technology advances much of the plastic would not be available for formation into recyclates for anything but mixed plastic which would be environmentally harmful compared to the alternative treatment or disposal routes.

6.2.3 Recycling of individual polymers

When the impacts of recycling into granulates are discussed in this impact assessment, it refers to the recycling of sorted polymers into recyclate. Only part of the plastics in an ELV would be able to be treated in this way, even under the highest technological scenario considered. For example, under the high technological development scenario, where innovation is expected to lead to improved separation techniques, it is predicted that a maximum of 7% of the ELV by weight or around 45% of the plastics in an ELV can be separated sufficiently and recycled into recyclate. The remainder of the plastics are assumed to go to other treatment options – the recycling of mixed plastic fractions into mixed plastic recyclate is not considered.

Similarly under the lowest technological development scenario for 2015 85% recycling targets, it is assumed that plastics representing 2% of the ELV (or 15% of the plastics in the ELV) are recycled into polymer recyclates with the remainder going to other treatment options.

All estimates on impacts are based on the recycling of that fraction of plastics in an ELV which can be separated with sufficient purity in 2015 to allow production of good quality recyclates that can be used to substitute 1:1 for virgin material in some applications, with losses during the recycling process taken into account.

The estimation of environmental impacts from plastics recycling in this impact assessment is based on the Fraunhofer[99] estimate of environmental impacts for recycling of PP/EPDM parts. This has been taken as representative for the types of polymers which would be recycled under advanced post shredder separation. Those are: PP, PE, PA/Nylon, PS/HIPS. These are also the polymers which make up the majority of plastics in ELVs and whose use in vehicles has been increasing in recent years.

The impacts for PP/EPDM are broadly representative for these polymers, being less environmentally beneficial in some impacts and more in others. The table below indicates these impacts[100]. Note that the Fraunhofer figures themselves only give an indication of the magnitude of impacts – the actual impacts of recycling these polymers would depend on a very large number of variables, concerning both the nature of the polymer, the level of impurities in the recyclate and the substituted material.

For the recycling of 1 kg of PP/EPDM bumper, the environmental impacts are:

RECYCLING	Benefit/ (Harm) per tonne	Unit
Energy consumption	5.680	MJ
Greenhouse gas emissions	992.000	g CO_2 equivalent
Air acidification	1.710	g SO_2 equivalent
Photochemical	720	g ethylene
Water pollution	(20)	m3
Eutrophication	780	g PO_4 equivalent
Municipal waste	(20)	kg
Hazardous waste	(8)	kg

Table 6. Environmental impacts of recycling of 1 kg of PP/EPDM bumper. Source: Fraunhofer Institut fur Verfahrenstechnik und Verpackung (Till Nurrenbach, Dr. Gertraud Godhan, Alexandra Wokock), Verwenung von Kunststoffbauteilen aus Altautos – Analyse des Umwelteffekte nach dem LCA-Prinzip und okonomische Analyse, 2002.

[99] *Verwertung von Kunststoffbauteilen aus Altautos – Analyse des Umwelteffekte nach dem LCA-Prinzip und ökonomische Analyse*, Fraunhofer Institut für Verfahrenstechnik und Verpackung (Till Nurrenbach, Dr. Gertraud Godhan, Alexandra Woköck, May 2002.

[100] More details on the ranges of the environmental impacts of recycling of mixed polymers are in Annex XVI.

6.2.4 Recycling of plastics as fibre

The use of shredder fibre fraction for alternative applications (e.g. sewage sludge treatment) will have very different environmental impacts. For example, where it is used to replace fibrous coal in sewage sludge dewatering, the largest environmental impact will come from the reductions in tonnage of coal burnt when that sewage sludge is burnt or incinerated.

6.2.5 Recovery of plastics

Recovery of plastics from ASR may involve processes of energy recovery in different facilities and substituting for different fuels at different levels of efficiency. Moreover, environmental results will vary according to plastic resin: each resin has different environmental impacts.

- Plastics recovery in cement kilns

Energy recovery in cement kilns has the most beneficial environmental performance of all the recovery options, regardless of the resin mix and the type of substituted resource. It scores very well in terms of energy savings, CO_2 emissions (greenhouse effect), production of municipal and hazardous waste. Compared to landfill, this option comes out better for all impact categories when the spared resource is brown coal. When other resources are substituted, the results will be more varied[101].

- Plastics recovery in blast furnace

Feedstock recovery in blast furnace brings about clear environmental benefits in terms of energy savings. As regards other impact categories, it can be either beneficial or detrimental to the environment, depending on the plastic resin considered and the substituted resource. It is environmentally beneficial when the substituted resource is heavy oil (except for water pollution). When the spared resource is hard coal, landfill can be better for some resins in terms of water pollution and air acidification[102].

- Plastics recovery – syngas production

Syngas production is environmentally beneficial in terms of energy savings, regardless of the resin recovered and substituted resource. For other impact categories, as in the case of blast furnace, the results will vary and depend on the type of plastic and spared resource. When plastics are used in syngas production to substitute waste oil, the environmental performance of this option is better compared to landfill. However, when plastics substitute other resources, the results are more varied and can bring about environmental detriments[103].

- Energy recovery from plastics in municipal incinerators

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[101] For details see GHK/BIOIS 2006, p. 155.
[102] For details see GHK/BIOIS 2006, p. 155.
[103] For details see GHK/BIOIS 2006, p. 155 and Annex XIII.

MSWI of plastics with energy recovery generates environmental benefits in terms of energy savings, with no potential detriments. On the other hand, it is detrimental for the environment in terms of greenhouse gas emissions and production of hazardous waste. When compared to landfill, this recovery option shows the most contrasted results, depending on the resin and the substituted resource. Only PP/EPDM recovery with savings of steam proves to be clearly better than landfill. For other resins, incineration with energy recovery performed often worse than landfill in terms of global warming potential and hazardous wastes production, but better for other impact categories[104].

All recovery options above have worse environmental performance than recycling when the resin treated is PA, PC or ABS. For other resins (PP, PUR, plastics mix from dashboard, PE), the results depend on the resin, the recovery option, the substitution rate and the impact category considered.

Recovery options available in 2015 will probably not only include the usual possible routes (blast furnaces, cement kilns, municipal incinerators) but also others whose price is equally hard to predict, e.g. gasification for feedstock.

Depending on the definition of recovery or recycling, the use of processed mineral fractions of shredder residue may be classed as recovery in some Member States, being used either in construction or filling of mines. In this case, there is greater flexibility in the amount of the shredder light fraction which could, depending on the relative prices, be sent to landfill.

6.2.6 Landfill of plastics

All the analysed ELV plastic resins prove a negative environmental impact when landfilled. Hence, this option proves to be clearly detrimental to the environment for all impact categories.

LANDFILL	Positive impact per tonne of plastics	Negative impact per tonne of plastics
Energy savings / losses	none	200 to 620 MJ
Greenhouse gas emissions	none	32.6 to 364 kg CO_2
Air acidification	none	0.01 to 1.5 kg SO2 equivalent
Photochemical oxidation	none	0 to 1.4 kg ethylene equivalent
Water pollution	none	600 to 47,440 litres polluted
Eutrophication	none	3 to 85 kg PO4 equivalent
Municipal waste	none	1000 kg
Hazardous waste	none	none

Table 7. Environmental costs from plastics in landfill[105]

104 For details see GHK/BIOIS 2006, p. 155.
105 For details see Annex V and Annex XIII.

It appears from the analysed data that higher recovery targets are environmentally beneficial where specific recovery techniques are used for a given mix of plastics and where recovery is used to substitute a given type of resource. Overall, cement kiln performs better than blast furnace, followed by syngas production and with waste incineration with energy recovery scoring worst[106] (see also Annex VII). Thus, an evaluation of whether recovery is in a given case more beneficial than landfill or recycling would require a case by case assessment of environmental performance of a given treatment option for a material treated. It appears possible to identify specific treatment options with defined characteristics for which plastics recovery would be beneficial compared to landfill and mechanical recycling, but further studies would be necessary. The above environmental benefits and uncertainty concerning certain scenarios are also valid for lower recovery targets.

6.3 Glass

Studies[107] and stakeholders confirm that the recycling route for vehicle glass is currently underdeveloped. There are three major types of automotive glass in an average ELV: windscreens, rear windows and side windows (each of approx. 10 kg / ELV). Glass recycling involves treatment of glass in special glass smelting plants (automotive glass has specific properties and cannot be recycled alongside with other major sources of recyclable glass, e.g. packaging glass). The use of recyclate in a production process reduces the use of raw materials and energy and results in the reduction of CO_2 emissions[108]. However, no numerical data on the environmental impacts of automotive glass recycling are currently available to the Commission.

The conditions for successful recycling of automotive glass include its separate collection and avoidance of mixing glass with other materials. The removal of glass is however difficult and costly, depending on the method of sealing. Mineral raw materials used in glass production are low-price commodities. Therefore, taking into account the expenses of collection, transport, and treatment of glass, the remuneration of saving the raw material is relatively low (compared to metals)[109].

6.4 Rubber and other residues

Typical routes of treating tyres include their retreading, rubber recycling, use as fuel, reuse in civil engineering and landfilling. Approximately 10% of tyres are exported. As of July 2006, a ban on landfilling tyres entered into force in the EU[110]. Hence, all tyres will need to find an alternative disposal route.

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106 Incineration performed worse than mechanical recycling with substitution rate = 1 for all impact categories, but the result for substitution rate below 1 was differentiated. Compared with landfill, incineration with energy recovery performs better for all impact categories except CO_2 emissions and eutrophication.

107 Neubacher, *Evaluation of the Measures and Targets of the Austrian End-of-Life Vehicles Ordinance with regards to the Implementation of Directive 2000/53/EC*, 2005.

108 Neubacher, 2005, p. 24.

109 Neubacher, 2005, p. 25.

110 Article 5(3)(d) of Directive 1999/31/EC on the landfill of waste, OJ L 182, 16.71999, p. 1.

Tyres have a high potential for recycling and recovery. Recycling of rubber brings about considerable savings of resources and energy[111]. Recycling is approximately 2.6 times more beneficial in terms of energy savings than thermal recovery. Thermal recovery of tyres can result in savings of approximately 20% of primary energy carriers (normally hard coal), depending on the furnace system. Recycling of tyres produces granulates which can be used in many applications, including rubber products, rubber asphalt and innovative plastic alloys ("Elaplasts, elastomers-polymer plastic alloys)[112].

6.5 Transportation issue

In some cases, due to a limited capacity of waste treatment plants, ELV waste fractions need to be transported over distances from dismantlers to recycling plants, which would produce negative environmental impacts from the transport that would offset part of the benefits from recycling.

To reduce transport costs, commercial operators are very likely to install post-shredder separation plants either at the shredder plants, or optimally located between shredders, particularly where diffusion of post-shredder technology becomes widespread. This will also have the effect of reducing the environmental impacts of transport, as only the required separated fractions would be sent to recyclers (e.g. the separated PP, PE and PS). Whether the result would be environmentally positive or negative would depend on the distance, material recycled, and efficiency of the plant, and needs to be assessed on a case by case basis for each set of conditions. Available data make it is impossible to precisely quantify the possible impacts of transport.

7. TREATMENT ROUTES UNDER DIFFERENT SCENARIOS

The costs and benefits of the targets will depend on the technologies, techniques and capacity of treatment facilities available in 2015. For example, if efficient treatment technologies develop to recycle some types of plastic, the environmental benefits from recycling that plastic will be higher than they would otherwise be.

It is expected that by 2015 and under different targets (scenarios) the following shares of materials will go for different treatment routes:

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111 An expenditure of energy of 15 kWh/kg is necessary to produce a rubber mix of primary material, while only 1.2 kWh/kg is necessary to recover the same weight from scrap tyres. Hence, production energy of 23.8 kWh/kg (85.7 MJ/kg) can be saved. Only 9.0 kWh/kg (32.4 MJ/kg) can be saved in a thermal recovery process of tyres. Therefore, the energetic benefit from the recycling of tyres is over 2.6 times higher than the energetic benefit from thermal recovery. Source: Neubacher 2005, p. 23.

112 Neubacher 2005, p. 23. For more details on possible applications of tyres, see Annex VIII.

Materials and Treatment Options	% for each scenario				
	No Policy Change (High Tech)	No Policy Change (Low Tech)	80% recycling, 95% recovery	85% recycling, 90% recovery	80% recycling, 85% recovery
Recycling					
Ferrous metals	**66%**	**66%**	**66%**	**66%**	**66%**
Non-ferrous metals	**9%**	**9%**	**9%**	**9%**	**9%**
Fluids	**1%**	**1%**	**1%**	**1%**	**1%**
Tyres	**2%**	**2%**	**1%**	**1%**	**1%**
Batteries	**1%**	**1%**	**1%**	**1%**	**1%**
Plastics	**7%**	**2%**	**2%**	**7%**	**2%**
Shredder sand (glass, road dust, rust, etc)	**4%**	**4%**	**0%**	**4%**	**0%**
Recovery					
Fluids	**1%**	**1%**	**1%**	**1%**	**1%**
Tyres	**1%**	**1%**	**2%**	**2%**	**1-2%**
Plastics	**5%**	**10%**	**10%**	**0-5%**	**0-10%**
Other residues (textiles, rubber)	**2%**	**2%**	**2%**	**2%**	**2%**
Landfill					
Other residues from shredder sand (glass, road dust, rust, etc)	**1%**	**1%**	**5%**	**1%**	**5%**
Plastics	**0%**	**0%**	**0%**	**0-5%**	**0-5%**

Table 8. Shares of materials going for different treatment routes under different targets and scenarios.

Under the High Technological Development Scenario, around half the plastics in ELVs would be able to by recycled from 2015 onwards (a large proportion of PP, some PE, ABS/HIPS and some PA) a greater proportion of tyres would be recycled and much of the 'shredder sand' fraction could be made inert and used in construction (see table 7 above). This would achieve re-use and recycling of 90% of ELV, with the potential (not shown in the table above) of higher recycling if the use of shredder fibre as a dewatering agent for sewage sludge takes places and is included as recycling. This may provide a use for around 7% of the ELV, comprising plastics, remaining tyres, textiles and rubber. However, under an 85% target recovery may be a more financially attractive option for this fraction.

Under the Low Technological Development Scenario, a significantly smaller proportion of ELV plastics would be recycled, a proportion of tyres, and either the majority of shredder sand or the fibrous fraction of ASR would be recycled. It is possible that the fibrous fraction of ASR, which would be made up of around 5% of plastics with textiles and rubber, is recycled to meet the 85% target instead of shredder sand.

8. Economic costs and benefits of different treatment routes under the scenarios

8.1 Economic impacts: the basis of cost estimates for different treatment routes

The details of cost estimates used in this impact assessment are presented here. The section below explains the underlying assumptions.

To assess the economic impact of the policy options requires looking at the value chain of the ELV, from the point that it becomes an ELV to the final use or disposal of its constituent materials. Market pressures and relations between the different parties in this chain will influence how value and costs are allocated between the different parties involved.

Working backwards, the total end value of the ELV is made up of:

- Value of ferrous metal for recycling (a % of the value of the recycled metal)
- Value of non-ferrous metals for recycling (a % of the value of the recycled metal)
- Value of the recycled plastics
- Value/cost of final use/disposal of the mineral fraction
- Value/cost of use/disposal of the fibrous shredder light fraction and un-recycled plastics

Out of this net value, there are certain costs of the processes steps:

- Cost of shredding
- Costs of advanced post-shredder sorting and separation
- Costs of processing high plastic fractions into plastic recyclates
- Transport costs:
    - of ELV to shredder
    - of shredder fractions to next use/disposal
- Depollution costs
- (Possibly) Dismantling costs

The difference between the values and the costs is divided between:

- Price paid to the last owner/supplier of the ELV
- Profit for the dismantler
- Profit for the shredder
- Profit for the plastics recycler
- Profit for the receiver of fractions for final disposal (e.g. landfill owner or cement kiln operator)

In a market economy, the net value of the ELV would be expected to be spread between these parties, though market pressure may give one of the parties/firms a strong position to be able to extract most of the benefits. For example, use of shredder fibre in a cement kiln may save cement firms money, but if they are the cheapest disposal route for that fibre that has no other uses and is banned from landfill, they will be able to charge almost any price for accepting the fibre – making a profit at the expense of the profit of the shredder and the last owner.

From this analysis, it is clear that the net economic benefit of the treatment of ELVs depends on:

- The price of metals
- The costs of processing
- The value of recycled plastics.

Note that there are no costs for automobile manufacturers, whose liability depends on the legislative regime in the Member State, but who in many Member States currently have no legal financial liability for the costs of ELV treatment, even if those are negative.

For each policy scenario, estimates can be made of the costs of the process, although with cost data often available in the form of transaction prices or gate fees for processing. With firms unwilling to state how much profit they make from processing, the net economic benefit is not easy to judge absolutely. It is easier to be clear about the relative impact of policy options on the economics, which is sufficient in this case to allow useful comparison.

8.2 The analysis of the economics of the ELV treatment process – scenarios considered[113]

2015 Low Technological Development scenario **(low technological development in recycling and dismantling technologies)**	
Value of metals that can be obtained from 2015 ELVs:	
Current value of metals extracted from ELVs	€120[114],[115]
Additional value in 2015 due to extra weight of metals (particularly non-ferrous in 2015 ELVs)	€20[116]
Value of greater separation of metals from shredder residue allowed by increased technology	€10[117]

[113] In these estimates, for clarity of understanding the figures, a 2015 ELV is assumed to weigh approximately 1 tonne. However, as indicated on p. 4 above, manufacturers' data indicates that ELVs from 2015 can, on average, be 20 to 25% heavier than this. The impact of this on the calculations is described below.

[114] 2002 Estimate from ADEME (2003) in Annex 4 of GHK/BIOIS 2006 France case study, plus value of catalytic converter.

[115] With the assumption that the current market price for metals remains broadly the same.

[116] Estimate from GHK/BIOIS 2006 study (p.19).

in 2015	
Total	**€150**
Other values:	
Value of plastics for recycling that can be (currently) obtained from ELVs:	€5[118]
Value of parts for re-use	€10[119]
Value/Costs of disposal of shredder mineral fraction (per ELV)	€0 to -€5[120]
Value/Costs of disposal of fibre and unwanted plastic fraction	€10 to -€10[121]
Total	**€25 to €0**
Process Costs:	
Costs of advanced separation of shredder light fraction (per ELV)	-€15[122]
Transport	-€15[123]
Costs of shredding and basic shredder fraction separation	-€35[124]
Costs of Depollution	-€30[125]

117 With the assumption that technologies that separate out a greater proportion of metals will be widely used by 2015. Existing advanced techniques can recover the 8% of ASR which is currently ferrous and non-ferrous metals. Source: GHK/BIOIS 2006, Annex 3, p. 7.

118 Under dismantling, achieving 83% recycling, as in the Netherlands, 8.4% of ELV weight (exc. fuel tanks and metals are recycled), which equals 77kg (GHK/BIOIS, Annex 4, p. 48, 2004 figures). Whilst high quality recyclate plastics can sell for €1000/tonne, the value (rather than the sales price) of the ELV recyclates before recycling is today much less. If technology does not improve, the value of plastics can be €5 per ELV, at a value of around 250€/tonne of recyclate.

119 €10 estimates the average value of parts taken by dismantling, including those from 'premature' ELVs, less the dismantling costs for these parts alone.

120 The mineral fraction of shredder residue is around 5%, or 50kg per ELV. When processed, this can be used in construction or as filler. Processing to make it inert may turn any value in that filler into a cost of €100/tonne or €5. Alternatively, a landfill fee for this fraction may be up to €140/tonne, so up to €7 per ELV here. In this table, using high landfill figures, it is estimated as up to €5 per ELV.

121 The shredder light fraction that does not go for recycling in 2015 worst case scenario is estimated to make up 10% of the ELV, i.e. around 100kg. Treated, the most financially advantageous use of this fraction is likely to be as a substitute in blast furnaces where it substitutes for coke and brings savings of around €100/tonne to the furnace operator – hence a value of €10. The most expensive treatment route for this section is municipal incineration, where costs are €100/tonne, so cost per ELV is €10.

122 The shredder light fraction, assuming some tyre re-use, is approximately 16% of the ELV (about 160kg). Current process costs for post-shredder separation are €100/tonne, so the maximum 2015 cost of treatment would be 15kg/ELV.

123 Transport costs depend greatly on distance. This is a high estimate of likely costs.

124 Estimate of shredding costs per ELV (using modern shredders that include some additional sorting of shredder residue). Source: data in Annex 4 to GHK/BIOIS 2006 and stakeholders.

125 Depollution costs are estimated at €30 (for France, so a high estimate for the EU). Source: data in Annex 4 to GHK/BIOIS 2006. (The Stakeholder Report gives a cost of €45-80 for depollution and

(Potential costs of dismantling)	(up to -€100)[126]
Total (no dismantling)	**-€95**
Low Tech Scenario Total Value/Cost of process (advanced separation rather than dismantling)	
Value of metals	€150
Value/costs of other materials	€25 to €0
Costs of processing	-€95
Net value/costs	**€80 to €55**

Table 9. Economics of ELV treatment under Low Technological Development Scenario

In the High Technological Development scenario, a greater share of plastics can be recycled at a higher value, some disposal costs are smaller and costs of the separation process are smaller. The changes are to the value of plastics for recycling that can be (currently) obtained from ELVs, the value/costs of disposal of fibre and unwanted plastic fraction, and the costs of advanced separation of shredder light fraction (per ELV).

2015 High Technology Development scenario (high technological development in recycling and dismantling technologies)		
Changed values/costs in the High Tech Scenario		
		Change
Value of plastics for recycling that can be obtained from ELVs	€40[127]	+€35
Value/Costs of disposal of fibre and unwanted plastic fraction	€15[128] to -€10	+€5 to 0

current dismantling to the Annex I standards, including admin costs, of which depollution will be the smaller part.)

126 See this IA's previous description of dismantling. Costs generally depend on the quantity of dismantling that takes places, with marginal costs rising steeply as levels near 70kg are reached. "Up to 100" is used as indicative. In practice, dismantling is only likely to take place in 2015 where labour costs are sufficiently low for dismantling to be cheaper than investment in post shredder technologies. For this reason, costs assumptions here are based on dismantling being a substitute for advanced separation and the costs of dismantling not included elsewhere in the calculations.

127 With technological advance it is estimated that 7% of plastics could be recycled in 2015 to produce good quality recyclate. If it is conservatively assumed that this produces 5% of recyclate, due to losses in the process, this would be 50kg. Prices for good recyclate are just below prices for virgin plastic which they substitute, currently around €1000/tonne for PP. If the cost of the recycling process is estimated at €200/tonne, the value of 50kg is around €40, giving a figure of €40/ELV.

Costs of advanced separation of shredder light fraction (per ELV)	-€15[129]	€0
Total Change in Value		**+€40 to €35**
High Tech Scenario Total Value/Cost of process (advanced separation rather than dismantling)		
Value of metals		€150
Value/costs of other materials		€65 to €35
Costs of processing		- €95
Net value/costs		**€120 and €90**

Table 10. Economics of ELV treatment under High Technological Development Scenario

80% recycling, 95% recovery in 2015 **Zero Technology Development scenario** **(No technological development in recycling and dismantling technologies)**	
No Technological Development scenario total value/cost of process with 80% recycling	
Value of metals	€140
Value/costs of other materials	€20 to -€10
Costs of processing	-€125 to - €145
Net value/costs	**€35 and -€15**

Table 11. Economics of ELV treatment under Zero Technological Development Scenario

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128 Technological advance in post shredder separation and combustion and gasification technologies may well produce more valuable uses of the shredder light fraction. Here, figures of €150/tonne are used for the most financially attractive uses. The potential highest cost option - municipal incineration - is retained.

129 The best case assumes that retained 85% targets boost on-going R&D and innovation diffusion, so that in the minimum of 8 years up to 2015 and afterwards technologies for separation are more efficient, and have reduced costs by at least 20%. Cost reductions in technology are widely observed across a number of fields as technology matures. However here, even under high tech, we assume constant costs, with scope for the need for more advanced technology to process ASR requiring more complex technology that offsets cost reduction.

8.3 Basis of the Economic Analysis

8.3.1 Metals recycling

Based on information from ADEME (2003)[130], ferrous metals attract a price of €90-95/tonne, and the mix of non-ferrous metals €200-350/tonne. At these prices, metals in a 2015 ELV weighing 1 tonne, with 650 kg ferrous and 100 kg non-ferrous would be worth around €80-90.

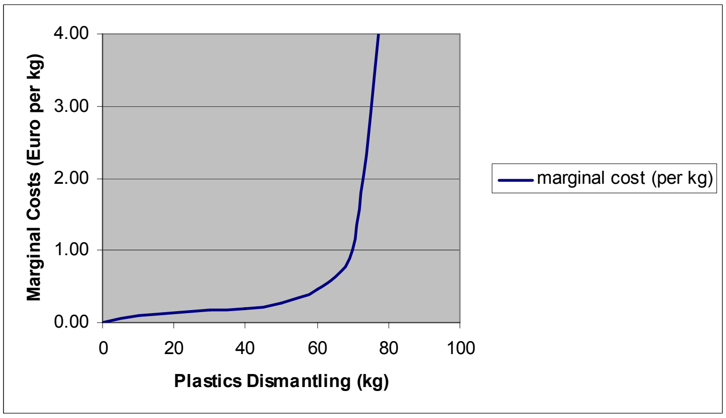
The value of the metals in a depolluted ELV depends on the weight of each metal involved and the market price at the time. The value in 2015 is likely to be around €20 higher than current values due to the increased weight of metals in each ELV and an increase in the more valuable non-ferrous metals. This figure reflects the average material composition of 2015 ELVs and similar metal prices. Movements in metals prices would lead to values of the metals being smaller or greater. Recycling of the catalytic converter with its precious metals content on an ELV will add another €25 to the value of the ELV.

8.3.2 Plastics recycling

The economics of plastics recycling depend on the route chosen, the technology used and the costs or labour and capital[131].

8.3.2.1 Dismantling

The time taken to dismantle parts from an ELV increases once the easy to remove parts have been taken out. Dismantling of a higher amount of plastics from an ELV becomes increasingly expensive as dismantlers have to reach smaller and difficult to access plastic parts within the ELV. The graph below shows an estimate for the marginal cost of dismantling for Western European dismantlers. The marginal cost is the price of removing an extra kg.



130 See GHK/BIOIS 2006, Annex 4, France case study.

131 The description below gives estimates of the estimated cost to society of the treatment route, not the gate fee paid by holders of waste to have it treated or disposed of. That gate fee - the price - may well not represent the true costs of treatment, but may be higher due to taxation, or include profits for the treatment facility. The extent to which treatment facilities can raise their prices/gate fees above costs depends on their market strength, and the prices and capacities of alternative treatment routes.

Diagram 6. Marginal Costs of Plastics Dismantling

In countries with lower wage costs, the costs of dismantling will be smaller but would follow the same pattern. In all cases, it implies that dismantling more than around 75kg of plastics from an ELV becomes very cost inefficient. The above curve is based on 2006 ELVs but is assumed not to change significantly for 2015 ELVs which contain more plastics. This additional plastic content may allow slightly greater amount (perhaps 90kg) of plastic to be dismantled before marginal costs rise so steeply.

GHK/BIOIS[132] draw on existing studies to suggest dismantling costs for plastics of €200-300/tonne for dismantling of 30-40kg of plastics from each ELV, with costs rising towards €1,000/tonne for dismantling much larger quantities (e.g. 70kg). Taking Poland as an example of a low wage country, the costs of dismantling will be proportionately lower[133].

8.3.2.2 Polymer recycling

Plastic recyclates are sold at just below the market price for virgin material to companies that specialise in producing good quality polymer recyclates. Plastics inputs into the process are bought from shredders or dismantlers for small amounts of money, with the recycler's profits coming from the difference between the costs of the process, the cost of buying the input, the costs of disposing of unused plastics and impurities and the price for recyclates. Whilst the business has been profitable for several years, recent increases in raw materials prices have substantially strengthened profits.

8.3.2.3 Advanced sorting of shredder residue

Gate fees for the VW-SiCon process are currently given as €20-50/tonne (GHK/BIOIS 2006). ARN, who are constructing a VW-SiCon plant estimate that, together with other initial costs of installation, treatment costs reach €100/tonne. Other advanced separation processes currently appear more expensive. By 2015, these costs are likely to have fallen as technology improves to €80.

8.3.3 Recovery of shredder residue

8.3.3.1 Cement kilns and power plants

Sorted plastics waste can be sent to cement kilns at no extra cost[134], although cement kilns may be able to charge for accepting plastics waste due to lack of alternative treatment options in some Member States. This suggests that cement kilns either face no extra costs from taking plastics waste, or that they gain because they can substitute more expensive alternative fuels. The required sorting of the shredder light fraction before it meets the standards usually required by cement kilns might be taken as a maximum of the VW-SiCon costs as €100/tonne, though this is likely to be cheaper in 2015. Power plants that can take shredder

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132 GHK/BIOIS 2006, Annex 2, pp. 17-20.

133 Gross average monthly remuneration in the enterprise sector as October 2004 was 2,100.911 PLN (i.e. around 515 € as of 28 June 2006). Source: Polish National Bank, www.nbp.pl (as of 28 June 2006); Polish Statistical Office, http://www.stat.gov.pl/.

134 Source: Personal communication from Galloo.

residue derived waste are likely to require similar levels of pre-sorting, estimated to be at similar cost.

8.3.3.2 Blast furnaces

Blast furnaces can take plastic waste without charge, or pay small sums to receive it as plastics can substitute for coke, a resource which has greatly increased in price in recent years. This indicates that there is no cost to the blast furnace; instead, shredder residue is worth just under the value of its substitute.

However, blast furnaces usually need thorough sorting of the shredder light fraction to ensure that impurities do not damage the quality of their output. This pre-sorting needs to be of a standard similar to the VW-SiCon process. Costs for pre-sorting in 2015 are difficult to judge, but might be taken as a maximum of the VW-SiCon costs of €100/tonne.

8.3.3.3 Gasification and feedstock recycling

Gate fees for Twin-Rec plants are between €120-200/tonne. Similar prices are likely for the SVZ Schwarze Pumpe process, which indicates the likely maximum 2006 cost of the process. Process costs are likely to decrease for similar technologies by 2015.

8.3.3.4 Municipal waste incineration with energy recovery

Charges for waste incineration in Germany range between €70-300/tonne[135]. For new plants, costs of €100/tonne are regarded as realistic. Only basic sorting, if any, to remove the inert fraction is required.

8.3.3.5 Capacity of recovery plants

In many EU Member States, there is currently insufficient recovery capacity to recover all the high-calorific plastics and fibre waste that will come from all waste streams in 2015. To treat these waste streams, investments will be needed in many Member States. These investments are high and range from 11 m € (VW-SiCon) to 90 m € (Citron) per plant[136]. Assuming a low investment scenario, at least 300 m € would need to be invested in order to establish PSTs of sufficient capacity to treat 2.8 m t of ASR in 2015 in the EU. Adding the operating costs of 100 €/t, total costs sum up to at least 580 m € in 2015 (excluding transport costs). The return of investment, however, can take place after approximately 3 years.

Investments may be stimulated by higher taxation or closure of landfills for some wastes. However, without sufficient capacity, the full range of recovery options described here may not be available. For other reasons, operators of blast furnaces or cement kilns may restrict access to their plant for recovery.

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[135] The April 2002 newsletter of the Swiss Auto Recycling Association quotes costs of 230-400 CHF/t (149-259 €/t) for transport and incineration in Switzerland and 345 CHF/t (223 € /t) in Germany.

[136] It is estimated that four VW-SiCon plants would be necessary to treat all shredder residue (also from WEEE) generated in Germany. One plant has a treatment capacity of 100,000 tonnes.

Regulatory uncertainty, from delays in deciding on targets or definitions, is likely to delay investments and potentially increase costs by reducing the window for investment and cutting planning time.

8.3.3.6 Note on the investment cycle and regulatory certainty

If (as seems likely) advanced separation technologies and recovery technologies are used to meet the targets, new investments will be required. When legislation requires firms to undertake investments outside of their investment cycle, the costs are higher than they might be where investments can be co-ordinated with pre-planned replacement of obsolete or worn-out equipment.

However, regulatory uncertainty from delays in deciding on targets or in definitions is likely to delay investments and increase costs by reducing the window for investment and cutting planning time.

8.3.3.7 Note on estimated weights in ELVs from 2015 onwards

In the calculations assumed in this economic analysis, for clarity of understanding, ELVs from 2015 onwards are assumed to weigh approximately 1,000kg. Estimations of ELV weight based on the weights of new manufactured cars indicate that the weights will be around 1,280kg by 2019 and on an increasing trend. This increased weight increases the total value of the materials in the ELV, but also increases the costs of processing, which are typically estimated per tonne. These increases offset each other, but do not balance out exactly.

The effect of changing the assumption about the weight (for example a weight of 1,200kg in 2015, increasing to 1,280 kg in 2019) would be an increase of the net costs in the low and zero technological development scenario by around €4/ELV and an increase of the net value in the high technological scenario by around €4/ELV. As weights get higher from 2015 onwards this effect would increase, e.g. with the increase in value being €5 towards 2020.

This increase in weight therefore accentuates the difference between the value from scenarios by around €8 to €10/ELV, with the high technological development bringing €10 greater net value than the low technological scenario.

This sensitivity should be bourn in mind when considering the estimates of value below.

8.3.4 Disposal of shredder residue or mineral fractions to landfill

The costs of landfilling shredder residue or any part of it in the MS where this is permitted by legislation currently vary greatly[137]. These differences result from varied operating costs,

[137] Today, landfill costs in the EU range from €30/tonne in the Czech Republic and €40/tonne in Hungary, to approx. €100/tonne in Sweden and in Denmark.137 Therefore, landfilling of the currently allowed volume of ASR brings about annual costs for the EU25 of a range between €9 million and €30 million, with a potential increase to €12.6 million to €42 million in 2015 if 15% of ASR continues to be landfilled. These figures do not take into account the costs of lost resources and potential social disbenefits of landfills. For details of costs of landfill in different Member States see GHK/BIOIS 2006, Annex 2, pp. 13-14.

market demand, legislation and taxation of landfill inputs. The costs of landfill operations have typically increased in the last decade as capacity decreases and tighter standards are required. Following this trend over the next decade, for the purposes of this assessment, we assume an average cost of landfill equal to the mid-point of the 2006 high Member State costs, i.e. €115/tonne.

Typical costs in:	**Range (€/tonne)**	**Midpoint (€/tonne)**
Low cost MS	30-40	35
Medium cost MS	50-80	65
High cost MS	90-140	115

Table 12. Typical Landfill Costs for ASR in the EU.

Summary of Estimated Costs per tonne[138]

Process	Current 2006 Actual Costs (Maximum)	Potential Economic Benefits	2015 High Tech Scenario Cost
Plastics recycling	€100 (AS)	Yes (from sales)	€80
Cement Kilns	€100 (AS)	Yes (from substitution)	€80
Blast Furnaces	€100 (AS)	Yes (from substitution)	€80
Municipal Incinerators	€100	No	€80
Gasification	€150	No (feedstock prices already included in figure)	€125
Landfill	€35-115	No	€35-€115
Dismantling	Up to €1000	Yes (from sales)	-

Table 13. Summary of estimated costs per tonne.

9. ASSESSMENT OF DIFFERENT OPTIONS

9.1 Baseline scenario – 85% recycling and 95% recovery in 2015

As investment in R&D and in types of treatment facilities will be strongly influenced by the targets chosen, the choice of policy option will change the technologies, capacity and practices for ELV waste treatment in 2015. High targets are likely to stimulate greater innovation in technologies dealing with recycling of the plastic fraction of ASR or with the dismantling of ELVs. These technologies are complex processes the outputs of which, under current definitions, can count partly as recycling and partly as recovery. Currently developed PSTs are technically able, with market and depollution practices, to recycle as much as 85%

138 Cost estimates for 2006 are used as the worst case costs (i.e. maximum costs) for 2015 and would occur if there was no technological progress in the intervening period.

and recover the remaining 10% of ASR[139]; thus, PSTs are technically capable to reach the 85% recycling and 95% recovery target.

Although there is a limited amount of information as regards the environmental performance of PSTs, an LCA of VW SiCon process[140] demonstrates that for a recycling target of 85% this PST performed better than manual dismantling with mechanical recycling for all impact categories analysed[141].

Targets of 85% for reuse and recycling and 95% for reuse and recovery will stimulate innovation in treatment technology by removing current existing blocks or market failures in innovation. The results of increased R&D in this area over the next 8 years can be predicted based on past innovation and the current state of technology. If R&D is successful, with high levels of innovation a scenario similar to the High Technological Development Scenario would be likely. If the R&D mostly failed to produce commercially attractive results, the Low Technological Development Scenario would occur. These two scenarios can be taken as indicators of the range of potential futures under 85% reuse/recycling and 95% reuse/recovery targets, with the actual outcome lying somewhere in between.

Policy options can be evaluated against the 85% reuse/recycling and 95% reuse/recovery baseline by considering their likely effects as a change from both the High and Low Technological Development Scenario.

Economic impacts are estimated by taking the estimated impacts per ELV and multiplying them by the number of ELVs predicted. The economic impacts are those described in the preceding sections of this Annex.

Environmental impacts are estimated by examining the likely material flows of materials from ELVs, estimates of the environmental impacts of those material flows per tonne, then multiplying those impacts by the number of tonnes of each material predicted. The environmental effects are those described in the preceding sections of this Annex. The majority of the environmental difference between the options depends on the treatment of plastics, and the analysis focuses on those.

As described above, the environmental impacts of thermal recovery processes depend both on the material (or polymers) being thermally recovered, the contaminants in that material and the process used: mainly dependent on the material which is substituted by the ELV waste and the efficiency of the recovery process. Introducing many different assumptions about these aspects would add to the detail of this impact assessment, but not to its clarity.

Here, the impact of thermal recovery of plastics waste is based on: 1) the life cycle figures for recovery of PP/EPDM; 2) an assumed mix of different recovery options in 2015. That mix assumes that for an 'average' tonne of recovery input in the EU, 40% would go to blast

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139 With the exception of Galloo for recovery and Schwarze-Pumpe for recycling. Source: GHK/BIOIS 2006.

140 Life Cycle Assessment of ELV Treatment – Comparison of the VW-SiCon process and the dismantling of plastic components followed by mechanical recycling, Volkswagen AG, June 2005.

141 Impacts categories analysed in the LCA include global warming potential, acidification potential, photochemical ozone creation potential and eutrophication potential.

furnaces, 40% to cement kilns, 10% to syngas generation and 10% to municipal solid waste incinerators. This mix has been chosen on the basis of judgements about the relative costs and availability of each of these four options across all Member States. There are a multitude of other assumptions which could be made, which would change the magnitude and, less frequently, the direction of the different environmental impacts. In general, the essential message of the environmental impacts would not change; under life cycle analysis, recovery is environmentally advantageous compared to landfilling of plastic waste.

Changing assumptions about recovery processes used can, on the figures used, change the balance between the environmental benefits/harm of recovery against recycling. Here, some of the limitations of Life Cycle Analysis are exposed: for instance it can not take account of the likelihood that recycled plastics also end their 'second' life in recovery, bringing about two sets of environmental benefits compared to landfill.

It appears from the analysed data that higher recovery targets are environmentally beneficial where specific recovery techniques are used for a given type of plastic and where recovery is used to substitute a given type of resource. Thus, an evaluation of whether recovery is in a given case more beneficial than landfill or recycling would require a case by case assessment of environmental performance of a given treatment option for a material treated.

9.1.1 Material flows in 2015

With the assumption that an average life span of a vehicle is 13 years, vehicles which will become waste in 2015 are already on the market, hence their material composition is known.

Materials and Treatment Options	% for this scenario No Policy Change (High Tech)
Recycling	
Ferrous metals	**66%**
Non-ferrous metals	**9%**
Fluids	**1%**
Tyres	**2%**
Batteries	**1%**
Plastics	**7%**
Shredder sand (glass, road dust, rust, etc)	**4%**
Recovery	
Fluids	**1%**
Tyres	**1%**
Plastics	**5%**
Other residues (textiles, rubber)	**2%**
Landfill	
Other residues from shredder sand (glass, road dust, rust, etc)	**1%**
Plastics	**0%**

Table 14. Shares of materials going for different treatment routes under 85% recycling/95% recovery targets and High Tech scenario.

Under the High Technology Development Scenario, environmental impacts can be estimated from the possible treatment routes for fractions of the ELV. This could lead to the reuse and recycling of 75% of metals, 7% of plastics (mainly polyolefins), and 3% of other fractions (fluids, tyres, batteries) per ELV. At the same time, 5% of the remaining mixed plastics would end up in recovery, as well as 5% of other non-metallic fractions including the remaining fluids, tyres textiles and rubber. Most of the rest (4%) glass, road dust, rust etc. would be made inert and could be recycled into construction, with the remainder (1%) landfilled.

It should be noted that an average estimated ELV weight used to assess the environmental impacts below is around 1,000 kg. In fact, this weight may be higher by 20 to 25%, as indicated above and as indicated by recent manufacturers' data. However, the direction of impacts will not change as a result of the increased weight, but and the magnitude of impacts would be greater. Possible differences in value are each time indicated in the text.

9.1.2 Environmental impacts (High Tech Scenario)

9.1.2.1 ELV recycling

Under the High Technology Development Scenario and with our assumptions, the environmental impacts from recycling 7% of plastic will be beneficial, resulting, for example, in annual savings of a range of 56 million GJ of energy and a range of 908,000 tonnes of CO_2 equivalent (70 million GJ of energy and a range of 1 220,000 tonnes of CO_2 equivalent in case of an ELV weighing 1,280 kg).

Energy savings (GJ)	56,000,000
Reduced greenhouse gas emissions (tonne of CO_2 equivalent)	980,000

Table 15. Additional environmental benefits of recycling 85% (compared to 80%) of PP/EPDM per year.

9.1.2.2 Recovery of shredder residue

The parts of the shredder light fraction which are not sorted and used for conversion into recyclates will need to be recovered in one of the four recovery options considered. This fraction will include the remaining mixture of plastics, rubber and textiles.

A 95% recovery, reuse and recycling target coupled with an 85% reuse and recovery target[142] would lead to the recovery of approx. 708,000 tonnes[143] of mixed plastics[144] per year) which would bring about estimated environmental benefits from the recovery process as set out below, in particular in terms of energy savings and reduced CO_2 emissions[145]. The actual impacts will depend on the above conditions.

Energy savings (GJ)	23,400,000[146]
Reduced greenhouse gas emissions (tonne of CO_2 equivalent)	225,000[147]

142 The recovery mix considered here includes 40% of plastics treated in blast furnace, 40% in cement kiln, 10% in syngas production and 10% in incineration.

143 881,000 tonnes for an ELV of 1,280 kg.

144 For details on the environmental impacts of mixed plastics for all impact categories considered, see Annex I, section 6.3, table 5.

145 For total impacts of recovery of PP/EPDM for a 95% recovery target see Annex XIII.

146 29,000,000 GJ for an ELV of 1,280 kg.

Table 16. Additional environmental benefits of recovery985% (compared to 85%) of PP/EPDM per year.

9.1.2.3 Landfill of shredder residue

Increase of the recovery target to 95% of ELVs by weight is likely to eliminate the landfill of plastics. Resulting benefits for the environment include reduced loss of resources, land savings, avoided contamination of landfills with pollutants from other waste streams such as PCBs, decreased emissions from plastics, reduced disamenity effects. Most importantly, since most of the plastics would no longer be disposed in landfills, negative environmental impacts of landfilling plastics would be avoided[148].

The mineral fraction of the shredder residue, containing sand, glass residues, road dust, rust etc. is likely to be landfilled, whether separated out using sorting technologies or sent directly to landfill. Sorted mineral fraction used in construction will be inert, but will substitute for other minerals. As the difference between these applications is small, and as the use or disposal of the mineral fraction is likely to be similar in each Member State whichever policy option is chosen, the environmental impacts of the mineral fraction make very little difference to the policy comparison and are not considered here.

9.1.2.4 Overall environmental impacts

Overall, the results of LCA illustrate that under a given set of conditions 85% recycling and 95% recovery targets can bring about average annual energy savings of almost 80 million GJ and reductions of greenhouse gas emissions of 1.2 million tonnes CO_2 equivalent from plastics treatment (99 million GJ and 1.5 million tonnes CO_2 equivalent for heavier ELVs). These results, however, are subject to changes once the basic conditions change (e.g. for other plastic fractions the results would be different).

Energy savings (GJ)	80,000,000
Reduced greenhouse gas emissions (tonne of CO_2 equivalent)	1,200,000

Table 17. Additional environmental benefits of 95% recovery and 85% recycling per year.

Impacts of 85% RR / 95% RRR (5% of plastics or 708,000 tonnes are recovered, 7% of plastics or 988,000 tonnes are recycled, 0 plastics landfilled)	5% recovery (708,000 tonnes plastics)	7% recycling (988,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-23.420.640	-56.118.400	0	**-79.539.040**	**GJ**
Greenhouse gas emissions	-225.144	-980.096	0	**-1.205.240**	**t CO_2 eq**

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147 280,000 tonnes of CO_2 equivalent for an ELV of 1,280 kg.

148 For total negative impacts of landfilling mixed plastics see Annex I, section 6.3.6, table 7. For impacts of landfilling PP/EPDM see Annex VI.

Air acidification	-991	-16.895	0	**-17.886**	**t SO_2 eq**
Photochemical oxidation	1.770	-711.360	0	**-709.590**	**kg ethylene**
Water pollution	1.309.800	-19.760	0	**1.329.560**	**m^3**
Eutrophication	-14.160	-770.640	0	**-784.800**	**kg PO_4**
Municipal waste	-101.173	19.760	0	**-81.413**	**t**
Hazardous waste	3.292	7.904	0	**11.196**	**t**

Table 18. Total environmental benefits of 95% recovery and 85% recycling (High Tech Development Scenario).

9.1.3 Environmental impacts (Low Tech Scenario)

Under similar assumptions to the ones above, the impacts from plastics if the targets bring about the Low Technological Development Scenario would be:

Impacts of 85% RR / 95% RRR (10% of plastics or 1,416,000 tonnes are recovered, 2% of plastics or 280,000 tonnes are recycled, 0 plastics landfilled)	10% recovery (1,416,000 tonnes plastics)	2% recycling (280,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-46,841,280	-15,904,000	0	**-62,745,280**	**GJ**
Greenhouse gas emissions	-450,288	-277,760	0	**-728,048**	**t CO_2 eq**
Air acidification	-1,982	-4,788	0	**-6,770**	**t SO_2 eq**
Photochemical oxidation	3,540	-201,600	0	**-198,060**	**kg ethylene**
Water pollution	2,619,600	-5,600	0	**2.625.200**	**m^3**
Eutrophication	-28,320	-218,400	0	**-246,720**	**kg PO_4**
Municipal waste	-202,346	5,600	0	**-196,746**	**t**
Hazardous waste	6,584	2,240	0	**8,824**	**t**

Table 20. Total environmental impacts of 95% recovery and 85% recycling (Low Tech Development Scenario).

9.1.4 Overall Environmental Impacts

The two scenarios above reflect the far ends of the estimated impacts: actual environmental impacts are likely to lie in between. The estimates indicate that these will be substantial and positive.

9.1.5 Economic impacts[149]

The analysis of the economics of the ELV treatment process is based on the cost estimates described above, the data on composition of ELVs and ELV arisings, and the assumed High or Low Technological Development Scenario[150].

In the High Tech Scenario, a greater share of plastics can be recycled at a higher value, while some disposal costs and the costs of the separation process are smaller. Based on these assumptions[151], the net added value from the treatment of ELVs would be between €120 and €90[152].

Under the Low Tech Scenario, the net added value from the treatment process would be between €80 and €55[153].

These two sets of values indicate estimates of the likely maximum and minimum values under the baseline, with the actual end impact lying somewhere in between. With an estimated 13.8 million ELVs treated per year from 2015, this range would approximate to a value of €1.6 bn to €760 million per year with 1 tonne ELV estimates.

Therefore, the total value of the ELV treatment process over a 10 year period under this set of targets would range between €16bn and €7.6bn[154].

9.1.5.1 Impacts on Innovation

An 85% recycling target gives certain markets for both advanced post-shredder technologies and advanced polymer recycling technologies. This will substantially increase R&D investment in new technologies by reducing the risks that lead to sub-optimal investment in R&D. Setting targets for 2015 gives seven years for R&D and 2 years for commercial installation of the technologies to meet the targets. Only the direction of the impacts of this innovation can be described (more details of current innovation can be found in section 4. of Annex I

Even if there were no further technology developments, 85% targets would boost the diffusion of the existing most efficient technologies. In any other case, R&D investment would increase further development of the existing technologies or lead to the development of new technologies and bring greater rewards from innovation.

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149 For details of assumptions see Annex II.

150 For each scenario, estimates can be made of the costs of the process, although with cost data often available in the form of transaction prices or gate fees for processing with firms unwilling to state how much profit they make from processing. As a result, the net economic benefit is not easy to judge absolutely.

151 For details, see Annex II of GHK/BIOIS 2006.

152 For 1.200kg ELV average, the net added value would be €123 to €93

153 For 1.200kg ELV average, the net added value would be €77 to €52

154 Using estimates of a 2019 ELV weighing 1,280 kg as an average weight across 10 years, the total value of the treatment process under this option would be between €17bn and €7bn.

9.1.5.2 Impacts on costs in the economy

New technologies would provide greater resource efficiency by facilitating the recycling of increased shares of plastics in ELVs and WEEE, production of better quality secondary materials, and providing those at lower prices than the existing materials that are substituted. This will reduce the costs of the EU economy in terms of energy costs (plastics are substituted for fuels or electricity generation) and of plastics processing feedstock. In the worst and most unlikely case, with no technological development, the best technologies currently available offer cost advantages over the use of current practices. In the future, it is likely that these costs substantially decrease since the costs of new technologies typically decrease by 20% a year.

9.1.5.3 Impacts on balance of trade

The greatest potential balance of trade impact comes from imports of new technologies. Stimulation of R&D in this area will make the EU the world leader in a technology market with great potential. The resource from ELV and WEEE is growing across the world. Technologies that offer products from these waste streams that can substitute currently used virgin materials at lower prices have a vast global potential. Moreover, the substitution of imported oil and other fossil fuels for plastics feedstock or energy production will have a significant impact on balance of trade.

9.1.5.4 Economic impacts on EU vehicle manufacturers

The evidence presented by stakeholders and consultants indicates that there will be savings to the EU vehicle industry from the promotion of high-quality plastic recycling and that other costs to vehicle manufacturers will not be affected by 2015 targets.

So far, the targets for treatment of ELVs have not led to design changes in vehicles which affect the weight, performance or costs of vehicles. Any increase in weight, change of design or performance of vehicles over the current period of operation of the ELV Directive resulted from the marketing or economic pressures, consumer preferences or safety requirements. Leading manufacturers have begun to incorporate greater amounts of recycled materials into their vehicles, but this does not affect the achievement of the ELV targets.

Since the targets apply equally to all ELVs in the EU, the EU manufacturers would not be disadvantaged by recycling and recovery target levels in ways that non-EU competitors were not. Meanwhile, the economic benefits of slightly reduced material prices in the EU market would be available to firms manufacturing in the EU, where EU vehicle manufacturers are dominant.

9.2. Reduced recycling (80% recycling and 95% recovery)

9.2.1 Environmental impacts

This policy option would lead to the recycling of 75% of metals, 3% of tyres, fluids and batteries, and only 2% of plastics. The majority of ELV plastics (10%) would be recovered, together with 5% of other materials including the remaining tyres, fluids, textiles and rubber. The remaining 5% of shredder residue mainly composed of glass, road dust, rust etc. might be landfilled or parts of it could be rendered inert and recycled as filler.

Materials and Treatment Options	% for this scenario
	80% recycling, 95% recovery
Recycling	
Ferrous metals	**66%**
Non-ferrous metals	**9%**
Fluids	**1%**
Tyres	**1%**
Batteries	**1%**
Plastics	**2%**
Shredder sand (glass, road dust, rust, etc)	**0%**
Recovery	
Fluids	**1%**
Tyres	**2%**
Plastics	**10%**
Other residues (textiles, rubber)	**2%**
Landfill	
Other residues from shredder sand (glass, road dust, rust, etc)	**5%**
Plastics	**0%**

Table 21. Material flows in 2015 for 95% recovery and 80% recycling.

9.2.1.1 Recycling of metals

It follows from the above figures that the 80% recycling target can be met without the use of new technologies, with some efforts to increase dismantling of large plastics, glass, or tyres. In fact, several Member States have already achieved the 80% or higher target for recycling[155], or are close to its attainment.

GHK/BIOIS conclude that, compared to the current situation (on average 78% of recycling achieved in EU 25), 80% recycling rate compared to lower recycling targets can increase environmental benefits. This would happen if additional metal fractions, some of easily recyclable large plastic parts of a substitution rate close to 1, and some other materials like glass or rubber were recycled.

The environmental impacts of the recycling of metals will remain unchanged from the baseline 2015 scenario due to the economic incentives and the lack of blocks to innovation for sorting and recycling of metals. However, lower targets for recycling will discourage the spread of advanced sorting technology at shredding yards. This would lead to the situation where less progressive shredding firms do not adopt advanced sorting technology but continue with their existing practices, leaving a proportion of ferrous and non-ferrous metals in the shredder residue which eventually goes to landfill.

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155 Sweden reached 84% recycling and 85% recovery target in 2004, Austria estimates that 80% can be achieved in 2006, Denmark reached 83% recycling and 85% recovery in 2004, Belgium reached 80% recycling and 81% recovery in 2005, the Netherlands attained 82.5% recycling and 85.3% recovery in 2005. Source: Technical Adaptation Committee for the ELV Directive, meeting of 5th July 2006.

9.2.1.2 Recycling of plastics

In order to meet the 80% recycling target, approximately 2% (280,000 tonnes per year in 2015)[156] of plastics per ELV need to be recycled. These plastics will be mainly polyolefins (in this based on a model of PP/EPDM bumper) coming from a bumper and other large easily removable parts. Environmental benefits from their recycling are presented in Annex I, section 6.2, table 6 on p. 24. Compared to the baseline, plastics constituting 5% of the ELV by weight will go to recovery rather than to mechanical recycling. This amounts to over 700,000 tonnes[157] per year in 2015 onwards. The environmental impact of this option will be the difference between the environmental impacts of these plastics going to recovery compared to the estimated impacts of their recycling in 2015.

If we assume no technological progress between 2006 and 2015, with the state of technology that only permits production of recyclates amounting to 2% of ELV by weight as described in the Low Tech Scenario, there will be no difference in environmental impacts from this option. If, however, any technological progress was to be achieved under the baseline scenario of 85% recycling and 95% recovery target, the 80% recycling and 95% recovery option would bring about the environmental costs.

Impacts of 80% RR / 95% RRR (10% of plastics or 1,416,000 tonnes are recovered, 2% of plastics or 280,000 tonnes are recycled, 0 plastics landfilled)	10% recovery (1,416,000 tonnes plastics)	2% recycling (280,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-46.841.280	-15.904.000	0	**-62.745.280**	**GJ**
Greenhouse gas emissions	-450.288	-277.760	0	**-728.048**	**t CO_2 eq**
Air acidification	-1.982	-4.788	0	**-6.770**	**t SO_2 eq**
Photochemical oxidation	3.540	-201.600	0	**-198.060**	**kg ethylene**
Water pollution	2.619.600	-5.600	0	**2.625.200**	**m^3**
Eutrophication	-28.320	-218.400	0	**-246.720**	**kg PO_4**
Municipal waste	-202.346	5.600	0	**-196.746**	**t**
Hazardous waste	6.584	2.240	0	**8.824**	**t**

Table 22. Total environmental impacts of 95% recovery and 80% recycling.

Compared to the High Technological Development Scenario with 85% recycling and 95% recovery, the total annual impacts[158] of 80% recycling and 95% recovery would include 63 million GJ of energy savings due to increased recovery and around 730,000 tonnes of saved

[156] 353,000 tonnes for heavier ELVs.

[157] 881,000 tonnes for heavier ELVs.

[158] These impacts include the costs and benefits of recycling reduced by 5%, recovery increased by 5%, and landfill of 5% of ELV plastics.

CO_2 equivalent[159] (78 million GJ and around 910,000 tonnes of saved CO_2 equivalent in case of ELVs of 1,280 kg). Environmental benefits for other impact categories would also be generated.

Energy losses avoided (GJ)	63,000,000
Additional greenhouse gas emissions (tonne of CO_2 equivalent)	730,000

Table 23. Environmental impacts of 80% recycling and 95% recovery (compared to baseline scenario) of PP/EPDM per year.

Compared to the Low Technological Development Scenario, there is no change as similar end points exist for the materials, with similar environmental impacts.

The environmental impacts from this option will, therefore, be negative – the difference between the environmental gain that would have been achieved under an 85% recycling and re-use target. However, the magnitude of that negative impact will be dependent on the environmental benefit that would be achieved under the baseline scenario.

9.2.1.3 Recovery of the remainder of the shredder light fraction not mechanically recycled

The parts of the shredder light fraction that went to recovery in the baseline scenario will still go to recovery. With consistent assumptions on the recovery routes used and the environmental impacts of those routes, the environmental impacts of this part of ELV waste will be unchanged from the baseline scenario.

9.2.1.4 Landfill or reuse of the mineral fraction

There will be no significant change compared to the baseline of 85% recycling and 95% recovery targets as the environmental disposal or reuse of the mineral fraction is likely to remain the same.

9.2.2 Economic impacts

9.2.2.1 Impacts on direct costs of ELV treatment

The direct economic impacts on costs of this option depend on the cost advantages foregone from technological innovation not becoming available to be used in 2015. GHK/BIOIS study concludes that "without any targets for recycling and recovery, given that there are no industrial scale plants to demonstrate and prove the technology, there is a risk that PSTs would not survive as commercially attractive options. Maintenance of the targets in the Directive would therefore be technology forcing and provide a strong legislative basis for continued investment".[160]

Under the most optimistic view of 80% recycling targets, there could still be sufficient market support for current levels of R&D. Stakeholders are of the opinion that this is possible but

159 As in the previous scenario, these figures relate to PP/EPDM and can change for other resins.
160 GHK/BIOIS 2006, p. 81.

unlikely, since innovation will be blocked by the market failures identified above. In the best case, the economics of 80% recycling and 95% recovery would be similar to those of the 85% recycling and 95% recovery targets under the Low Technological Development Scenario.

An 80% recycling target is achievable with current dismantling and recycling practices. The change in the target from 85% will significantly slow down development of new technologies, removing incentives for technological development and increasing the risks to companies planning any R&D investments. Moreover, the 80% recycling target will slow diffusion of current most eco-efficient technologies.

Again, the range of economic impacts depends on the assumptions of innovation under the no policy change option. If absolutely no innovation would have been expected under an 85% recycling target, there will be no cost difference under this policy option.

If, however, the High Technological Development Scenario under the 85% recycling and 95% recovery target is predicted, the estimated maximum lost direct benefits will be the difference between the best case scenario under the 85% recycling target and the worst case scenario without the targets. This is the situation where lower targets undermine existing technological development and the level of technology remains as it does in 2006, with the use of the techniques available now[161].

The 80% recycling and 95% recovery targets would result in very similar costs to the Low Technological Development Scenario, so the best case for this option would be a cost neutrality, no gain and no loss, compared to the baseline[162].

However, compared to the baseline with High Technological Development, for the EU as a whole, basic calculations suggest the net value from processing ELVs would be up to €40 lower[163]. This would cost a maximum of value of €550m a year. The maximum direct loss over a ten year period against the baseline scenario would be up to €5.5bn (or €6.9 bn if 2019 ELVs weighing 1,280 kg are taken as average across the 10 year period).

If a pessimistic view is taken of technological development under an 80% target, so that zero technological development is assumed, dismantling might remain the route to the 80% targets. In this case, the value from the ELV chain would be between €35 and -€15. The difference between this scenario and the High Tech and Low Tech Scenarios would be €85 and the minimum €20, making the maximum cost of this option (€85 times 13.8m) would be €1.1bn a year and the minimum €260m a year. However, the part of the change in costs from the need for dismantling is likely to be lower in low wage Member States. There are no estimates of average dismantling EU costs or estimates of the trade in ELVs which would result, but together these factors might significantly reduce the cost of dismantling. Greater low cost dismantling would bring about maximum costs closer to the €550m/year.

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161 For details of the assumptions leading to this estimate, see Annex I, section 5, p. 19.

162 For details of the assumptions leading to this estimate, see Annex I, section 5, p. 19.

163 €46 lower for 1,200 kg 2015 ELVs, increasing to €50 lower for 2019 ELVs.

9.2.2.2 Impacts on competitiveness

Apart from the loss of direct costs savings, the negative impacts on innovation mentioned above will have further negative impacts on EU competitiveness from the increased costs to the economy, greater imports of raw materials, and the loss of export markets for waste technologies. These costs are hard to quantify and monetise, but nevertheless significant.

9.3 Reduced recovery targets (85% recycling and modified recovery target)

Under this policy option, 75% of metals will continue to be recycled, as well as 7% of plastics and 3% of fluids, tyres and batteries. The major change compared to the baseline scenario includes a shift of between 0 to 5% of plastics to recovery and an increased landfill of plastics.

Materials and Treatment Options	% for this scenario
	85% recycling, 90% recovery
Recycling	
Ferrous metals	**66%**
Non-ferrous metals	**9%**
Fluids	**1%**
Tyres	**1%**
Batteries	**1%**
Plastics	**7%**
Shredder sand (glass, road dust, rust, etc)	**4%**
Recovery	
Fluids	**1%**
Tyres	**2%**
Plastics	**0-5%**
Other residues (textiles, rubber)	**2%**
Landfill	
Other residues from shredder sand (glass, road dust, rust, etc)	**1%**
Plastics	**0-5%**

Table 24. Material flows in 2015 for 85% recycling and 90% recovery.

With lower targets for recovery, the percentage of ELVs that goes to recovery or landfill will be determined by the relative prices of landfill and recovery options available in each Member State. In the example above, if in one Member State landfill costs €150/tonne including gate fee and tax, while at the same time a cement kiln accepts processed shredder residue at a cost of €120/tonne (including processing costs), then the maximum permitted percentage (here 15%) of shredder residue would go to cement kilns. There may be limited capacity in several recovery options in many Member States, in which case not only the price, but also the availability will determine the proportions of ELV going to either recovery or landfill.

Whilst the example above considers 85% recycling and 90% recovery targets, other targets for recovery below 95% would have similar impacts for each % as the ones described here.

9.3.1 Environmental impacts

Leaving the current targets allows for landfilling of 15% of ASR. This accounts for detrimental environmental impacts including resources loss, occupied space, and potential problems linked to landfill of ASR (pollutant discharge via leachates from plastics). Moreover, a cross contamination of the material in the shredding process due to its contact with pollutants from other waste streams such as PCBs may occur[164], which has led some Member States to classify ASR as hazardous waste and to ban its landfilling completely. Finally, higher landfill rates bring about various disamenity effects including visual disturbance, noise and odours.

The environmental impacts of a changed recovery target compared to the baseline are estimated as the difference in environmental impact per tonne between landfill and recovery, multiplied by the number of tonnes estimated to go to landfill instead of recovery. The result will depend on the mix of recovery options in each Member State. Assuming that 7% of plastics are recycled, 2.5% goes to a mix of recovery options and the remaining 2.5% is disposed of in landfills, an average of 70 million GJ of energy would be saved and emissions of over 1 million tonnes of CO_2 equivalent per year would be avoided.

Energy losses avoided (GJ)	70,000,000[165]
Additional greenhouse gas emissions (tonne of CO_2 equivalent)	1,000,000[166]

Table 25. Environmental impacts of 85% recycling and 90 % recovery.

For any other change in the percentage, similar calculations can be made. These calculations assume that changes in recovery targets bring about changes in the treatment of the shredder light fraction, with use or disposal of the inert fraction remaining the same.

9.3.2 Economic impacts

The change in direct costs to the economy from changes in the recovery targets will depend to a large extent on the costs of landfill relative to other disposal options. With the costs of recovery options estimated at between €80 and €100 per tonne, depending on the level of innovation expected under the baseline scenario of 85% recycling and 95% recovery, only landfill prices below €80 and €100 per tonne would have any impact on the economic costs. If landfill prices were above those figures, a reduction in the recovery target would not make any difference. Note that trade in shredder residue might allow landfill outside the boundaries of the Member States with high landfill costs.

164 Landfill operators maintain that the contamination of ASR is typically very low (below 50 ppm), and thus the classification of ASR as hazardous waste is misleading. Source: GHK/BIOIS 2006, p. 82.

165 84,000,000 for 1,280 kg ELVs.

166 1,300,000 for 1,280 kg ELVs.

9.4 Reducing both targets (80% recycling and 85% recovery – lowering the 2015 targets to the 2006 levels)

9.4.1 Environmental impacts

The environmental impacts of this option are the sum of the impacts from lowering recycling targets from 85% to 80% plus the impacts of lowering the recovery targets from 95% to 85%. Using the calculations of these impacts from consideration of the two options above, this set of targets would generate almost 40 million GJ of energy savings and save over 360,000 tonnes of CO_2 equivalent. The figures below are based on plastics representing 5% going to recovery and 5% going to landfill, although the percentage for either option will be between 0 and 10, depending on the capacity and economics in each Member State.

Energy losses avoided (GJ)	40,000,000[167]
Additional greenhouse gas emissions (tonne of CO_2 equivalent)	360,000[168]

Table 26. Environmental impacts of 80% recycling and 85 % recovery targets.

However, although this set of targets will bring about environmental benefits in terms of energy savings and reduced CO_2 emissions, these effects will be smaller than for other options. In addition, this set of targets is environmentally detrimental for most of the remaining impact categories[169].

	80% recycling / 85% recovery	*unit*
Energy savings / losses	**-39.041.440**	**GJ**
Greenhouse gas emissions	**-362.366**	**t CO_2 eq**
Air acidification	**-5.248**	**t SO_2 eq**
Photochemical oxidation	**-150.270**	**kg ethylene**
Water pollution	**18.342.800**	**m^3**
Eutrophication	**75.420**	**kg PO_4**
Municipal waste	**612.427**	**t**
Hazardous waste	**5.532**	**t**

Table 27. Environmental impacts of 80% recycling and 85 % recovery for all impact categories.

9.4.2 Economic impacts

Similarly, the economic impacts are the sum of the impacts from lowering recycling targets from 85% to 80% plus the impacts of lowering the recovery targets from 95% to 85%. Using

167 50,000,000 for 1,280 kg ELVs.
168 456,000 for 1,280 kg ELVs.
169 For details see Section 6 of the IA (Comparing the Options).

the calculations of these impacts from consideration of the two options above, there are negative impacts from the lowering of recycling targets, and possible reductions in costs from lowering the recovery targets. With the cost reductions from recovery targets uncertain, the net impact is hard to estimate.

9.4.2.1 Economic impacts of decreased recovery targets

10% of ELV arising will represent an estimated 1,416,000 tonnes[170] in 2015. For a 10% lowering of the recovery target, the cost saving for the EU will be the cost saving per tonne from allowing this material to go to landfill rather than recovery. The value or cost of recovery options is estimated to range from a maximum value of €100/tonne for use as coke substitute in blast furnaces to a maximum cost of €140/tonne for disposal in municipal incinerators.

At the same time, current costs of landfill vary across the EU from €30 to €140/tonne. These costs are on an upward trend so are likely to be higher by 2015.

With a 10% lower recovery target, a part of the material that would be recovered under the 95% recovery target would go to landfill. The actual amount of this material going to landfill instead of recovery would depend on Member State legislation and landfill costs compared to the costs of recovery options. As a result, in some Member States lowering the recovery target would be likely to have a zero impact on costs, in others it might induce a large swing of residue towards landfill with substantial cost savings per tonne and large cost savings as a whole. This would be determined by the capacity and pricing of recovery and landfill options in the Member States.

9.4.2.2 Economic impacts of decreased recycling targets

The negative impacts on cost and competitiveness for the EU economy from lowering recycling targets remain as described above in section 4 of Annex I.

9.5 Social impacts of all considered policy options

The ELV treatment sector comprises various operators, from small ELV collection points and dismantlers, scrap yards, salvage operators and secondary metals businesses, to large capital intensive shredders. In EU 25, there are approx. 8,000 authorised treatment facilities and over 200 shredders (for more details see table in Annex XV). No reliable data is available on the total employment figures in the ELV treatment sector.

GHK/BIOIS estimate that additional 21 PST plants would be necessary in the EU to treat ASR generated as a result of an increase of the reuse/recovery/recycling target to 95%. The increased targets would involve approx. 400 new jobs. At the same time, however, there would be a displacement of jobs from the landfill sector due to reduced amount of ASR going there. As a result, even a net loss of employment could take place in the sector related to ELV treatment, partly reflecting the increased efficiency of treatment. Lowering the recycling target without any significant technological progress could maintain the need for continued

[170] 1,762,000 for 1,280 kg ELVs.

dismantling and support jobs in the dismantling sector, one indirect benefit of the increased costs. Development of cost-efficient post shredder technologies would reduce the need for costly dismantling and thus could affect employment in the dismantling sector. In any case, according to GHK/BIOIS, none of the discussed policy options seems to have major social impacts.

Annex II
Comments on Stakeholder views

Main Issues from the Final Report of the Stakeholder Working Group

Over the course of the policy making process, the Commission has received a large amount of useful information and opinion from stakeholders. The work of the Stakeholder Working Group and the consultation on the GHK/BIOIS report have been particularly useful in informing the analysis in this impact assessment.

With a wide range of stakeholders, there is a wide range of opinions, and strategic use, or withholding, of information. The Commission has looked at the evidence behind some of the stakeholder assertions when balancing conflicting stakeholder statements to reach a view on the correct analysis. This Annex describes some of the stakeholder positions and provides for the Commission's analysis on the points raised.

Some specific extracts of the report that raise key issues for the setting of targets are included here as the background to Commission comments. These extracts should also be read in their original context of the full Stakeholder's Final Report available at: http://ec.europa.eu/environment/waste/pdf/elv_final_report_051104.pdf.

Stakeholders' Comments:

Extracts from the section "Barriers to Progress" (p.15/16) on Post-Shredder Technologies, innovation and legislation:

- *Post-Shredder Technologies (...) have not yet been proven and deployed, either individually or in combination, with enough capacity to reach the 2015 Targets. Nevertheless they represent a real opportunity to improve environmental protection by recovering useful materials from the ELV waste stream.*

- *In the most recent study comparing pre-treatment operations (dismantling) to post-shredder media and metal separation technologies, it was shown that at this time the 2015 target of 95% was not achievable, though 89.6% was, with 4.1% being sent to cement kilns with a gate fee as an alternate fuel source, and the 4.8% mineral fraction (e.g. sand and glass) proving difficult to dispose. This national experience shows there is a need to find or create new markets for certain separated non-metallic materials.*

- *However, pressure from legislation upon many material and product streams, perhaps particularly in response to the Landfill Directive (99/31/EC) has encouraged a push for innovation as more and more materials will be sorted from mixed waste which would have been lost to landfill, but which will now be available for separate treatment and will need to find an outlet via recycling or recovery channels.*

- *In addition, recent studies suggest that the environmental impact of post shredder treatment technology may be at least as good as that of dismantling and recycling for the specific non metallic materials following this treatment route.*

- *Changes are underway to add new, efficient post-shredder treatment capacity and move the focus away from dismantling, driven by the dual problems of high costs and the lack of sustainable markets.*

- *In most, if not all cases, non metallic wastes dismantled or sorted and separated post shredder cannot be reused for their original purpose but need to find other markets where they displace materials from other sources.*

- *In order to achieve this market penetration, there are three key requirements:*

    - *Competitive pricing*

    - *Comparable or superior quality*

    - *Stability of volume supply*

Commission's comment:

This section of comments deals in particular with three issues:

1) Post Shredder Technologies

These are – *at this time* - not yet proven with enough capacity to meet 2015 targets but do represent a real opportunity.

Additionally, as commented in the Conclusions of the Report, "Insufficient availability of post shredder treatment capacity in many Member States could be expanded with fairly modest capital investment and without unduly long lead times. Drivers of expansion would be a clear and predictable increase in demand so as to reduce investment risk and to provide economies of scale, as well as technological innovations, which would deliver improved economics and thereby encourage uptake".[171]

The demand for post shredder treatment capacity would be one result of keeping current levels of recycling and recovery targets, which are best achieved through development and use of post-shredder technology.

2) Innovation

There is a push for innovation from legislation, but there are still blocks that are holding back innovation, in particular the lack of current markets for non-metallic recyclates.

3) Markets

Both in this section and other sections, stakeholders are clear that lack of markets for non-metallic recyclates is a block to greater recycling of ELV waste (see pages 12, 13 of the Report and Stakeholders' Comments below).

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[171] Stakeholder Working Group Report, p. 35.

Stakeholders' Comments:

- *The costs imposed by Annex 1, pt.4 are not matched by an equivalent environmental benefit, as no recycling markets exist for the bulk of the materials, which can be recovered by post shredder treatment in any event, at much lower costs.*

- *It stands to reason that this will simply not happen as long as the lack of markets and the negative costs remain insurmountable barriers to progress. A more flexible approach is needed to lower costs and facilitate the development of alternative routes to achieve the Directive's key objective of reducing the disposal of waste (p.13).*

- *Performance standards for non-metallic vehicle components are too high to permit extensive "closed loop" recycling applications in new vehicles (p. 23).*

- *If a step up in recycling levels is unlikely based upon today's market realities, it is important to assess the role which recovery technologies could play (whether of materials or of energy) in helping to achieve the Directive's aim of diverting all but 5% of ELV waste from disposal in landfills (p. 12).*

- *We need to recognise that sizeable markets for post shredder residue are not yet developed enough, but broader acceptance and accreditation of the technologies would provide a positive stimulus, as would treatment capacity expansion (Conclusions, p.35).*

- *The lack of drivers for change, whether legislative (at the grass roots Member States level), or economic (funding, incentives, profitable markets) will hold back the development of the ELV waste sector (p. 11).*

Commission's Comment:

These comments illustrate the problems facing development of changes in recycling practice, in particular the development of post-shredder techniques. Current recyclate markets do not exist – if a target of 85% recycling was set now for 2007, it would produce large volumes of poor quality, mixed, non-metallic recyclate which had little market value. This lack of current markets creates great uncertainty about future markets, blocking development of technologies which would tackle the three issues stated above as necessary for market penetration.

There are very large potential future markets for plastic recyclate if the issues of competitive pricing, quality and stability of volume supply can be tackled. Individual stakeholders have described how plastics recycling is a much lower cost process than virgin material production, with current recyclates, despite being sold at a lower price (not least for quality reasons) still being profitable. Quality is a key issue – as described elsewhere in the Annex to this impact assessment, improvements in quality rely on development of post-shredder sorting technology (which itself must be stimulated in some way). Stability of volume supply is an issue one solution of which is a legislative requirement to recycle 85% of ELVs, providing secure raw material.

Uncertainties in technological development, particularly in the relative success in developing much improved sorting and processing post shredder technologies, are reflected in the range between the Low Technology and the High Technology Scenarios in the Commission's analysis.

Stakeholders also tell of existing high demand for mixed, partly sorted plastics from the Far East, which are then sorted further by hand before recycling. It is recognised that there are markets for plastic recyclates including those containing some impurities.

There is a market for use of recyclates in vehicle manufacture (note for example Renault's targets of 50kg recycled plastic in all new vehicles by 2015), but the potential here should not be over-stated: closed loop recycling of all of the ELV plastics is not a solution. That 50kg will substantially be made up of plastics from other recyclate sources. ELV plastics will not be recycled into the same parts that they were in, even though there is a market for them in some applications in vehicles, particularly when quality and reliability of sourcing are tackled.

The solution to the current problem to markets therefore relies on development of technologies. As the development of technologies relies on the existence of markets, there is an impasse: the blocks to innovation described in Annex I which targets would alleviate.

Stakeholders' Comments:

- *Costs: As recycling activities are pushed beyond pragmatic limits, disregarding the market's fundamental function in balancing supply and demand, the marginal cost tend to rise out of proportion to the real potential for environmental benefit (p.18).*

- *Key barriers to progress are high treatment costs driven by the prescriptive nature of the legislation and the lack of economically viable markets for secondary materials, with the exception of the metals (Conclusions, p.35)*

Commission's Comment:

This comment – in the Conclusions of a section - appears to be based on a belief that high recycling activities are not "pragmatic" and that increasing recycling will become more costly, particularly as markets do not currently exist to provide revenues from materials. This is a similar point to the statement of the severe costs that would occur if an 85% recycling target was set for this year, or next year. That target would not be pragmatic, and, particularly as it would most usually be achieved through increased manual dismantling of ELVs, be very costly. The impact assessment, appropriately, looks to the situation in 2015 onwards and the impact from technology development from setting targets when dismantling is likely only to take place in low wage countries.

The reference to "prescriptive nature of the legislation" refers to current legislation, partly to the dismantling requirements for specific materials and partly to the presence of a recycling target itself. The dismantling requirements (e.g. for bumpers) typically apply where these materials are not recycled from post-shredder materials. The indications are that in future, in all but lower wage countries, materials will be sorted from post-shredder waste, giving the flexibility sought.

The market issue is discussed above.

Stakeholders' Comments:

- *The need for changes to the design of vehicles: With an average life length of 15/17,5 years it is clear that the great majority of ELVs in 2015 are in use already, therefore* *changes in the material composition of these vehicles is unlikely to play any significant part in making The Directive's targets easier or harder to achieve (p. 20).*

Commission's Comment:

Whilst the Commission has used a shorter estimate of life of ELVs (13 years), it remains true that any design changes that began to be made now would affect ELVs arising in around 2022/23, with the consequence that industry response to meeting recycling targets will not be to change the design of vehicles – which would have no effect until after 2022, but through recycling technology.

Stakeholders' Comments:

- *Significance of ELV recycling and recovery: "...the potential for environmental impact reduction from increasing recycling of materials in the ELV phase of the life-cycle beyond the 2006 target levels is of low significance or value, when compared to the use phase of the vehicle life cycle."*

Commission's Comment:

The aim of the ELV targets should be put into the context of the overall environmental performance of vehicles over the life-cycle. It attempts to tackle only a small part of the impacts – and the consideration in setting targets is whether those targets are beneficial and whether the environmental and economic benefits outweigh the costs. The economics of recycling vehicles are a smaller part of the economic life-cycle costs of the vehicle than the proportion of environmental impacts is to the life-cycle environmental impact.

Stakeholders' Comments:

- *"A few stakeholders questioned whether enough certainty of success existed to support taking a new approach at this stage. However the barriers to reaching the Directive's 2015 targets are fundamental and will not change with time alone. Postponement of action would only create uncertainty. Doing nothing is not an option." p36*

- *"Consideration should be given to readjusting the 2015 reuse and recycling target from 85% and freezing it at 80% in line with the 2006 target level as established by the Directive. The 2015 target for reuse and recovery should be maintained at 95%. (See Option 5) This is still ambitious but closer to reality and avoids the generation of disproportionate costs in pursuit of marginal environmental gains." P.35*

- *"Some stakeholders, but certainly not all, believe that even more flexibility is needed and that this would be provided by repealing the reuse and recycling target for 2015 completely and regrouping reuse and recycling with material recovery and energy recovery under a single 95% target for reuse and recovery. (See Options 7,abc) p.36"*

- *None of the alternative options explored present the possibility of an "overnight success" , but facilitating the deployment of material recovery technologies by setting clear policy goals would encourage innovation and investment and create a positive climate for continuous improvement in the reduction of environmental impacts from ELV waste.*

Commission's comment:

The basis of the stakeholders' opinion rests on a belief that maintaining recycling targets will increase costs. This may be based on the current costs and availability of technology and the current market for recyclates.

The Commission's analysis of 2015 targets indicates that the existing targets are likely to reduce costs through stimulating technology when compared to lower targets, bringing economic benefit by removing blocks to innovation. The main direct effects will be to the waste processing industry, and whilst some small benefits might accrue to vehicle manufacturers, the effects of the targets for them are very likely to be insignificant. The impact on other individual stakeholder sectors has not been analysed, but it can be estimated that increased availability of recyclate would have a small negative impact on virgin plastics manufacturers whose customers might instead buy recyclates.

Stakeholders' Comments:

Additional Specific Issues raised by Plastics Europe (from a submission in response to Commission questions on the GHK/BIOIS report, dated 2 June).

- *"Although sorting technologies will undoubtedly improve by 2015; we expect these improvements will not overcome the increased use of composite "harder-to-recycle" materials. This will make mechanical recycling even more difficult than already today, and complex mechanical recycling is a synonym with low substitution rates or low value and low performance applications such as park benches"*

- *"High substitution rates are possible only with large amounts of clean plastics separated by type, a situation which is not achievable with post-consumer plastics from ELV unless considerable effort and costs for dismantling, sorting and separation are made"*

Commission's comment:

The impact of the use of composite materials will feed into the ELV stream increasingly in the period after 2015, with a time lag of around 13-15 years for the majority of ELVs. It is certainly the case that even with high levels of technological development many of the plastics in ELVs will not be able to be recycled into plastic granulate recyclate for conversion into other uses. The Commission's analysis estimates that only between less than 60% and less than 20% of plastics in ELVs will be recycled, with the proportion depending on technological development.

The issue of high or low substitution rates is discussed in this Annex's comments on the GHK/BIOIS report, and will not make a substantial difference to the economic or environmental impacts estimated in the impact assessment. The comment about post-shredder plastic being of low value at the moment holds true, as does the statement that to achieve clean recyclates considerable investment is required. Both comments have shaped the Commission's analysis.

Stakeholders' Comments:

- *"A system without any recycling or recovery targets can achieve the same environmental performance from a life cycle perspective while being more efficient if based on post-shredder treatment (PST) techniques" (p. 2)*[172].

Commission's comment:

The first half of this statement is a distortion of evidence from the 2004 LIRECAR study on the life-cycle impact of vehicles. That study found that the end-of-life impact of a vehicle was at most 5% of the life-cycle impact of a vehicle, much smaller for some environmental impacts. The difference between different targets for end-of-life treatment is only a proportion of the total end-of-life impact, so is a substantially smaller percentage of the total life-cycle impacts. From this, ACEA concludes that the differences between targets are "insignificant" and thus that the environmental impacts with any recycling or recovery targets are "the same".

The differences between the environmental impacts of targets are relatively small compared to the life-cycle impacts (which are very large) but, as demonstrated in this analysis, are still significant and when applied to the estimated 14 million tonnes of ELV generated each year, substantial.

Stakeholders' Comments:

- *"There is no scientific evidence for any recycling/recovery quota from an environmental and sustainable point of view if going beyond metal recycling".*

Commission's comment:

The Commission has based its analysis on life-cycle analyses of various treatment options for plastic parts of vehicles conducted by the Fraunhofer Institute (2002) and AMPE. These analyses show significant environmental benefits from plastics recycling and recovery, particularly obvious when ELV materials are sorted and treated appropriately by fraction.

172 Note from ACEA on the GHK/BIOIS report, date May 2006.

Annex III
The GHK/BIO Intelligence Service Report[173]

In 2005, the Commission asked GHK and BIO Intelligence Services to examine the costs and benefits of different options of 2015 targets under the ELV Directive. This formed part of a study which also looked at the benefits of the Directive as a whole.

The information contained in their detailed report, published in May 2006, forms the basis for much of the Commission's analysis of the targets, particularly the background information. The GHK/BIOIS report is based on information from:

- ELV arisings and treatment practices in 6 Member State case studies;
- A review of post-shredder technologies;
- An analysis of the life-cycle impact data on the environmental impacts of ELV materials, comparing different treatment methods.

The available information in these areas is not complete, but is extensive. Conclusions to be drawn from the information, as is usual for complex issues, must rest on assumptions. Stakeholders were asked for, and many provided, comments on the key questions or information gaps in the report, which also informed the Commission's work.

Whilst the GHK/BIOIS report is not included as a formal annex to the impact assessment, as the source of much of the data used, it forms an important part of the documentation behind the Commission's position. Neither the impact assessment nor its annexes repeat the level of detailed information which can be found in the Annexes to the report.

Whilst based on much of the same data, the Commission's analysis of ELV targets differs in some important respects from the GHK/BIOIS analysis, being informed by further discussion with industry stakeholders. This leads to different conclusions to those presented by GHK/BIOIS (referred to as 'GB Report' below). The key differences in the analysis are:

(1) The GB Report estimates the difference in achievement of targets in 2015 from a baseline of activity in 2006. The Commission's IA presents a clearer comparison of different 2015 targets by setting a 2015 target set as the baseline and comparing other targets to that. This reduces one element of complexity in the presentation of this complex topic.

(2) The GB Report bases 2015 activity on existing post-shredder technologies, adjusted for a 10% reduction in current costs by 2015 to factor in development. This otherwise ignores the effects of technological development by 2015, which are likely to be significant under high targets. The Commission's analysis takes a deeper look at the possible technological state in 2015 to show a broader range of possible scenarios the range of which are described by the Low Technological Development and the High

[173] Full text of the report is available at: http://ec.europa.eu/environment/waste/elv_study.htm.

Technological Development Scenarios. The GHK/BIOIS estimates equate to the Low Technological Development Scenario.

(3) The GB Report sets the costs of mechanical separation technologies as between €20 and €50/tonne ASR. Even allowing for likely price reductions through development up to 2015, the Commission uses a substantially more conservative cost of €100/tonne ASR for this type of PST. This also allows reflecting possible increases in sophistication of PST to separate a greater proportion of plastics under the High Technological Development Scenario.

(4) The GB Report estimates that 6 existing PSTs can currently achieve a recycling and re-use rate of over 85%, some with near 100% (see p. 80 and Annex 3). The Commission does not share the view that all of these existing PSTs currently achieve the rates stated and is aware that some of them may well not be able to achieve such rates by themselves in 2015.

(5) The GB Report environmental analysis of mechanical recycling options produces a range of impacts based on estimates of impacts when recyclates have different substitution rates in replacing virgin material. This is an extrapolation of results for polyurethane foam (PUR) to other materials and rests on an assumption that more than 1kg of low quality recyclate must be used to substitute for 1kg of virgin material. However, in the Commission's analysis, plastic recyclates are not expected to be used in this way, which is also likely to be uneconomic. Rather, recyclates are expected to replace virgin materials at a ratio of 1:1. For example, in a 2kg application, 1kg of recyclate might be used to replace 1kg (being 50%) of virgin material. This is a much more likely outcome: those plastics which could not substitute in this way are unlikely to be recycled. It is explained in more detail in section 6.2 of Annex I to the IA. Note, too, that this does not mean that 1kg of sorted plastic waste would become 1kg of recyclates: there would be a loss in the recycling process and this has been taken into account in the Commission's analysis. The Commission's analysis uses the same (Fraunhofer) life-cycle report figures for environmental impacts at 1:1 substitution rate.

(6) It is the difference explained in the point directly above that leads to the substantially different views of the environmental benefits of mechanical recycling. The GB Report's different interpretation of *substitution rates* leads them to conclude that the use of plastics with impurities from ELV waste would be environmentally harmful where there were low substitution rates. In fact, substitution rates will be 1:1 for those recyclates which are used, but only a proportion of the plastics in ELVs will be turned into recyclates.

<u>**Annex IV**</u>

<u>**Environmental impacts of recycling PP/EPDM (per tonne)**</u>[174]

RECYCLING	Impact (per tonne)*
Energy consumption (MJ)	-105.200
Greenhouse gas emissions (g CO_2 equivalent)	-6.090.000
Air acidification (g SO2 equivalent)	-45.600
Photochemical oxidation (g ethylene)	-358.000
Water pollution (m3)	-1.075.000
Eutrophication (g PO4 equivalent)	-530.000
Municipal waste (kg)	-272.000
Hazardous waste (kg)	-30.000

** Minus stands for environmental benefits.*

174 *Source: Fraunhofer 2002.*

Annex V
Environmental impacts of recovery PP/EPDM (per tonne)[175]

RECOVERY MIX of 40% blast furnace, 40%cement kiln, 10% syngas, 10% MSWI	Estimated impact of mix/tonne*
Energy consumption (MJ)	-33.080
Greenhouse gas emissions (g CO_2 equivalent)	-318.000
Air acidification (g SO2 equivalent)	-1.000
Photochemical oxidation (g ethylene)	-2.000
Water pollution (litres)	-3.730
Eutrophication (g PO4 equivalent)	-2.000
Municipal waste (kg)	-151
Hazardous waste (kg)	5

** Minus stands for environmental benefits.*

175 Source: Fraunhofer 2002.

Annex VI
Environmental impacts of landfilling PP/EPDM (per tonne)[176]

LANDFILL	Estimated impact of mix/tonne*
Energy consumption (MJ)	200 to 620
Greenhouse gas emissions (kg CO_2 equivalent)	32.6 to 364
Air acidification (kg SO2 equivalent)	0.01 to 1.5
Photochemical oxidation (kg ethylene)	0 to 1.4
Water pollution (litres)	600 to 47,440
Eutrophication (kg PO4 equivalent)	3 to 85
Municipal waste (kg)	1.000
Hazardous waste (kg)	none

** Minus stands for environmental benefits.*

176 Source: Fraunhofer 2002.

Annex VII

Qualitative Summary of Comparative Environmental Impact Assessment – All plastic resins (per kg)[177]

Comparison	Broad Treatment Option	Detailed Treatment Option	Non renewable resource depletion	Climate Change (g eq CO2)	Energy Cons. (MJ)	Water Pollution (critical vol)	Municipal Waste (g)	Air Acidification (g eq SO2)	Photochem. Oxidation (g eq ethylene)	Eutrophication (g eq PO4)	Haz. Waste (g)	Land use	External costs (Euros)
With Landfill	Mechanical Recycling	Substitution rate (SR=1)	Despite the 2 LCA studies used do not quantify this indicator; experts are used to say that this indicator comes out favourable to the recovery option compared to landfill.	☺ [1]	☺	☺	☺	☺	☺	☺	☺ [1]	Land use is not quantified in LCA. But landfill is known for being detrimental to land use. It is theoretically possible that some recovery options are better than landfill for this impact category but this would need to be demonstrated because all the facilities involved in the recovery system also occupy land.	☺
		Substitution rate (SR=0.65) [2]		☹	☹	☺	☺	😐	☹	☹	☺		☹
	Feedstock Recovery	Blast Furnace (S=heavy oil)		☺ [3]	☺	(4)	☺	☺ [5] or 😐 [6]	☺	☺ [7]	😐		☺
		Blast Furnace [8] (S=hard coal)		☺	☺	☹	☺	😐	☺	☹	😐		☺
		Syngas Production (S=mix 1) [10]		☹	☺	☺[12]	☺	☹ [12]	☹	☺[7]	😐 [13]		☹
		Syngas Production (S=waste oil) [11]		☺ [12]	☺	☺	☺	☺	☺	☺	😐 (PA-GF) ☺ (PP/EPDM)		☺

177 Source: GHK/BIOIS 2006.

		Syngas Production (S=mix 2) [14]		15	☺	☺	☺	☺	☺	☺	😐[16]		☺ except PUR
	Energy Recovery	Cement Kiln (S=hard coal)[17]		☺	☺	☹	☺	😐	☺	☺ [9]	😐		☺
		Cement Kiln[18] (S=brown coal)		☺	☺	☺	☺	☺	☺	☺	😐		☺
		Cement Kiln (S=48% coal and 52% brown coal)[44]		☺	☺	☺	☺	☹	☹ [19]	☺[20]	😐		☺
		MSWI		☹ [21]	☺	☺	☺	22	☺ [23]	☺ [24]	☹ [25]		☹ except PP/EPDM steam

The table above summarises the results of the comparison of the environmental impacts of the end-of-life options for the different plastics resins (PP/EPDM, PUR, PA and a mix of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, ABS, PE, PC, PP). A ☺ means that the recovery option comes out better than landfill (resp. mechanical recycling) in terms the impact category considered, a 😐 means that the environmental impacts are equivalent[178], and a ☹ signifies that the recovery option comes out worse than landfill (resp. mechanical recycling) in terms the impact category considered.

[178] Due to first intrinsic LCA data uncertainties (usually assessed at 10% by LCA practitioners) and second the fact that these uncertainties can invert the relative positioning of 2 options, a difference between 2 treatment options of less than 10% was considered non significant thus the impacts equivalent.

Comparison	Broad Treatment Option	Detailed Treatment Option	Climate Change (g eq CO2)	Energy Cons. (MJ)	Water Pollution (critical vol)	Municipal Waste (g)	Air Acidification (g eq SO2)	Photochem. Oxidation (g eq ethylene)	Eutrophication (g eq PO4)	Haz. Waste (g)	External costs (Euros)
With Mechanical Recycling (SR=1)	Feedstock Recovery	Blast Furnace (S=heavy oil)	☹ [1]	☹ [26]	☹	☹ [27]	☹	☹ [26]	☹	☹ [28]	☹ except dashboard
		Blast Furnace (S=hard coal) [8]	☹	☹	☹	☹	☹	☹	☹	☹	☹
		Syngas Production (S=mix 1) [10]	☹	☹ [29]	(30)	☹ [31]	☹	☹	☹ [32]	☹ [33]	☹
		Syngas Production (S=waste oil) [11]	☹	☹	☹ PA-GF ☺ PP/EPDM	☹ PA-GF ☺ PP/EPDM	☹	☹	☹	☹	☹
		Syngas Production (S= mix 2) [14]	☹	☹	☹	☺	☹	☹ [35]	☹ [36]	😐 [37]	☹
	Energy Recovery	Cement Kiln (S=hard coal) [17]	☹ [34]	☹ [29]	☹	☹	☹	☹	☹	☹ [1]	☺ dashboard, PP/EPDM ☹ PUR, PA
		Cement Kiln (S=brown coal) [18]	☺	☹	☹	☺	☹	☹	☹	☹	☺
		Cement Kiln (S=48% coal and 52% brown coal) [44]	☹ [38]	☹	☹	☺ [39]	☹	☹	☹	😐 [40]	☹
		MSWI	☹	☹	☹ [41]	☹ [21, 42]	☹	☹	☹	☹ [43]	☹
With Mechanical Recycling (SR=0,65) [2]	Feedstock Recovery	Blast Furnace (S=heavy oil)	☺	☺	☹	☹	☺	☺	☺	☹	☺
		Syngas Production (S=mix 2)	☺	☺	☹	☹	☺	☺	☺	☹	☺
	Energy Recovery	Cement Kiln (S=hard coal)	☺	☺	☹	☹	☺	☺	☺	☹	☺
		MSWI	☺	☺	☹	☹	☺	☺	☺	☹	☺

(7) For all resins (PA-GF, PUR, PP/EPDM, PA, PP, PE, PC, ABS) except for dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV
(8) Results for the mechanical recycling option with a substitution rate of 0,65 are available for PUR in the Fraunhofer study.
(9) For all resins except PA and PC.
(10) ☺ for all resins in the APME study (PC, PP, ABS, PUR, PA, PE) and ☹ for all resins in the Fraunhofer study (PA-GF, PP/EPDM, PUR, and 12,5% PVC, PVC/ABS/PUR/PP-TV)
(11) PP, dashboard, PA, PE, PC, ABS, PUR in the APME study
(12) PP/EPDM, PUR in the Fraunhofer study, PA-GF
(13) For all resins (PA-GF, PUR, PVC/ABS/PUR/PP-TV, PA, PP, PE, PC, ABS) except for PP/EPDM
(14) Results for the blast furnace option with substitution=hard coal are only available for PP/EPDM.
(15) Except PP/EPDM which is 😐
(16) S=mix1= 73,4% natural gas, 22,1% waste oil, 4,5% brown coal. Results for the syngas production recovery option when the spared resource for the production of methanol is waste oil alone are available for PP/EPDM and PA.
(17) Results for the syngas production recovery option when the spared resource for the production of methanol is composed of 73,4% natural gas, 22,1% waste oil, 4,5% brown coal are available for PP/EPDM, PA-GF, PUR and PVC/ABS/PUR/PP-TV in the Fraunhofer study.
(18) For all resins (PP/EPDM, PUR, PVC/ABS/PUR/PP-TV) except for PA-GF which is 😐
(19) For all resins except for PP/EPDM when syngas production occurs after dismantling of the plastic piece.
(20) S=mix2= natural gas + electricity and nitrogen. Results available for (PC, PP, ABS, PUR, PA, PE) in the APME study.
(21) ☺ for PA, PE, and PP, and ☹ for PUR, PC, and ABS.
(22) For all resins (ABS, PE, PUR, PC) in the APME study except PA and PP.
(23) Results for the cement kiln option with substitution=hard coal are available for PP/EPDM, PA-GF, PUR and PVC/ABS/PUR/PP-TV in the Fraunhofer study.
(24) Results for the cement kiln option with substitution=brown coal are only available for PP/EPDM
(25) For all resins (PA, PP in air duct, PUR, PC) in the APME study except for ABS which is equivalent and PE and PP in bumper which are☹.
(26) For all resins (PA, PP, ABS, PC, PE) in the APME study except PUR.
(27) For all resins except for PP/EPDM when the recovered energy enables to save steam alone.
(28) ☺ for all resins in the Fraunhofer study (PA-GF, PP/EPDM, PUR, and 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV), ☹ for ABS, PC, PE, PP in bumper in the APME study and 😐 for PP in air duct, PUR in the APME study.
(29) For all resins (PA-GF, PUR, PVC/ABS/PUR/PP-TV, PP/EPDM, PP, PE, PC, ABS) except PA.
(30) For all resins (PA-GF, PP/EPDM, PVC/ABS/PUR/PP-TV, PUR in the Fraunhofer study, PP in air duct, PA, PC) except for ABS, PE, PP in bumper, and PUR in the APME study which are ☹.
(31) For all resins (PA-GF, PUR in the Fraunhofer study, PVC/ABS/PUR/PP-TV, PP/EPDM, PA, PP, PE, PC, ABS) except for PUR in the APME study.
(32) For all resins (PA-GF, PUR, PP/EPDM, PA, PP, PE, PC, ABS) except dashboard in PVC/ABS/PUR/PP-TV which is 😐
(33) For all resins (PA-GF, PUR, PVC/ABS/PUR/PP-TV, PP/EPDM, PA) except PP, PE, ABS in APME study where the impacts are equivalent and PC where the impacts are ☹.
(34) For all resins (PUR, PA, PA-GF, PP in air duct, PP/EPDM) except for PC, ABS, PP in bumper, PE which are equivalent and dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV where the impacts are☹.
(35) For all resins except for dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV when only PP-TV is recycled
(36) ☺ for PP/EPDM and dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, and ☹ for PUR and PA-GF

(37) For all resins except for PP/EPDM when the spared resource for the production of methanol is waste oil alone, PP in bumper in the APME study, PUR in the APME study, PA, PC, ABS.

(38) For all resins except PP in bumper in APME study, PE.

(39) For all resins except PP, PE, ABS and PC in APME study where the impacts are equivalent and dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV which is ☹

(40) For all resins (PA-GF, PUR, PA, PP, PE, PC, ABS) except for PP/EPDM and dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV

(41) For all resins (PA, PUR, ABS, PP in air duct, PE, PC) except for PP in bumper.

(42) For all resins (PA, PUR, ABS, PP in air duct, PC) except for PP in bumper and PE.

(43) For all resins (PUR, PP, PE, PC) except for ABS and PA which are ☹.

(44) For all resins (ABS, PP, PC, PA, PUR, PA-GF, PVC/ABS/PUR/PP-TV, PP/EPDM) except PE.

(45) For all resins (ABS, PE, PC, PA, PUR) except PP in the APME study (☹ PP in bumper, 😐 PP in air duct).

(46) For all resins (ABS, PE, PP, PC) in the APME study except for PA, PUR which are ☹.

(47) For all resins (PA-GF, PUR, PP/EPDM, PA, PP, PE, PC, ABS) except PP/EPDM when the recovered energy enables to save electricity alone or electricity and steam together and dashboard composed of 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV

(48) For all resins (PP/EPDM, PA-GF, PC, PUR in Fraunhofer study, PVC/ABS/PUR/PP-TV, PA) except for ABS, PE, PUR in APME study, and PP in bumper in APME study which are ☺, and PP in air duct which is equivalent.

(49) For all resins (PA-GF, PUR, PVC/ABS/PUR/PP-TV, PP/EPDM, PA, PP in air duct, PC) except PE, ABS, and PP in bumper in APME study where the impacts are equivalent.

(50) Results available for PA, PE, PP, ABS, PC, PUR in the APME study.

Annex VIII (a)

Environmental benefits of plastics treatment per resin and treatment option (per kg) *Source: GHK/BIOIS 2006, p. 128.*

Mechanical recycling

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	-105,2 to -20	-57	-95 for SR=1	-67,83	-105,2	-29 to -20	-67,33	-94,21	-77,77	-74,3	-65,85 to -50,35
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	-6090 to -934,74	-992	-3638 for SR=1	-2042,5	-6090		-1046,51	-5838,89	-2956,7	-1740,7	-1231,53 to -934,74
Air acidification (g SO2 eq.)	-45,6 to -2,39	-17,1	-25 for SR=1	-15,83	-45,6	-6,5 to -4,7	-15,98	-2,39	-16,03	-11,63	-15,54 to -12,21
Photochemical oxidation (*10-1 g ethylene eq.)	-358,3 to -2	-7,2	-12 for SR=1	-9,6	-23,9	-2,3 to -2	-21,4	-358,3	-16	-14,4	-8,4 to -6,4
Water pollution (critical volume in liter)	-1075 to -10,8	-18	-406 to -100	-1075	-343	-10,9 to -10,8	-31,63	-416,39	-362,43	-120,74	-30,96 to -23,37
Eutrophication (*10-2 g PO4 eq.)	-530 to -1	-78	-380 for SR=1	-237	-530	-3 to -1	-91	-463	-162	-113	-91 to -71
Municipal waste (g)	-272 to 0	-20	-254 to -77	-30	-243	-272 to -268	0	-10		0	0
Hazardous waste (g)	-30 to 0	-8	-29,9 to -7,5	-30	-13,6		0	-10	0	0	0
External costs (Euros)											

Feedstock recovery

Blast furnace

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	-47,67 to -19,9	-44 to -37	-29,7	-30,49	-25,8	-27	-47,67	-21	-19,9	-38,85	-47,39 to -26,61
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	-293 to -32	-293 to -32		-88,33			-167,44			-55,56	-165,61 for bumper
Air acidification (g SO2 eq.)	-3,19 to -0,07	-0,3 when S=heavy oil		-1,92			-3,19	-0,07	-0,53	-2,33	-3,15 to -1,16
Photochemical oxidation (*10-1 g ethylene eq.)	-6,9 to -0,7	-3,5 when S=heavy oil	-2,3	-1,3	-2	-2,1	-2,6	-6,9	-0,7	-1,9	-2,5 to -1,1
Water pollution (critical volume in liter)				0			-0,7			-0,37	-0,64 for bumper
Eutrophication (*10-2 g PO4 eq.)				-4			-14			-8	-14 to 0
Municipal waste (g)	-1 to 0	-1 to -0,4	-0,2	-10			0			0	0
Hazardous waste (g)	0			0			0	0	0	0	0 for bumper

Syngas production

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	-58,19 to -17	-49 to -17	-22,9	-35,18	-25,8 to -19,9	-21	-58,19	-27,96	-26,8	-48,22	-57,85 to -34,35
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	-162,8 to -74,74	-160 when S=methanol from WO					-162,8				-161,46 to 74,74
Air acidification (g SO2 eq.)	-11,42 to -0,42	-3,4 when S=methanol from WO		-2,5	-1,7 when S=methanol from waste oil		-11,42	-0,42	-5,17	-9,44	-11,34 to -6,63
Photochemical oxidation (*10-1 g ethylene eq.)	-54,2 to -0,7	-1,5 when S=methanol from WO		-0,7	-0,7 when S=methanol from waste oil		-8,6	-54,2	-4	-7	-8,6 to -5,2
Water pollution (critical volume in liter)	-7,7 to -2,5	-7,7 to -2,5	-3,6		-2,5 when S=methanol from waste oil	-3,49					
Eutrophication (*10-2 g PO4 eq.)	-102 to -10	-23 when S=methanol from WO		-13	-10 when S=methanol from waste oil		-102	-48	-46	-84	-101 to -59
Municipal waste (g)	- 90 to -15	-29 when S=methanol from WO		-150	-15 when S=methanol from waste oil		-90	-30	-30	-70	-90 for bumper
Hazardous waste (g)	-0,1 to 0	-0,1 when S=methanol from WO		0			0	0	0	0	0

Energy recovery

Cement kiln

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	-48 to -18,63	-48 to -44	-26,7	-25,62	-25,5	-26	-42,81	-19,57	-18,63	-35,11	-42,56 to -24,47
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	-1670 to -369,44	-1670 to -1488	-578	-310	-747	-734	-1104,65	-369,44		-500	-1099,04 to -588,42
Air acidification (g SO2 eq.)	- 0,9 to -0,03	- 0,9 to -0,2	-0,03		-0,1						
Photochemical oxidation (*10-1 g ethylene eq.)	-1,4 to 0	-1,4 to 0	-0,8		-0,8	-0,8					-0,01 for bumper
Water pollution (critical volume in liter)	-0,6	-0,6 when S=brown coal									
Eutrophication (*10-2 g PO4 eq.)	-3	-3 when S=brown coal									
Municipal waste (g)	-390 to 0	-32 to -0,2	-0,1	-370	-0,1	-0,1	-50	-390	0	-40	-50 to 0
Hazardous waste (g)	0	0	0	0	0	0	0	0	0	0	0

MSWI

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	-35 to -12,7	-35 to -17	-14,5	-19,49	-12,7	-14	-31,67	-15,17	-14,5	-26,26	-31,51 to -18,63
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)											
Air acidification (g SO2 eq.)	-4,1 to -0,06	-4,1 to -0,9	-0,5		-0,4	-0,3		-0,06			
Photochemical oxidation (*10-1 g ethylene eq.)	-4,4 to -0,03	-4,4 to -0,3	-1,3	-0,7	-1,2	-1,3	-0,12		-0,03	-0,11	-0,11 to -0,06
Water pollution (critical volume in liter)	-10,1 to -0,9	-10,1 to -0,9	-3,7		-3,5	-3,32					
Eutrophication (*10-2 g PO4 eq.)	-29 to -5	-29 to -5									
Municipal waste (g)	-70 to 0	-32 to -0,5	-9	-40			-70			-40	-70 to 0
Hazardous waste (g)	0			0			0			0	0 for bumper

Annex VIII (B)

Environmental costs of plastics treatment per resin and treatment option (per kg) *Source: GHK/BIOIS 2006, p. 129.*

Landfill

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	0,2 to 0,53	0,2	0,2	0,62	0,2	0,2	0,53	0,53	0,5	0,52	0,52 to 0,53
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	32,56 to 364	364	269	36,67	237	248	32,56	33,33	33,33	33,33	32,63 to 32,80
Air acidification (g SO2 eq.)	0,01 to 1,5	0,1	0,7	0,25	1,5	0,4	0,21	0,01	0,2	0,22	0,19 to 0,21
Photochemical oxidation (*10-1 g ethylene eq.)	0,1 to 1,4	1,1	0,8	0,1	0,7	0,8	0,2	1,4			0,1
Water pollution (critical volume in liter)	0,6 to 47,44	0,6	0,6	35,83	0,6	0,6	47,44	46,94	47,2	47,04	47,20 to 47,26
Eutrophication (*10-2 g PO4 eq.)	2 to 85	2	38	3	85	18	18	18	18	18	18
Municipal waste (g)	1000 to 1001	1001	1001	1000	1001	1001	1000	1000	1000	1000	1000
Hazardous waste (g)											

Mechanical recycling

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)	12,7		12,7 for SR=0,65								
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	395 to 3983		3983 for SR=0,65			395 to 595					
Air acidification (g SO2 eq.)	3,1		3,1 for SR=0,65								
Photochemical oxidation (*10-1 g ethylene eq.)	98		98 for SR=0,65								
Water pollution (critical volume in liter)											
Eutrophication (*10-2 g PO4 eq.)	75		75 for SR=0,65								
Municipal waste (g)	70								70		
Hazardous waste (g)	2 to 11					2 to 11					

Feedstock recovery

Blast furnace

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)											
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	9,47 to 110		71		92	85		63,89	110		9,47 for air duct
Air acidification (g SO2 eq.)	0,1 to 0,5	0,5 when S=hard coal	0,1		0,2	0,14					
Photochemical oxidation (*10-1 g ethylene eq.)	1	1 when S=hard coal									
Water pollution (critical volume in liter)	0,74 to 1,75	15 to 17	17		17	17,5		0,83	0,97		0,74 for air duct
Eutrophication (*10-2 g PO4 eq.)	4 to 11	6 to 11	9		9	9		4	5		
Municipal waste (g)	2 to 30				2	2,4		30	30		
Hazardous waste (g)	0,1 to 10	0,1	0,1		0,6	1					10 for air duct

Syngas production

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)											
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	29,17 to 1420	1297 to 1420 when S=methanol from mix	1168	660,83	225 to 1045	1047		29,17	380	262,96	
Air acidification (g SO2 eq.)	1,3 to 2,7	2,1 to 2,7 when S=methanol from mix	1,4		1,4 when S=methanol from mix	1,3					
Photochemical oxidation (*10-1 g ethylene eq.)	1,7 to 3,0	3 when S=methanol from mix	1,8		1,8 when S=methanol from mix	1,7					
Water pollution (critical volume in liter)	17 to 37,67			22,5	17 when S=methanol from mix		37,67	19,58	18,87	31,48	24 to 37,55
Eutrophication (*10-2 g PO4 eq.)	10 to 34	12 to 34 when S=methanol from mix	11		10 when S=methanol from mix	10					
Municipal waste (g)	6 to 10	11 to 12 when S=methanol from mix	6		8 when S=methanol from mix	8,6					10 for air duct
Hazardous waste (g)	0,04 to 3	0,1 to 3 when S=methanol from mix	0,04		0,5 to 0,6	1					

Energy recovery

Cement kiln

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)											
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	3,33								3,33		
Air acidification (g SO2 eq.)	0,04 to 0,8			0,67		0,05	0,23	0,04	0,8	0,41	0,22 to 0,63
Photochemical oxidation (*10-1 g ethylene eq.)	0,3 to 8,3			0,3				8,3	0,3		0,3 for air duct
Water pollution (critical volume in liter)	1,11 to 5	5 when S=hard coal	5	1,67	5	4,7	1,16	1,53	1,57	1,11	1,18 to 1,58
Eutrophication (*10-2 g PO4 eq.)	3 to 14	3 when S=hard coal	4	12	4	4	9	14	14	10	9 to 13
Municipal waste (g)											
Hazardous waste (g)											

MSWI

	General	PP/EPDM	PUR (Fraunhofer)	PUR (APME)	PA-6,6 GF	12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	PE	PA	PC	ABS	PP
Energy consumption (MJ)											
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	301 to 2131	301 to 2131	1146	1282,5	909	971	1540	840,28	1157	1674,1	916,34 to 1531,21
Air acidification (g SO2 eq.)	0,21 to 0,33			0,25			0,33		0,27	0,33	0,21 to 0,32
Photochemical oxidation (*10-1 g ethylene eq.)	2,8							2,8			
Water pollution (critical volume in liter)	6,77 to 8,74			5,83			8,14	6,94	6,77	7,04	7,99 to 8,74
Eutrophication (*10-2 g PO4 eq.)	8 to 26		8	17	8	8	26	14	15	23	17 to 26
Municipal waste (g)	44 to 230				44	63,3		220	230		
Hazardous waste (g)	1,9 to 50	3	1,9		16,7	32		40	30		50 for air duct

Annex IX
Current practice per material – overview

Material / component	Amount in ELV arisings	Specific properties	Current treatment
Metals	75%	Easy to separate and recycle, high market value but subject to significant variations[179]	100% recycled or reused
Tyres	3%	Easy to separate, high calorific value (20% greater than coal), highly polluting when burnt (dioxins and particulates), recycling can have considerable environmental effects (high savings of energy and resources)[180]	Landfill banned in the EU as of 2006 (Directive 1999/31/EC on landfill). Various option applied: reuse in cars, reuse in landfill sites and other applications (crash barriers, boat and dock fenders), retreading, recycling through crimbing (use in sports facilities, construction (rubber asphalt), as crumb in the production of new tyres, in other applications), other recycling techniques (cryogenic fragmentation, de-vulcanisation, microwave technology), energy recovery (burning, pyrolysis, cement kilns).
Batteries	1%	Easy to remove, incorrect disposal poses high environmental and health hazards, incorrect incineration leads to hazardous emissions (release of lead)	Mandatory removal (ELV Directive), disposal regulated by Directive 91/157/EC on batteries, under revision. Established collection and recovery systems in MS (recycling and recovery rates exceed 90%).
Plastics	12% (on increase due to light weight and fuel efficiency issues)	Varied mixture of plastics (variety of polymer types used),	Removal of large plastic components obligatory (ELV Directive). Low recycling rates due to mixed composition, majority of plastic material arises as mixed ASR (difficult to separate from other fractions), recycling of large parts technically feasible and on increase, removal of small parts not economically viable (landfilled in ASR or recovered in PSTs)
Glass	2%	Low market value, high costs of removal. Two types used (toughened and laminated). Toughened easier to remove, laminated more difficult and costly, but easiness of removal largely	Removal obligatory under ELV Directive, however majority landfilled in ASR since the costs of removal by far exceed the market price for cullet. Careful separation from other materials (to avoid

179 Compared to manufacture from virgin materials, recycled steel uses 74% less energy, 40% less water, reduces air pollution by 86% and water pollution by 76%. Source: The Environmental Impacts of Motor Manufacturing and Disposal of End of Life Vehicles, Cleaner Vehicles Task Force (Department of the Environment, Trade and the Regions), UK, March 2000 and; Shredding and Media Separation, Bureau of International Recycling, Brussels, www.bir.org/biruk/eolv.htm, 2000.

180 Use of secondary material from tyres saves 23.8 kWh/kg (85.7 MJ/kg) when compared to the production of tyres from a rubber mix of primary material. Only 9.0 kWh/kg (32.4 MJ/kg, i.e. 2.6 times less than in recycling) can be saved in thermal recovery. Source: www.EnTire-Engineering.de.

		depends on the method of sealing glass in place during manufacture. Thermal recovery possible (28-32 MJ/kg energy savings), to some extent recycling also possible.	contamination) needed to use in recycling or recovery. Limited capacity of treatment plants can require distant transport.
Fluids: Antifreeze with glycol Brake fluids Mineral oils	2% (0.1%) (0.07%) (0.7%)	May contain ecologically sensitive substances. Small amounts originating in depollution centres and costs of transport to treatment facilities make recycling/recovery economically not viable. Waste oils possible to recycle (Germany).	Removal obligation under ELV Directive. Recovered (removal of excess water, filtering out particulates) or used as fuel in heavy industry and power stations, refined for use as lubricants (small scale).
Catalytic converters	(*)	Made up of stainless steel box housing a catalyst containing ceramic or metallic substrates, with active coatings of alumina, ceria and other oxides and a combination of precious metals – platinum, palladium and rhodium. High market value of precious metals.	Removal obligation under ELV Directive. Precious metals recovered and reused in catalysts or other applications. Ceramic casing recovered as a powder for refining. Steel recycled.
Airbags and pretensioners	(*)	Low market value	Removal obligation under ELV Directive. Reuse in cars impossible due to high product specifications and specialist installation procedures. Some reuse in other applications (tree holders). Recycling economically not viable.
(*) Rubber, textiles, fluids and other materials account for 8% of ELV arisings.			

Annex X
Impact Categories[181]

This Annex explains the impact categories applied to measure the environmental impacts of plastics treatment.

Two basic kinds of uncertainty have to be distinguished: the first one is due to the calculation modelling (used to describe a physical phenomenon), the other one is introduced as far as the inventory dataset may be reliable and accurate.

The soundness of every impact indicator is scored ('+++' high reliability to '+' = very low reliability) in the table above. The scores for the reliability of the calculation methods are representative of the today's state of the art for impact assessment within the LCA framework; additional works are in progress to improve the indicators related to human and ecosystem health.

Area of protection	**Impact category**	**Scientific unit for the indicator**	**Reliability of the calculation methods**	**Confidence in the inventory data**
Consumption of resources	Total energy	MJ	+++	+++
Air pollution	Global warming potential	g eq. CO_2	+++	+++
	Acidification potential	g eq. SO_2	++	++
	Photochemical oxidation	g eq ethylene	+	+
Water pollution	Eutrophication potential	g eq. PO_4	+	+
	Water pollution (critical volume)	m^3	+++	++
Waste	Municipal waste	kg	+++	+++
	Hazardous waste	kg	+(+)	+(+)

Source: BIO Intelligence Services, 2005.

Total energy (MJ)

Energy carriers are divided in renewable and non-renewable resources. For determining the energy content of resources, the method considers the fundamental material input and the net calorific value. This is done irrespective of whether the resources are to serve for material purposes or for energy refining. For the latter, the following methodology is generally employed in LCA studies.

The energy demands of an analysed system (as far as fossil fuels are concerned) are traced back in the inventory to the removal of the primary energy carriers from a raw materials source. Based on the material input (given in mass unit in the inventory), the resource demand

181 Source: GHK/BIOIS 2006.

can be assessed by taking the net calorific value because for the majority of technical applications the net calorific value and not the gross calorific value represents the relevant information.

Global warming

When determining the climatic impact of a substance, the Global Warming Potential (GWP) is used. This is a measure of the effect on radiation of a particular quantity of the substance over time relative to that of the same quantity of CO_2. The GWP depends on the time which a gas spends in the atmosphere, and on the gas's capacity to affect radiation, which describes the immediate effects on overall radiation of a rise in concentration of the gas.

The GWP is calculated with combined climatic and chemical models and covers two effects: the direct effect a substance has through the absorption of infrared radiation and the indirect chemical effects on overall radiation.

In the life cycle assessment of the end-of-life of plastic parts from ELVs, radiation effects due to CO_2, methane (CH_4) and nitrogen protoxide (N_2O) are considered in the impact assessment.

The GWP value for CO_2 is chosen as equivalence factor. Considered over a time span of 100 years, methane should have a GWP CO_2 value of 21, and N_2O a GWP of 310.

Air acidification

In order to describe the acidifying effect of substances, their acid formation potential (ability to form H+ ions) is calculated and set against a reference substance, SO_2.

Acid producer (in air)	SO_2 equivalence factor
1 kg HCl	0.88 kg eq SO_2
1 kg HF	1.60 kg eq SO_2
1 kg NO2	0.70 kg eq SO_2
1 kg SO2	1.00 kg eq SO_2
1 kg H2S	1.88 kg eq SO_2
1 kg NH4	0.89 kg eq SO_2
1 kg NH3	0.93 kg eq SO_2

SO_2 Equivalence Factors of Various Acid Producers

Photochemical oxidation

As a measure for estimating airborne substances' potential for forming atmospheric oxidants, POCP (Photochemical Ozone Creation potential) values are used. The POCP value of a particular hydrocarbon is a relative measure of how much the ozone concentration measured at a single location varies if emission of the hydrocarbon in question is altered by the same amount as that of a reference hydrocarbon, usually ethylene.

The POCP value is not constant, but can very over distance and time, since formation of oxidants along the path of an air pocket is determined by the composition of the prior mixture and the meteorological conditions, which can also vary spatially and chronologically.

Eutrophication

Additional input of plant nutrients into water can bring about excessive growth of water weeds (phytobenthon), free-floating plant organisms (phytoplankton) and higher plant forms (macrophytes). This does not only represent a change in the stock of a species, but also in the balance between species. Due to the increased generation of biomass and the consequently heavier sedimentation of dead organic material, the oxygen dissolved in deep water is consumed faster, through aerobic decomposition. This can lead to serious damage in the biological populations inhabiting the sediment. In addition to this, direct toxic effects on higher organisms, including humans must be taken into account when certain species of algae appear in mass.

While phosphorus determines the degree of eutrophic activity in the majority of cases in the limbic area, in marine and terrestrial ecosystems nitrogen is most often the decisive factor. Equivalence factors suggested by CML (University of Leiden, 1992) are generally used in LCA.

Nutrient	PO4 equivalence factor
1 kg Nitrogen oxides (NOx, air)	0.13 kg eq PO4
1 kg Total nitrogen (water)	0.42 kg eq PO4
1 kg Total phosphorous (water)	3.07 kg eq PO4
1 kg Chemical O2 demand (COD)	0.022 kg eq PO4
1 kg NH3	0.35 kg eq PO4
1 kg NH4+	0.33 kg eq PO4
1 kg NO3-	0.095 kg eq PO4
1 kg NO2-	0.13 kg eq PO4

PO_4 equivalence factors of various substances

Water pollution

Water emissions are calculated as critical volume. For every emission a volume of water is calculated, which is necessary to ensure sufficient dilution to an acceptable effect level in the environment. The acceptable levels for the calculations in this study are based on the German legislation (waste water regulation from 1997).

Nutrient	Dilution factor (l/mg)
COD	1
BOD	5

Total N	4
NH4	8
PO4	75
AOX	75
Heavy metals	75
Hydrocarbons	38

Water pollution dilution factors of various substances (APME, 2003)

Annex XI
Ranges of impacts per treatment option for all plastic resins (per kg)

Broad Treatment Option	Mechanical recycling		Feedstock recovery				Energy recovery				Landfill	
Detailed Treatment Option			Blast furnace		Syngas production		Cement kiln		MSWI			
Range	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Energy consumption (MJ)	-105,2	12,7	-47,67	-19,9	-58,2	-17	-48	-18,6	-35	-12,7	0,2	0,62
Greenhouse effect (direct, 100 yrs) (g CO2 eq.)	-6090	3983	-293	110	-163	1420	-1670	-588	301	2131	32,6	364
Air acidification (g SO2 eq.)	-45,6	3,1	-3,19	0,5	-11,4	2,7	-0,9	0,8	-4,1	0,33	0,01	1,5
Photochemical oxidation (*10-1 g ethylene eq.)	-358	98	-6,9	1	-54,2	3	-1,4	8,3	-4,4	2,8	0	1,4
Water pollution (critical volume in liter)	-1075	-10,8	-0,7	17,5	-77	37,7	-6	4,7	-100,1	8,74	0,6	47,44
Eutrophication (*10-2 g PO4 eq.)	-530	75	-14	11	-102	34	-3	14	-29	26	3	85
Municipal waste (g)	-272	70	-10	30	-150	12	-390	0	-70	230	1000	1001
Hazardous waste (g)	-30	11	0,1	10	-0,1	3	0	0	0	50	0	0
External costs (Euros)	-1,58E-01	2,08E-01	-6,79E-03	7,03E-03	-1,09E-02	7,32E-02	-3,36E-02	-2,61E-02	4,07E-03	1,09E-01	4,67E-03	4,01E-02

This table summarises results obtained with respect to the following resins: PP/EPDM, PA-GF, PUR, PVC/ABS/PP-TV/PUR, PE, PC, PA, PP, PUR, and ABS. The ranges presented in the table above cover negative and positive values which are interpreted as benefits or disbenefits for the environment respectively. Source: GHK/BIOIS 2006, p. 126.

Annex XII
Global warming potential for different ELV materials and treatment options[182]

treatment option of 1 kg of material	Global warming potential over 100 years. Equivalent of CO_2/kg of a material (in kg)
steel	
recycling	- 0.39
reuse	- 2.20
landfill	
aluminium	
recycling	- 10.69
reuse	- 13.50
plastics (all fractions)	
reuse	- 1.20 to - 31.00
recycling	- 6.10 to + 4.00
recovery	- 1.70 to + 2.10
landfill	+ 0.03 to + 0.36
tyres	
recycling	- 2.70
cement kiln	- 1.20
waste incineration	0.68

182 Source: GHK/BIOIS 2006.

Annex XIII (a)
Environmental impacts of different sets of recycling and recovery targets (for a 1,000 kg ELV)

Impacts of 85% RR / 95% RRR (5% of plastics or 708,000 tonnes are recovered, 7% of plastics or 988,000 tonnes are recycled, 0 plastics landfilled)	5% recovery (708,000 tonnes plastics)	7% recycling (988,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-23.420.640	-56.118.400	0	**-79.539.040**	**GJ**
Greenhouse gas emissions	-225.144	-980.096	0	**-1.205.240**	**t CO_2 eq**
Air acidification	-991	-16.895	0	**-17.886**	**t SO_2 eq**
Photochemical oxidation	1.770	-711.360	0	**-709.590**	**kg ethylene**
Water pollution	1.309.800	19.760	0	**1.329.560**	**m^3**
Eutrophication	-14.160	-770.640	0	**-784.800**	**kg PO_4**
Municipal waste	-101.173	19.760	0	**-81.413**	**t**
Hazardous waste	3.292	7.904	0	**11.196**	**t**

Impacts of 80% RR / 95% RRR (10% of plastics or 1,416,000 tonnes are recovered, 2% of plastics or 280,000 tonnes are recycled, 0 plastics landfilled)	10% recovery (1,416,000 tonnes plastics)	2% recycling (280,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-46.841.280	-15.904.000	0	**-62.745.280**	**GJ**
Greenhouse gas emissions	-450.288	-277.760	0	**-728.048**	**t CO_2 eq**
Air acidification	-1.982	-4.788	0	**-6.770**	**t SO_2 eq**
Photochemical oxidation	3.540	-201.600	0	**-198.060**	**kg ethylene**
Water pollution	2.619.600	5.600	0	**2.625.200**	**m^3**
Eutrophication	-28.320	-218.400	0	**-246.720**	**kg PO_4**
Municipal waste	-202.346	5.600	0	**-196.746**	**t**
Hazardous waste	6.584	2.240	0	**8.824**	**t**

Impacts of 80% RR / 85% RRR (5% of plastics or 708,000 tonnes are recovered, 2% of plastics or 280,000 tonnes are recycled, 5% or 708,000 tonnes plastics landfilled)	0-10% recovery (708,000 tonnes plastics) Assumed: 5%	2% recycling (280,000 tonnes plastics)	0-10% landfill (708,000 tonnes plastics) Assumed: 5%	total impacts	*unit*
Energy savings / losses	-23.420.640	-15.904.000	283.200	**-39.041.440**	**GJ**
Greenhouse gas emissions	-225.144	-277.760	140.538	**-362.366**	**t CO_2 eq**
Air acidification	-991	-4.788	531	**-5.248**	**t SO_2 eq**
Photochemical oxidation	1.770	-201.600	49.560	**-150.270**	**kg ethylene**
Water pollution	1.309.800	5.600	17.027.400	**18.342.800**	**m^3**
Eutrophication	-14.160	-218.400	307.980	**75.420**	**kg PO_4**
Municipal waste	-101.173	5.600	708.000	**612.427**	**t**
Hazardous waste	3.292	2.240	0	**5.532**	**t**

Impacts of 85% RR / 90% RRR (2.5% of plastics or 354,000 tonnes are recovered, 7% of plastics or 988,000 tonnes are recycled, 2.5% or 354,000 tonnes plastics landfilled)	0-5% recovery (0 to 708,000 tonnes plastics) assumed here: 2.5%	7% recycling (988,000 tonnes plastics)	0-5% landfill (0 to 708,000 tonnes plastics) assumed here: 2.5%	total impacts	*unit*
Energy savings / losses	-11.710.320	-56.118.400	141.600	**-67.687.120**	**GJ**
Greenhouse gas emissions	-112.572	-980.096	70.269	**-1.022.399**	**t CO_2 eq**
Air acidification	-496	-16.895	266	**-17.125**	**t SO_2 eq**
Photochemical oxidation	885	-711.360	24.780	**-685.695**	**kg ethylene**
Water pollution	654.900	19.760	8.513.700	**9.188.360**	**m^3**
Eutrophication	-7.080	-770.640	153.990	**-623.730**	**kg PO_4**
Municipal waste	-50.587	19.760	354.000	**323.173**	**t**
Hazardous waste	1.646	7.904	0	**9.550**	**t**

	85% recycling / 95% recovery	80% recycling / 95% recovery	80% recycling / 85% recovery	85% recycling / 90 % recovery	*unit*
Energy savings / losses	**-79.539.040**	**-62.745.280**	**-39.041.440**	**-67.687.120**	**GJ**
Greenhouse gas emissions	**-1.205.240**	**-728.048**	**-362.366**	**-1.022.399**	**t CO_2 eq**
Air acidification	**-17.886**	**-6.770**	**-5.248**	**-17.125**	**t SO_2 eq**
Photochemical oxidation	**-709.590**	**-198.060**	**-150.270**	**-685.695**	**kg ethylene**
Water pollution	**1.329.560**	**2.625.200**	**18.342.800**	**9.188.360**	**m^3**
Eutrophication	**-784.800**	**-246.720**	**75.420**	**-623.730**	**kg PO_4**
Municipal waste	**-81.413**	**-196.746**	**612.427**	**323.173**	**t**
Hazardous waste	**11.196**	**8.824**	**5.532**	**9.550**	**t**

Data for recycling are based on PP/EPDM from Fraunhofer 2002, data for recovery based on plastics mix from GHK/BIOIS 2006.

Note the assumptions on which these are based – particularly in relation to the proportion of the ELV going to landfill rather than recovery under the lower RRR targets. The impacts for equal proportions of landfill/recovery have been shown above – whilst in practice a range of outcomes is possible, which would have very significant effects on the impacts of these lower RRR options.

Annex XIII (b)
Environmental impacts of different sets of recycling and recovery targets (for a 1,280 kg ELV)

Impacts of 85% RR / 95% RRR (5% of plastics or 881,000 tonnes are recovered, 7% of plastics or 1,234,000 tonnes are recycled, 0 plastics landfilled)	5% recovery (881,000 tonnes plastics)	7% recycling (1,234,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-29.154.860	-70.091.200	0	**-99.246.060**	**GJ**
Greenhouse gas emissions	-280.267	-1.224.128	0	**-1.504.395**	**t CO_2 eq**
Air acidification	-1.234	-21.101	0	**-22.335**	**t SO_2 eq**
Photochemical oxidation	2.203	-888.480	0	**-886.277**	**kg ethylene**
Water pollution	1.630.486	24.680	0	**1.655.166**	**m^3**
Eutrophication	-17.627	-962.520	0	**-980.147**	**kg PO_4**
Municipal waste	-125.944	24.680	0	**-101.264**	**t**
Hazardous waste	4.098	9.872	0	**13.970**	**t**

Impacts of 80% RR / 95% RRR (10% of plastics or 1,762,000 tonnes are recovered, 2% of plastics or 353,000 tonnes are recycled, 0 plastics landfilled)	10% recovery (1,762,000 tonnes plastics)	2% recycling (353,000 tonnes plastics)	no landfill	total impacts	*unit*
Energy savings / losses	-58.309.719	-20.050.400	0	**-78.360.119**	**GJ**
Greenhouse gas emissions	-560.535	-350.176	0	**-910.711**	**t CO_2 eq**
Air acidification	-2.468	-6.036	0	**-8.504**	**t SO_2 eq**
Photochemical oxidation	4.407	-254.160	0	**-249.753**	**kg ethylene**
Water pollution	3.260.973	7.060	0	**3.268.033**	**m^3**
Eutrophication	-35.254	-275.340	0	**-310.594**	**kg PO_4**
Municipal waste	-251.888	7.060	0	**-244.828**	**t**
Hazardous waste	8.196	2.824	0	**11.020**	**t**

Impacts of 80% RR / 85% RRR (5% of plastics or 881,000 tonnes are recovered, 2% of plastics or 353,000 tonnes are recycled, 5% or 881,000 tonnes plastics landfilled)	5% recovery (881,000 tonnes plastics)	2% recycling (353,000 tonnes plastics)	5% landfill (881,000 tonnes plastics)	total impacts	*unit*
Energy savings / losses	-29.154.860	-20.050.400	352.400	**-48.852.860**	**GJ**
Greenhouse gas emissions	-280.267	-350.176	174.879	**-455.565**	**t CO_2 eq**
Air acidification	-1.234	-6.036	661	**-6.609**	**t SO_2 eq**
Photochemical oxidation	2.203	-254.160	61.670	**-190.287**	**kg ethylene**
Water pollution	1.630.486	7.060	21.188.050	**22.825.596**	**m^3**
Eutrophication	-17.627	-275.340	383.235	**90.268**	**kg PO_4**
Municipal waste	-125.944	7.060	881.000	**762.116**	**t**
Hazardous waste	4.098	2.824	0	**6.922**	**t**

Impacts of 85% RR / 90% RRR (2.5% of plastics or 440,500 tonnes are recovered, 7% of plastics or 1,234,000 tonnes are recycled, 2.5% or 440,500 tonnes plastics landfilled)	0-5% recovery (0 to 881,000 tonnes plastics) assumed here: 2.5%	7% recycling (1,234,000 tonnes plastics)	0-5% landfill (0 to 881,000 tonnes plastics) assumed here: 2.5%	total impacts	*unit*
Energy savings / losses	-14.577.430	-70.091.200	176.200	**-84.492.430**	**GJ**
Greenhouse gas emissions	-140.134	-1.224.128	87.439	**-1.276.822**	**t CO_2 eq**
Air acidification	-617	-21.101	330	**-21.388**	**t SO_2 eq**
Photochemical oxidation	1.102	-888.480	30.835	**-856.543**	**kg ethylene**
Water pollution	815.243	24.680	10.594.025	**11.433.948**	**m^3**
Eutrophication	-8.813	-962.520	191.618	**-779.716**	**kg PO_4**
Municipal waste	-62.972	24.680	440.500	**402.208**	**t**
Hazardous waste	2.049	9.872	0	**11.921**	**t**

	85% recycling / 95% recovery	80% recycling / 95% recovery	80% recycling / 85% recovery	85% recycling / 90 % recovery	*unit*
Energy savings / losses	**-99.246.060**	**-78.360.119**	**-48.852.860**	**-84.492.430**	**GJ**
Greenhouse gas emissions	**-1.504.395**	**-910.711**	**-455.565**	**-1.276.822**	**t CO_2 eq**
Air acidification	**-22.335**	**-8.504**	**-6.609**	**-21.388**	**t SO_2 eq**
Photochemical oxidation	**-886.277**	**-249.753**	**-190.287**	**-856.543**	**kg ethylene**
Water pollution	**1.655.166**	**3.268.033**	**22.825.596**	**11.433.948**	**m^3**
Eutrophication	**-980.147**	**-310.594**	**90.268**	**-779.716**	**kg PO_4**
Municipal waste	**-101.264**	**-244.828**	**762.116**	**402.208**	**t**
Hazardous waste	**13.970**	**11.020**	**6.922**	**11.921**	**t**

Annex XIV
Numbers of deregistered vehicles in the EU[183]

	Deregistrations (000)	ELV Treated (000)
Germany	3068	1200
UK	2200	2110
Italy	1830	915
France	1800	1300
Spain	850	1000
Netherlands	473	272
Sweden	258	237
Austria	247	124
Portugal	130	52
Ireland	130	130
Finland	105	89
Denmark	73	73
Belgium	92	92
Greece	30	20
Luxembourg	10	9
EU15	**11,296**	**7,623**

Number of Vehicles Deregistered and ELVs Treated, EU15, ACEA 2004.

	Deregistrations (000)
Cyprus	17
Czech Republic	215
Estonia	25
Hungary	159
Latvia	36
Lithuania	65
Malta	12
Poland	682
Slovakia	79
Slovenia	51
New MS	**1,342**

Estimated number of Vehicles Deregistered and ELVs Treated, EU15, GHK/BIOIS.

183 Source: GHK/BIOIS 2006.

Annex XV
ELV Treatment sector in Europe[184]

Member State	No. of ATFs	No of ATFs certified	No. treated ELVs per ATF	No. of shredders	No. treated ELVs per shredder (000)
Austria	200	200	620	6	21
Belgium	48	48	1,917	12	8
Cyprus	1	n/a	n/a	0	n/a
Czech Republic	80-100	n/a	n/a	3	n/a
Germany	1,178	1,178	1,019	41	29
Denmark	210	210	381	13	6
Spain	540	501	1,852	22	45
Estonia	70	n/a	214	1	15
Greece	4	n/a	5,000	4	5
France	1,000	420	1,300	42	31
Finland	60	30	1,483	2	45
Hungary	150	n/a	n/a	2	n/a
Italy	1,800	314	508	18	51
Ireland	35	35	3,714	2	65
Luxembourg	2	1	4,500	0	n/a
Latvia	161	n/a	311	1	50
Lithuania	43	n/a	465	1	20
Malta	n/a	n/a	n/a	0	n/a
Netherlands	500	500	544	11	25
Portugal	8	1	6,500	2	26
Poland	670	n/a	119	4	27
Sweden	370	120	641	7	34
Slovenia	20	n/a	n/a	1	n/a
Slovakia	30	n/a	n/a	1	n/a
UK	732	732	2,883	37	57
EU	**7,922**	**4,290**	**1,788**	**232**	**34**

[184] Source: Stakeholder Report 2005.

Annex XVI
Typical landfill costs for ASR in the EU[185]

Typical costs in:	**Range (€/tonne)**	**Midpoint (€/tonne)**
Low cost MS	30-40	35
Medium cost MS	50-80	65
High cost MS	90-140	115

185 Source: GHK/BIOIS 2006, Annex 2, p.14.

Annex XVII
Estimated composition of ASR in Germany, 1998[186]

Material	Share % or weight (mg/kg)
Metals	4-15 %
Plastics	25-35 %
Elastomers	5-30 %
Wood and textile	6-12 %
Road dirt	5-20 %
Operating fluids	6-7 %
PCB[187]	0.05-0.20 mg/kg
PAK	18-45 mg/kg

186 Source: Zoboli et al (2000).

187 The classification of ASR is still subject to uncertainties as ASR is classified as hazardous by the Basel Convention on transboundary movements of waste and by EC Regulation 259/93 (Amber list) (due to the presence of substance as PCB) while at present, ASR is not considered as hazardous in the EC legislation. Due to the inclusion of ASR among hazardous waste in the Basel Convention the movements of ASR across EU countries are estimated to be negligible.

Annex XVIII
List of Contributing Stakeholders

List of Stakeholders who participated in the Stakeholder Working Group:

The names appear in alphabetical order. This order does not bear any relation to the relative importance of the contributions.

Member States

Belgium (*Service Public Fédéral Santé Publique, Sécurité de la Chaîne Alimentaire et Environnement*)
Denmark
France
Hungary
The Netherlands (*Ministry of Housing, Spatial Planning and the Environment*)
UK DTI

Local and Regional Authorities

Flemish Waste Agency (OVAM)
Office wallon des déchets
Waste Denmark

Industry and Trade Associations

Alternative Management of Vehicles Hellas (AMVH) (EDOE)
Association of the Hungarian Automotive Industry (AHAI)
Association of European Storage Battery Manufacturers (EUROBAT)
European Aluminium Association (EAA)
European Association of the Non-Ferrous Metals Industry (Eurometaux)
European Association of the Rubber Industry (BLIC)
European Automobile Manufacturers Association (ACEA)
European Confederation of Iron and Steel Industries (EUROFER)
Japanese Automobile Manufacturers Association (JAMA)
Korean Automobile Manufacturers Association (KAMA)
PlasticsEurope (Association of Plastics Manufacturers)
PBW Metal Products Ltd
Society of Motor Manufacturers and Traders (UK)

Associations of Vehicle Dismantlers and Recyclers

Auto Recycling Netherlands (ARN)
Bilindustriforeningen Sweden (BIL Sweden)
Bureau of International Recycling (BIR)
Danish Waste Management Association (DAKOFA)
European Ferrous Recovery & Recycling Federation (EFR)
European Group of Automotive Recycling Associations (EGARA)
European Shredder Group (ESG)
EUROMODULERS
Fabelauto Belgium
Nordic Recycling Federation (NRF)
Stowarzyszenie Forum Recyklingu Samochodów Polska (FORS Poland)
Verband der Automobilindustrie, German Association of the Automotive Industry (VDA)

NGOs, Consumer Organisations and Environmental Agencies

Association for the Sustainable Use and Recovery of Resources in Europe (ASSURE)
European Environmental Bureau (EEB)
Deutscher Naturschutzring (DNR)
Umweltbundesamt, Federal Environmental Agency Germany (UBA)

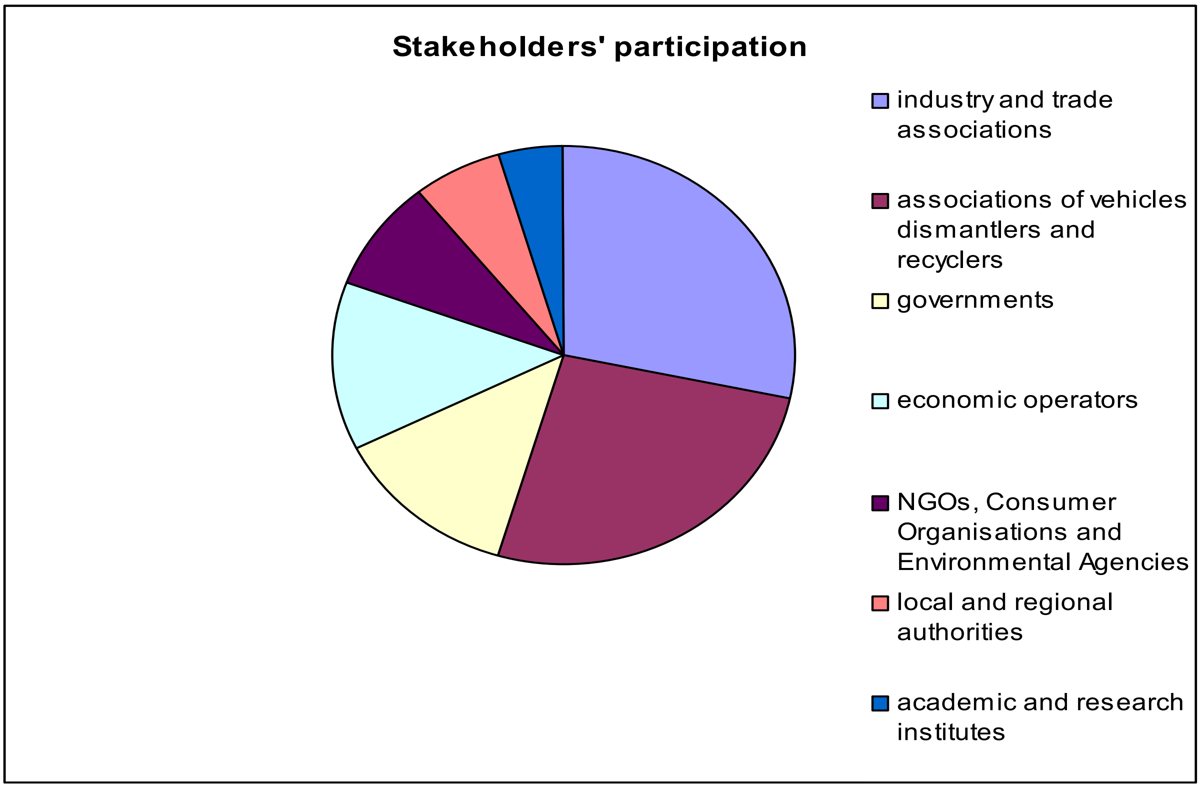
Economic Operators

AUDI AG
Ford
Hyundai-Platz
Opel
Renault
Stena Metall Group

Academic and Research Institutes

Oekopol
T.U Delft (Delft University of Technology)

The main contributors were industry and trade associations (13), associations of vehicles dismantlers and recyclers (12), governments (6), economic operators (6), NGOs, Consumer Organisations and Environmental Agencies (4), local and regional authorities (3), and academic and research institutes (2), as illustrated by the following chart:



List of stakeholders who participated in the on-line stakeholder consultation on the GHK/BIOIS report

The names appear in alphabetical order. This order does not bear any relation to the order in which the contributions have been received, nor to the relative importance of the contributions.

(1) ACEA
(2) Bureau for International Recycling (BIR)
(3) Cometsambre
(4) Confédération belge de la recuperation asbl (COBEREC)
(5) European Environmental Bureau (EEB)
(6) European Ferrous Recovery & Recycling Federation (EFR)
(7) European Shredder Group (EFR)
(8) French Federation of Recovery and Recycling (FEDEREC)
(9) MARAS
(10) PlasticsEurope
(11) Sims Group
(12) Toyota
(13) University of Melbourne

Annex XIX
List of Abbreviations

ABS	Acrylonitrile-butadiene-styrene resin
ACEA	Association of European Automobile Manufacturers
APME	Association of Plastic Manufacturers in Europe now known as PlasticsEurope
ARN	Auto Recycling Netherlands
ASA	Acrylic-styrene-acrylonitrile polymers
ASR	Auto shredder residue
ATF	Authorised treatment facility
CEN	European Committee for Standardisation
ELV	End-of-life vehicle
EPDM	Ethylene-propylene terpolymer
EU	European Union
EU10	Ten Member States which joined the European Union on 1 May 2004
EU15	Member States of the European Union before the 1 May 2004 enlargement
EU25	All 25 Member States of the European Union
GWP	Global Warming Potential
HCl	Hydrochloric acid
HIPS	High Impact Polystyrene
LCA	Life Cycle Analysis
LCI	Life Cycle Inventory
MS	Member State
MSW	Municipal Solid Waste
MSWI	Municipal Solid Waste Incineration
PA	Polyamide
PBT	Polybrominated terphenyl
PC	Polycarbonate plastic
PE	Polyethylene
PET	Polyethylene terephthalate
PMMA	Polymethyl methacrylate plastic
POM	Polyoxymethylene
PP	Polypropylene
PPE	Polyphenylene ether compounds
PST	Post Shredder Technology
PUF	Polyurethane foam
PUR	Polyurethane
PVC	Polyvinyl chloride
R&D	Research and Development
SMA	Styrene-maleic anhydride
UK	United Kingdom
UP	Unsaturated polyester
WEEE	Waste electrical and electronic equipment