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ANALYSIS OF THE KEY CONTRIBUTIONS TO RESOURCE EFFICIENCY

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Contents

Annex A: Definitions and additional data Chapter 1 and 2.....	5
Data sources.....	5
Material flow indicators.....	8
Land Use.....	13
Annex B: Savings estimation approach for each material stream.....	14
Annex C: Recycling.....	20
1. Summary of current recycling targets in the EU.....	20
Assumptions and calculations for estimating material savings through recycling.....	24
Assumptions and calculations for estimating the total contribution of recycling assuming all current recycling targets are fully reached.....	47
Assumptions and calculations for estimating the potential contribution of recycling assuming best practices are fully implemented.....	56
Annex D: Waste prevention.....	73
1. Waste prevention related policies.....	73
1.1 ELV Directive.....	73
1.1.1. WEEE Directive.....	74
1.1.2. Packaging and Packaging Waste Directive.....	75
1.2 RoHS Directive.....	76
1.3 EMAS (Eco-Management and Audit Scheme).....	77
1.4 ETAP (Environmental Technologies Action Plan).....	78
1.5 Waste prevention policies in MS.....	79
1.6 Voluntary waste prevention agreements.....	80
2. The potential of waste prevention approaches.....	82
2.1 Lean production.....	82
2.2 Reuse.....	83
2.3 Sustainable consumption behaviour.....	87
Annex E: Ecodesign.....	93
1. Ecodesign related policies.....	93
1.1 Ecodesign Directive.....	103
1.2 EU Ecolabel.....	104
1.3 Waste Electrical and Electronic Equipment Directive.....	107
1.4 Packaging and Packaging Waste Directive.....	108
1.5 End-of-Life Vehicle Directive.....	112
2. The potential of ecodesign approaches.....	114

2.1	Design for recyclability.....	114
2.2	Product lightweighting.....	115
2.3	Design for longevity	117
3.	Material Savings of light bulbs from Ecodesign Directive	118
Annex F: Overall savings		120
Material savings from recycling.....		120
1.	Overall material savings.....	123
1.1	Data uncertainties, relevance of assumptions and calculation uncertainties.....	125
Environmental impact assessment.....		132

ANNEX A: DEFINITIONS AND ADDITIONAL DATA

CHAPTER 1 AND 2

DATA SOURCES

The definitions and data sources used as a basis for the discussions in the main report chapters 1 and 2 are presented in this Annex.

Table 1: Definition of indicators for material flow analysis¹

Category	Description	Name	Definition
Input	Materials entering the socio-industrial metabolism used for production and consumption	DEU	Domestic Extraction Used is the part of the materials extracted that enters into the economy
		UDE	Unused Domestic Extraction is the part of the materials extracted that does not enter into the economy.
		DMI	Direct Material Input = DEU + imports
		TMI	Total Material Input = DMI + UDE
		TMR	Total Material Requirement = TMI + indirect resource extraction from imports
Output	Materials that have been used and are leaving the system in the form of emissions and waste, or exports.	RME	Raw materials equivalents = direct trade flow (import or export) + the associated indirect flows
		DPO	Domestic Processed Output = sum of wastes from production processes and households, emissions to air and water and other dissipative flows.
		TDO	Total Domestic Output = DPO + disposal of unused domestic extraction
Consumption	Materials entering the	TMO	Total Material Output = TDO + exports
		DMC	Domestic Material Consumption = DMI - exports

¹ Bringezu, S. & Bleischwitz, R. (editors) (2009) Sustainable Resource Management. Global trends, visions and policies. Greenleaf Publishing.

Category	Description	Name	Definition
	economy only for consumption purposes (can be calculated by subtracting exports)	TMC	Total Material Consumption = TMR - exports - indirect flows associated with exports
Balance	Measures the economy growth	NAS	Net Addition to Stocks = DMI - DPO - exports
		PTB	Physical Trade Balance = imports - exports
Productivity		GDP/TMR	Total resource productivity
		GDP/DMI	Direct material productivity
		GDP/DMC	Resource productivity

Table 2: Material flow indicators domestic extraction, imports, exports and domestic material consumption and for the four material categories for EU-27 in 2004 in million tonnes²

	Biomass	Fossil fuels	Minerals	Metals	Total
Domestic extraction	1,656	992	3,706	123	6,477
Imports	568	1,572	352	545	3,038
Exports	494	616	324	367	1,801
DMC	1,730	1,949	3,734	301	7,714

Table 3: Summary of data sources

Data	Source
Chapter 3 – Recycling	
Municipal waste	European Topic Centre on Resource and Waste Management (2009): EU as a Recycling Society - Present Recycling Levels of Municipal Waste and C&D Waste in the EU
C&D waste	Study on Management of construction and demolition waste in the EU. EC, 2010 Umweltbundesamt (2008): Aggregates Case Study - Final Report Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010..
End of life vehicles	Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010. GHK and BIO IS (2006), A study to examine the benefits of

² Derived from Eurostat 2009. Source: Analysis of the evolution of waste reduction and the scope of waste prevention. Sixth study request European Commission, DG Environment. Interim report. Draft 3.1.

Data	Source
	the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, reuse and recovery under the ELV Directive ANNEX 2 : arising and treatment of End of Life Vehicles
Waste from electric and electronic equipment	Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010. EEA – European Environment Agency (2009): Statistics for member states for SOER part C waste. Copenhagen. Submitted on 10.02.2010
Packaging waste	Eurostat Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010..
Chapter 4 – Waste prevention	Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010.. Preparatory study on food waste across EU-27. EC, 2010
Chapter 5 – Product design	EUROPEN; Packaging and Packaging Waste Statistics 1998 – 2006. BIO Intelligence Service (2010); “Technical support to identify product categories with significant environmental impact and with potential for improvement by making use of ecodesign measures” Final report.
Chapter 6 – Overall implications	
Data from waste statistics	Chapter 3 – recycling
Data from production statistics – metals	Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010.. EUROFER- European Confederation of Iron and Steel Industries Organisation of European Aluminium Refiners and Remelters EAA -European Aluminium Association EUROcopper- European Copper Institute Nickel Institute World Bureau of Metal Statistics EC DG ENTR DIRECTORATE G Unit G/3 : Steel, non-ferrous-metals, minerals & mineral products
Data from production statistics – plastics	Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010.. Plastics Europe EPRO (2008) Plastic Waste Management in Europe
Data from production statistics – non metallic minerals	Study on Management of construction and demolition waste in the EU. EC, 2010 Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. EC, 2010..
Data from production statistics – wood and paper	Eurostat database Eurostat forestry statistics 2009 edition
Data from production statistics – agriculture	Eurostat database

MATERIAL FLOW INDICATORS

In this Annex a discussion of the main material flow indicators is given.

Domestic extraction of raw materials (DE)

The aggregate Domestic Extraction (DE) flow covers the annual amount of raw materials, excluding water and air, extracted from the national territory in order to be used as material inputs for economic processing. The term “used” refers to an input that acquires value within the economic system. These materials consist of biomass³, construction and industrial minerals, gross ores, and fossil fuels⁴. “Unused flows” are materials that are extracted from the environment without the intention of using them. These ‘unused flows’ are referred to as “domestic hidden flows.”

DE, as an aggregate flow, in metric tonnes, makes sense on the global and the national level. The sum of DE for all countries equals global raw material extraction. Monitoring this quantity across time, and calculating its dynamics over time, reflects the overall scale of human activity on the planet. For each country, one may indicate the share of global raw material extraction. DE on the national level is an indicator of resource depletion within each country’s territory. The depletion may be temporary (as with agricultural biomass), or long-term (as with the destruction of primary forest or the extraction of minerals and ores). This is related to the sustainable development concept of intergenerational equity.

- Global DE, differentiated by class of materials, in metric tonnes, may be related to specific scarcities. DE of plant biomass, for example, can be related to the global net primary production of biomass, the DE of fossil fuels, minerals and ores to known reserves.
- National DE per capita of population (tonnes/capita) provides information on how much natural endowment an average person can draw from his or her own territory. It is not a very useful indicator relating to sustainability as such, but may serve as a means of standardisation for cross-country comparison.
- National DE per square kilometre (material intensity of land use in tonnes/km²) indicates environmental pressure on the domestic natural environment in relation to its size and to the intensity of human use. The specific environmental pressure may consist of competitive pressure on other species and loss of biodiversity. Most material streams of DE somehow relate to area: Biomass is clearly area dependent; construction materials are

³ Livestock is considered to be part of the economic processing system, so their inputs, whether fed by humans or consumed directly, belong to DE, while their body mass in the case of consumption is considered an internal transfer within the economic system. The body mass of wild animals, on the other hand (such as fish catch and game), if economically used, belongs to DE.

⁴ If these raw materials contain a certain amount of water and/or air, their weight is included and usually has to be balanced in the course of industrial transformation to wastes and emissions (see figure 1).

used⁵ to seal land and regulate water bodies which compete with biotic uses of land; and fossil fuels enrich the atmospheric carbon cycle which in turn must be neutralised by the growth of vegetation. So DE per km² appears to be quite a valid gross indicator for human intensity of land use.

- DE per unit of GDP (in tonnes/€) makes mainly sense on a global level as it expresses the overall material intensity of the human economy. On a national level, this should rather be represented by Domestic Material Consumption (DMC)/GDP.

Direct Material Input (DMI)

Direct Material Input (DMI) comprises all materials that enter a country's production process. It encompasses Domestic Extraction (DE) and Imports. In most studies, DMI is used as the indicator for resource use. However, it proves to be a difficult indicator to interpret when international trade becomes a substantial component of material input. On one hand, a shift from producing domestically towards importing commodities reduces DMI in a country (since all wastes generated during extraction and production are externalised from its territory). This reduction, which appears to be "dematerialisation", is in fact nothing more than an externalisation of impacts. On the other hand, countries that extract raw materials for export (in particular metal ores or highly processed biomass like meat) tend to have very high DMI without this being reflected by a corresponding Domestic Material Consumption level. Therefore, DMI per capita and DMI per unit of area are not very useful as indicators.

DMI/GDP is a useful indicator as it informs on the material requirements of a national economy. Quite legitimately, it is one of the most common indicators for the "dematerialisation" of an economy. One has to be aware, though, as explained above, that the easiest way to "dematerialise" a national economy is to shift from producing to importing commodities. Mathematically, this indicator can of course also be formulated as resource efficiency of the economy (GDP/DMI) measured in €/tonne or €/kg, which allows tracking the progress towards a more sustainable economy.

Domestic Material Consumption (DMC)

Domestic Material Consumption (DMC) measures the annual amount of raw materials extracted from the domestic territory (DE), plus all imports minus all exports (both in tonnes). There are, however, some interpretational ambiguities related to DMC. From the point of view of consumption, an imported commodity is functionally equivalent to a domestically produced commodity. In DMC, though, these functional equivalents lead to great differences. Likewise, producing a commodity for export is not related to the domestic consumption of materials at all, but according to the composition of DMC, all waste created during the production process is a component of domestic consumption.

⁵ Bulk construction materials are practically always used in close proximity to their extraction.

Identifying the similarities of material components aggregated to DMC could provide a better understanding. The materials are, quite obviously, not “consumed” by a country’s inhabitants and do not even necessarily serve the needs of the domestic population, but they are “consumed” or absorbed, by the natural environment of a country (by its soil, its waters and its atmosphere). There are three possible final destinations for all materials aggregated to DMC:

- Conversion to CO₂ that is emitted to the atmosphere, thereby contribution to global warming
- Emissions to air, water and soil exerting a more local effect on the environment (e.g. into solid wastes to be stored in landfills)
- Contribution to stock, which increases the physical stock, in particular the number of buildings and the size of built infrastructure⁶.

The proportions between the three final destinations of DMC in terms of mass are roughly 6:1:6 in the EU⁷. It is common for all these final destinations to be located within the national environment, and therefore they represent an annual flow of potential domestic waste. This national waste potential will either add to environmental pressure within the national territory (immediately or sometime in the future), or it will create international environmental pressure which may be attributed to the global responsibility of the country (as is the case of CO₂ emissions). As an indicator for the annual flow of potential domestic waste, this represents the “scale” of the physical economy⁸. The different denominators (population, total land area, and total GDP) of DMC express the three relevant reference scales against which the physical scale of an economy is to be measured to relate to sustainability. Per capita amounts of DMC point to the social scale of the domestic waste potential, per land area amounts to the environmental scale and per GDP measures of DMC indicate the overall resource efficiency of a national economy.

- National DMC per capita of population (tonnes/capita) indicates the material use per inhabitant of a country, and the domestic waste potential generated.
- National DMC per land area (tonnes/km²) specifies the amount of national waste potential in relation to the available land area. Thus, it is another indicator for intensity of land-use.

⁶ In a more long term perspective, of course also the materials which make up the physical stock are emitted to the environment through replacement or dissipative losses, although a total replacement of the physical stock most certainly will not occur within a period of time accessible to purposive planning.

⁷ Matthews, E., Amann, C., Fischer-Kowalski, M., Bringezu, S., Hüttler, W., Kleijn, R., Moriguchi, Y., Ottke, C., Rodenburg, E., Rogich, D., Schandl, H., Schütz, H., van der Voet, E., Weisz, H., 2000. The Weight of Nations: Material Outflows from Industrial Economies. World Resources Institute, Washington, D.C.

⁸ Daly, H. (1992), ‘Allocation, distribution, and scale: towards and economics that is efficient, just, and sustainable’, *Ecological Economics*, 6, pp. 185-193.

- National DMC per GDP (tonnes/€) measures the scale of the physical to the scale of the monetary economy, thereby representing one way to indicate the overall material intensity of a national economy, or, put the other way round (GDP/DMC) the resource efficiency, measured in €/tonne or €/kg.

Imports and exports in biophysical units (tonnes)

Within the MFA framework, import and export flows are accounted for by their actual weight at the time the material or product crosses the border of a nation state. In the country of resource extraction, additional material flows usually occur for the production of traded goods that are not part of the imports or exports. These flows are called “indirect” or “hidden flows”. If a country produces a commodity for domestic consumption internally, this typically generates more material flows within the country than importing the same commodity, and vice versa with exports. This makes it difficult to compare traded commodity flows with flows of resource extraction.

The ratio of imports to DE indicates import dependency. A high ratio of imports to DE expresses a high dependence on foreign natural resources, but also a tendency to outsource environmental burdens due to resource extraction. The ratio of exports to DE indicates export dependency. A high ratio of exports to DE describes a country that exploits its natural resources for final consumption elsewhere. Material intensity of imports (tonnes imported/€ value of imports) in relation to the material intensity of exports (tonnes exported/€ value of exports) promises to be an interesting indicator for economic pressure on domestic natural resource extraction for trade. Countries need to balance their economic trade balance. If the material intensity of imports and exports differs significantly, a country becomes either a systematic importer or exporter of raw materials (presuming that raw materials have a higher material intensity than processed commodities).

Net additions to stocks (NAS)

Net additions to stocks (NAS) equals all materials added to stocks (i.e. with an expected lifespan as commodity of more than a year) minus wastes and emissions from stocks. NAS represents the net growth rates of the biophysical stocks of a society. NAS are of strong relevance for sustainable development for the following three reasons:

- Biophysical stocks are mainly comprised of built up infrastructure such as roads etc. Increasing NAS therefore indicates an increase in land sealing.
- All biophysical stocks bind future material inputs, as the stocks have to be maintained and reproduced.
- And finally, stocks will turn into waste and emissions in the future when they are disposed of. Stocks therefore have to be regarded as future waste flows and thereby burden future generations.

Unfortunately, the present level of methodological sophistication in MFA hardly allows the generation of reliable indicators for NAS. To calculate NAS following parameters are required:

- Estimates of existing stocks and their lifespan so that annual wastes and emissions from stocks can be calculated
- Precise estimates for balancing items between inputs and outputs (additional air and water vapour) so as not to statistically lump them together with stock changes
- Above average-quality data for the input of construction minerals⁹

Some efforts have already been made to improve this situation¹⁰, and in the light of the importance of this indicator for sustainability further efforts seem well warranted.

Material consumption in different sectors

In order to reflect actual materials consumption within the EU, production and trade data are carefully gathered and processed. Mathematically, material consumption equals the **production** of a certain material (metal, non-metallic minerals, wood, plastics, glass, etc.), plus **import** from outside the EU and minus **export** from the EU. A large portion of the data is collected from the Eurostat database or European industrial associations. For example, data for steel comes from a publication of the European Confederation of Iron and Steel Industries (Eurofer)¹¹. As for the glass industry, the data is provided by the Standing Committee of the European Glass Industry (CPIV).

However, data is not always obvious retrievable hence the calculation is necessary. For all the non-metallic minerals and some metals (lead, zinc and aluminium), the material consumption data is calculated based on the *European Mineral Statistics* published by British Geological Survey. In addition to the consumption data of various materials, the breakdown of end-use sectors segmentation is obtained from a publication by DG ENTR¹², together with some other relevant sources¹³.

Special attention has been paid to woods as its co-products and recovered wood products are considered as “secondary” raw materials. This “cascade use” is a typical advantage of wood resources and reflected in the *Wood Resource Balance*. It should be noted that only material use¹⁴ of woods is taken into account in this study. Within

⁹ Stocks consist mainly of built infrastructure. In most countries, the use of construction minerals is statistically not very well documented (see Weisz et al., 2004).

¹⁰ Van der Voet, E., Kleijn, R., Huele, R., Ishikawa, M., Verkuijlen, E., (2002) Predicting future emissions based on characteristics of stocks. *Ecological Economics*, 41 (2), 223-234.

¹¹ European Confederation of Iron and Steel Industries (EUROFER, 2009), *European Steel in Figures 2005 - 2009*

¹² Directorate General Enterprise and Industry (2009), Annex V to the Report of the Ad-hoc Working Group on Defining Critical Raw Materials

¹³ Such as the *European Mineral Statistics* and information provided by European industrial associations.

¹⁴ UNECE, FAO, University Hamburg (2008), *Wood Resources Availability and Demands (Part I): National*

the paper industry, packaging (incl. case materials, carton board, wrapping papers and other papers for packaging) is an important component of wood resource consumption, amounting to 42% in average¹⁵.

LAND USE

Table 4: Land use coverage in EU-27 (2004 & 2005)¹⁶

Land type	2004		2005	
	Area (1000 ha)	%	Area (1000 ha)	%
Cropland	138 806	31.9%	138 210	31.8%
Grazing land	58 463	13.5%	58 976	13.6%
Forest	132 124	30.4%	131 752	30.3%
Water, coastal flats and salines	13 160	3.0%	13 160	3.0%
Built area	18 277	4.2%	18 326	4.2%
Other natural areas	73 656	17.0%	74 062	17.0%
Total	434 486	100%	434 486	100%

and Regional Wood Resource Balances 2005 (EU/EFTA Countries). In this study, material use of wood is differentiated from energy. Material use falls into sawmill industry, panel industry, pulp industry, pellets briquettes etc. and other physical utilisation. In a rough, sawmill industry and other physical utilisation is regarded as the construction sector compatible with the study. The rest is treated as industry in general.

¹⁵ Calculated based on Eurostat (2009), *Forestry Statistics*

¹⁶ EEA, CORINE (Coordination of Information on the Environment) Land Cover database



ANNEX B: SAVINGS ESTIMATION APPROACH FOR EACH MATERIAL STREAM

The savings estimation approach for each material stream is presented in this Annex. Compared to the LCA approach it only considers the material stream itself and not all the up-stream effects. For example, in the case of aluminium it only considers crude ore at the extraction and assumes that the relevant products/ores are imported. The savings of fossil fuels necessary for the production of the aluminium that is replaced by recycling, are not considered. At the same time the material requirements for the preparation of waste for recycling was not considered either. Since these two aspects have opposite directed effects, it is assumed that they cancel each other. This assumption is supported by the calculation with the LCA approach. Figures showed a quite similar net effect if calculated with, and without, all up-stream material requirements (within a range of 10%).

Material savings due to recycling in the context of MFA - Example Iron

Due to its specific characteristics iron can be separated out of waste streams to a very high degree. Recovered iron is then used in the production process and substitutes the production of pig iron. In order to understand its related material savings within the material flow accounts it is necessary to backtrack material streams from the point where recycled iron is inserted to the point where it crosses the system boundary of the EU-27. Depending on the pathway the recycling of 1 tonne of pig iron may lead to different amounts of material savings in the material flow accounts, as shown in Table 5.

Table 5: Material savings per ton recycled iron (recycling amounts) in dependency on what pathway of iron making it replaces

Path	Name	Description Recycling replaces ...	Accounted for in ...	Material savings per tonne recycled iron	Illustration
1	solely domestic	pig iron produced from ores which were domestically extracted.	domestic extraction (DE) as ores	about 2.2 tonnes of ores	
2a	import of ores	pig iron produced inside the EU-27 out of imported ores.	imports as ores	approximately 2,2 tonnes of ores imported	


2b	import of products, semi-finished products and pig iron	imported pig iron and imported iron contained in various products and semi-finished products. Since MFA does not differentiate in the different stages of production an average product is assumed.	imports as products of various finishing stages	1 tonne of imported iron contained in products of various finishing stages	
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Table 6: Estimates on material savings to set priorities for calculations

Material category	Recycling amount (ktonnes)	Factor*	Material savings (ktonnes)	% of total material savings
Iron & steel	77,700	4	310,800	22%
Aluminium	3,100	9	27,900	2%
Copper	900	100	90,000	6%
Lead	600	33	19,800	1%
Zinc	700	19	13,300	1%
Glass	10,700	1	10,700	1%
Aggregates	769,200	1	769,200	54%
Plastic	4,500	1	4,500	0%
Paper	44,200	1.1	48,620	3%
Wood	21,700	1	21,700	2%
Other	119,200	1	119,200	8%
Total	1,052,500		1,435,720	100%

*Amount of extracted raw material required to produce a tonne of pure (recycled) material, e.g. tonnes of iron ore needed to produce one tonne of iron

For the situation in 2004, recycled iron is ascribed proportionally to the flows to the following pathways and therefore leads to the material savings shown in Table 7.

Table 7: Recycled iron (recycling amounts) and relevant material savings in the context of MFA - current situation in 2004.

	Recycled iron (in ktonnes)*	Material savings (in ktonnes)**	Material savings as
Pathway 1: Solely domestic	1,470	3,200	domestic ores
Pathway 2a: import of ores	8,460	18,380	imported ores

	Recycled iron (in ktonnes)*	Material savings (in ktonnes)**	Material savings as
Pathway 2b: import of products, semi-finished products and pig iron	3,960	3,960	products in various finishing stages
Sum	13,890	25,540	

*recycling amounts are based on waste statistics

**the material savings are calculated by applying own methodology

If there would be no recycling then the pig iron demand would increase by 13,886 tonnes. Assuming that this would proportionally increase domestic extraction, imports of ores and products in various finishing stages the additional material requirements will be 25,536 tonnes.

LCA approach

The most accurate way to calculate material savings is to employ LCA methodology to the data. At present the best available data is from Ecoinvent database since it has been developed in the European context. With such a database, factors can be generated to calculate the necessary raw materials extraction **(b)** for one unit of material replaced by recycled material **(c)** like metals or plastics. If the recycling needs additional materials they need to be deducted in the calculation **(e)** as in Figure 2-8 in the report.

A first attempt to determine the material savings of paper showed that in practice this approach was not feasible with the available data and information on process chains. Many assumptions had to be made in order to arrive at a more reliable estimation. For the other material categories the limitation of available data and process chains turned out to be a major problem. The case of plastic waste serves to illustrate these difficulties: there is no reliable information on the percentage of collected waste and out of this the total recycling rates. The percentage of waste that goes for downcycling and for incineration is also unknown. However, even with rough estimates there are no process chains available to calculate the necessary preparation of plastic waste for the production of new products. Finally the calculated raw materials represent only the global perspective and do not reflect in which stage (raw material, semi-finished products, and finished products) it crosses the border of EU-27. For the calculation of material savings within the EU-27 such an estimate is necessary.

With C&D waste there is a similar picture. There are no process chains for the preparation of C&D waste for recycling. Furthermore due to literature¹⁷ it can be assumed that most of the material is just used in base layers and as such it is just

¹⁷ Moser, K., Bertschinger, H., Hugener, M., Kramer, H., Richner, P., Richter, K., (2004) Schlussbericht Baustoffmanagement 21. Stand des Wissens und Forschungsbedarf. EMPA Dübendorf, Departement Materialien für das Bau- und Ingenieurwesen

replacing sand, gravel and stone. Such it does not substitute material and energy intensive processing steps. Therefore an LCA approach is not appropriate.

Metals

a) Data MFA level

Starting point for this simple modelling exercise are extraction (b), imports (a) and exports (h) (see Figure 2-8 in the report). Extraction data are taken from Eurostat MFA data for 2004¹⁸ since at the time of calculation the time series up to 2005 was the latest available one. Due to the fact that the latest year in a statistical time series involves more data uncertainty than the one before, the 2004 data were used. MFA data include import and export data; however these are total trade data. This means that in the EU-27 aggregate imports and exports include both the so called intra EU-27 trade and extra EU-27 trade. For the calculation of the DMC this is appropriate since intra EU-27 trade is compensated in such a calculation (for intra EU-27 trade import from one member state is always an export of another one). For our purpose the extra EU-27 trade is required since imports and exports need to be considered separately. Therefore the extra EU-27 imports and exports were taken from UN Comtrade statistics since the MFA data for 2004 are partly based on Comtrade statistics (www.comtrade.un.org). To counter check for each relevant material stream the DMC was calculated and compared with Eurostat's original MFA data. Since there was a satisfying match between the data from different sources these figures were used.

b) Calculation of recycling amounts

b1) Conversion to pure metal

Raw materials: By looking at the LCA based eco invent data base and the MFA compilation guide an ore grade was identified. The conversion from raw material to pure metal was done by the ore grade.

Products: For finished products the average metal content was estimated by expert judgement with 80%.

Imports: Imports consist of produce in the continuum between ores, semi-finished and finished products. For the sake of simplicity here imports were only considered to be ores or finished products. By looking at UN comtrade statistics a share was estimated.

With these factors and assumptions pure metals coming from domestic extraction, imports of ores and imports of products were calculated. The mix as percentages was calculated for step c) the calculation of resource savings.

b2) Production

¹⁸ Eurostat, 2007a. Economy Wide Material Flow Accounts and Resource Productivity. EU15 1970-2004. European Statistical Office, Luxembourg.

The sum of the pure metal can be called production. At this point a check with production statistics was performed. The match was quite good and therefore the data were used for further calculation.

b3) Export and domestic metal consumption

At this stage exports needs to be deducted since they are not available for recycling. The export statistics show that Europe is pre-dominantly exporting products (and not ores). For the products, the imports' average metal content factor of 80% for the exports could be used. With this calculation of deduction exports from production, the domestic metal consumption could be obtained.

b4) Net addition to stocks

Since metals are used in infrastructure (e.g. buildings) and long-lasting products (e.g. cars) they increase stocks (i) and consequently the annual input flows are only partly available for recycling in the same year. On the other hand old infrastructure and long-lasting products come to their end of life and are available for recycling ((j), (k), (l), see Figure 2-8 in the report). Therefore only the net addition to stocks matters to calculate the material stream available for recycling (g). Literature only shows the share of the domestic consumption that goes into stocks¹⁹. Therefore a factor was estimated which considers only the net effect.

b5) Recycling amount

Finally with this calculation the flow (g) that is available for recycling was obtained. By using recycling rates from literature²⁰ and waste statistics (see Chapter 3) finally a recycling amount was calculated.

c) Calculation of resource savings

This modelled material stream can be used in the backwards direction to calculate the additional resource requirements if no recycled material would be available. This was done in two steps. First the recycling amount understood as pure metal was in the same proportion as reflected in the actual MFA ascribed to extraction (ores), import of ores and import of products. Second the same factors (ore grade and metal content in products) as for the conversion to pure metal were applied for the resource savings at the level of direct material inputs.

Glass and plastic

With these categories there is high data uncertainty. With glass there are no process chains available reflecting the difference of preparing and melting of collected glass compared to glass from raw materials. Same applies to plastic with and additional high uncertainty which share of collected plastic is actually recycled. A simple check by increasing the factor between recycling amount and resource savings for all three material categories at the same time by 50% shows that this alters the overall

¹⁹ Allwood, J.M., Cullen, J.M., Milford, R.L., (2010) Options for Achieving a 50% Cut in Industrial Carbon Emissions by 2050.

²⁰ Allwood, J.M., Cullen, J.M., Milford, R.L., (2010) Options for Achieving a 50% Cut in Industrial Carbon Emissions by 2050.

resource savings by less than 2%. Due to this the recycling amounts were taken as resource savings.

Wood

Since this flow is not significant it seems a plausible proxy that recovered wood replaces the extraction of 110% of roundwood (based on Eurostat compilation guide²¹).

C&D waste

According to the rough estimate this is the most significant flow. However, data that explain what share of demolished construction minerals is used for which purpose are rare. According to studies it can be assumed that most of the material is just used in base layers and as such it is replacing sand, gravel and stone. Furthermore there is no long distance trade of the bulk of these materials. In a first proxy it was assumed that the extraction of sand, gravel and stone is a simple step where extracted material equals the produce used for base layers. Therefore the factor 1 was used, meaning that the recycled amount replaces the same amount of extraction. However, it is highly recommended to improve data quality and knowledge on the bulk flows of minerals.

Paper

The example of paper was used to test the feasibility of the preferred LCA approach. The calculations using Ecoinvent data provided a comprehensive list of upstream material requirements for the process chains paper production 0% recycling paper and 100% recycling paper. In the calculation the situation as is was calculated by producing paper out of the available recovered paper with the process chain for 100% recycling paper. The rest of paper was produced with the production chain for 0% recycling (from raw materials). Such the two production chains providing together the paper as produced in the respective year. The resource requirements for both were added and are seen as proxy for the actual resource requirements (including recycling). Finally the whole production was produced solely by the process chain with 0% recycling. From the resource requirements of this no recycling scenario the resource requirements of the actual situation (including recycling) was deducted showing the proxy for material savings (as raw materials and not at the level of actual direct material inputs of the EU-27).

For the sake of consistency with other material categories just the resource savings of round wood was put into the overall calculation of resource savings for all material categories.

²¹ Eurostat (2009) Economy-wide Material Flow Accounts. Compilation Guidelines for reporting to the 2009 Eurostat questionnaire (Version 01 - June 2009). European Statistical Office, Luxembourg

ANNEX C: RECYCLING

Additional text and data sources used as a basis for the discussions in the main report chapter 3 are presented in this Annex.

1. SUMMARY OF CURRENT RECYCLING TARGETS IN THE EU

In this section details are provided about the requirements of the individual waste and recycling Directives, including definitions of waste streams, deadlines for implementation, exceptions, derogations and reporting mechanisms.

WASTE FRAMEWORK DIRECTIVE (2006/98/EC)

The Waste Framework Directive sets a number of waste recycling targets. Member States are obliged to develop national waste prevention programs and take the necessary measures designed to achieve the following targets:

- by 2015 separate collection shall be set up at least for paper, metal, plastic and glass waste;
- by 2020 the preparing for reuse and the recycling rates at least of waste materials such as paper, metal, plastic and glass from households and similar waste, shall be increased to a minimum of overall 50 % by weight;
- by 2020 the preparing for reuse, recycling and other material recovery rates of non-hazardous construction and demolition waste shall be increased to a minimum of 70% by weight. The reuse, recycling or recovery of naturally occurring materials, defined in category 170504 in the List of Waste, is not included in this target. Material recovery comprises backfilling operations using waste to substitute other materials.

The Commission will establish detailed rules on the application and calculation methods for verifying compliance with these targets. These can include transition periods for Member States which, in 2008, recycled less than 5% of either categories of waste referred to in the targets.

Specific reference is made to the outputs of the study "*Management of construction and demolition waste in the EU*"²², which has defined the framework for calculating the specific recycling targets for construction and demolition waste.

Every three years, Member States are obliged to inform the Commission on the implementation of this Directive by submitting an electronic report; the first report will cover the period from 12 December 2010 to 12 December 2013.

²² BIO Intelligence Service (2010) Study on the management of construction and demolition waste in the EU. Commissioned by the European Commission, DG Environment.

DIRECTIVE ON END-OF-LIFE VEHICLES (2000/53/EC)

End-of-Life Vehicles Directive (2000/53/EC) aims to reduce the amount of waste from vehicles when they reach their end-of-life. The following targets have to be met (in terms of average weight per vehicle per year):

- Increase in the rate of reuse and recovery to 85% by 2006
- A rate of reuse and recovery of at least 95% by 2015
- A rate of reuse and recycling of at least 80% by 2006
- A rate of reuse and recycling of at least 85% by 2015

For the 2006 targets, less stringent objectives could be set for vehicles produced before 1980, but these were not to be lower than 75 % for reuse and recovery and 70 % for reuse and recycling.

The targets apply to all end-of-life vehicles designated as a category M1 or N1 vehicle as defined in section A of Annex II to Directive 70/156/EEC (where M1: Vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat, N1: Vehicles used for the carriage of goods and having a maximum weight not exceeding 3.75 metric tonnes). Two- or three-wheel motor vehicles are not bound by these reuse, recycling and recovery targets. Member States must report to the Commission every three years on the implementation of the Directive, the first report covering the period from 2002-2004.

DIRECTIVE ON WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) (2002/96/EC)

By 31 December 2006 at the latest, a rate of separate collection of at least 4 kg on average per inhabitant per year of waste electrical and electronic equipment from private households had to be achieved. At present, this collection target of 4kg/person/year does not properly reflect the situation in individual Member States. Illegal trade of electrical and electronic waste to non-EU countries continues to be widespread. By 31 December 2006, the rate of recovery by an average weight per appliance had to be:

- at least 80% in the case of large domestic appliances and automatic dispensers
- 70% in the case of small domestic appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment and monitoring and control instruments
- 75% in the case of IT and telecommunications equipment and consumer equipment.

By the same date, the rate of component, material and substance reuse and recycling by an average weight per appliance had to be:

- at least 80% in the case of discharge lamps

- 75% in the case of large domestic appliances and automatic dispensers
- 50% in the case of small domestic appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment and monitoring and control equipment
- 65% in the case of IT and telecommunications and other consumer equipment.

For Greece and Ireland, these targets were to be achieved by 31 December 2008. Every three years, Member States must send a report to the Commission on the implementation of this Directive. The first such report covers the 2004-2006 period.

The Commission now has proposed to set mandatory collection targets of 65% of the average weight of electrical and electronic equipment placed on the market over the two previous years in each Member State. The recycling and recovery targets of such equipment will cover the reuse of whole appliances and weight-based targets will increase by 5%. Targets will also be set for the recovery of medical devices.

DIRECTIVE ON BATTERIES AND ACCUMULATORS AND WASTE BATTERIES AND ACCUMULATORS (2006/66/EC)

For waste portable batteries and accumulators, collection rates of at least 25% and 45% have to be reached by 26 September 2012 and 26 September 2016 respectively.

Member States also have to ensure that, from 26 September 2009 at the latest, batteries and accumulators that have been collected are treated and recycled using the best available techniques. Recycling must exclude energy recovery.

However, Member States may dispose of collected portable batteries or accumulators containing cadmium, mercury or lead in landfills or underground storage when no viable end market is available, or as part of a strategy to phase out heavy metals which, on the basis of a detailed assessment of the environmental, economic, and social impacts, shows that this disposal option should be preferred over recycling.

The disposal by landfill or incineration of waste is prohibited for industrial and automotive batteries– in effect setting a 100% collection and recycling target by 26 September 2009. However, residues of any batteries and accumulators that have undergone both treatment and recycling may still be disposed of in landfills or by incineration. Batteries of the button type are excluded from the scope of the Directive. All collected batteries must undergo treatment and recycling. The recycling of battery and accumulator content to produce similar products or for other purposes has to reach the following efficiencies by 26 September 2010²³:

²³ Key definitions:

“battery” or “accumulator”: any source of electrical energy generated by direct conversion of chemical energy and consisting of one or more primary battery cells (non-rechargeable) or consisting of one or more secondary battery cells (rechargeable)

“portable battery or accumulator”: any battery, button cell, battery pack or accumulator that is sealed and can be hand-carried and is neither an industrial battery or accumulator nor an automotive battery or accumulator

- at least 65% by average weight of lead-acid batteries and accumulators, including the recycling of the lead content to the highest degree that is technically feasible;
- 75% by average weight of nickel-cadmium batteries and accumulators, including the recycling of the lead content to the highest degree that is technically feasible;
- at least 50% by average weight of other battery and accumulator waste.

Member States must report on the levels of recycling achieved in each calendar year concerned. Besides, Member States are obliged to send the Commission a report on the implementation of this Directive and the measures they are taking to encourage developments affecting the impact of batteries and accumulators on the environment (including new recycling and treatment techniques) every three years, the first report covering the period until 26 September 2012.

DIRECTIVE ON PACKAGING AND PACKAGING WASTE (94/62/EC)

Directive 94/62/EC, the Packaging and Packaging Waste Directive, covers all packaging placed on the market in the Community and all packaging waste, whether it is used or released at industrial, commercial, office, shop, service, household or any other level, regardless of the material used. It requires the return and/or collection of used packaging in order to meet targets for the recovery, incineration with energy recovery and recycling of this material. The Directive obliges Member States to take measures, which may include national programmes to prevent the formation of packaging waste, and encourage them to develop packaging reuse systems.

Directive 2004/12/EC, amending the Packaging Directive, states Member States must introduce systems for the return and/or collection of used packaging to attain the following targets:

- by no later than 30 June 2001, between 50 and 65% by weight of packaging waste to be recovered or incinerated at waste incineration plants with energy recovery;
- by no later than 30 June 2001, between 25 and 45% by weight of the totality of packaging materials contained in packaging waste to be recycled (with a minimum of 15% by weight for each packaging material);

"button cell": any small round portable battery or accumulator whose diameter is greater than its height and which is used for special purposes such as hearing aids, watches, small portable equipment and back-up power.

"automotive battery or accumulator": any battery or accumulator used for automotive starter, lighting or ignition power

"industrial battery or accumulator": any battery or accumulator designed for exclusively industrial or professional uses or used in any type of electric vehicle

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

New targets for the third five-year phase, 2009 until 2014, were to be proposed by the Commission and fixed by the European Parliament and the Council, not later than 31 December 2007, based on the practical experience gained in the Member States and the findings of scientific research and evaluation techniques.

For Greece, Ireland and Portugal, because of the large number of small islands, the presence of rural and mountain areas and the low level of packaging consumption respectively, the first two targets in the list above were postponed until 31 December 2005, the latter three targets until 31 December 2011. However, by no later than 30 June 2001 they needed to attain at least a level of 25 % for recovery or incineration at waste incineration plants with energy recovery.

Directive 2005/20/EC sets a later deadline for the 10 new Member States (the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, Slovakia) to meet the latter three targets of the revised Packaging Directive. The extensions are until 31 December 2012 for the Czech Republic, Estonia, Cyprus, Lithuania, Hungary, Slovenia and Slovakia, until 31 December 2013 for Malta, until 31 December 2014 for Poland, and until 31 December 2015 for Latvia.

Member States are required to report to the Commission on the application of this Directive every three years on the basis of a questionnaire or outline drafted by the Commission, the first report covering the period 1995 to 1997.

ASSUMPTIONS AND CALCULATIONS FOR ESTIMATING MATERIAL SAVINGS THROUGH RECYCLING

The data collection was based on the final report on “The analysis of the evolution of waste reduction and the scope of waste prevention”²⁴. The report provides a summary of the most complete EUROSTAT data sets which are relevant to this study. Most of the data sets, however, show certain gaps. In order to fill these gaps following assumptions were made:

²⁴ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

- If there is a value for the preceding or subsequent time period (year), the gap is filled with this value.

From those Member States for which a complete data set is reported, the Member State which has the waste/capita ratio in the respective waste category, most similar to the EU-27 average ratio, is selected as reference country. The data gap is filled by multiplying the per capita value of the corresponding reference cell with the total population of the data-gap-country.

The Eurostat waste flow data were complemented by data of the European Environment Agency (EEA) on the generation and recycling of construction and demolition waste, municipal solid waste and battery waste²⁵. Data on Construction and Demolition Waste are based on the results of the Study “Management of construction and demolition waste in the EU”²⁶. Data on packaging and packaging waste are taken from the EC report on the implementation of the Packaging Directive and on the options for increasing the prevention and reuse of packaging²⁷ (2006), the preparatory studies for this report and Eurostat data. The product flows that are the subject of this study are estimated based on the available data about material flows and on the current recycling rates.

Municipal waste

The Waste Framework Directive has set the following waste recycling target:

- By 2020 preparing for reuse and the recycling rates of waste materials such as at least paper, metal, plastic and glass from households and similar waste, shall be increased to an overall minimum of 50% by weight.

The COM(2010) draft²⁸ defines ‘household waste’ as the waste generated by households and ‘similar waste’ as waste which is comparable to household waste in nature and composition, excluding production waste and waste from agriculture and forestry. The term ‘municipal waste’ covers both waste types.

For the evaluation of the status of the recycling rate, the results of the ETC/SCP working paper 2/2009²⁹ were used. This paper provides an indication of recycling trends for different municipal waste and C&D waste streams in the EU and Norway. The study goes beyond the ‘difference methodology’ which is often used to calculate recycling levels (waste generated minus waste landfilled and incinerated). Instead it uses national reports and statistics on the recycling levels of various wastes and

²⁵ EEA – European Environment Agency (2009), Statistics for member states for SOER part C waste. Copenhagen. submitted on 10.02.2010

²⁶ EC (2010), Study on management of construction and demolition waste in the EU

²⁷ European Commission (2006) Report from the Commission to the Council and the European Parliament on the implementation of Directive 94/62/EC on packaging and packaging waste and its impact on the environment, as well as on the functioning of the internal market COM(2006) 767.

²⁸ European Commission (2010) Draft Commission Decision establishing rules and calculation methods for verifying compliance with the targets set in Article 11(2) of Directive 2008/98/EC of the European Parliament and of the Council.

²⁹ ETC/SCP working paper 2 (2009) EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU

combines them to find a total recycling level. The paper provides figures on percentages of waste recycled for the EU-15 (Figure 1) and the new Member States (Figure 2).

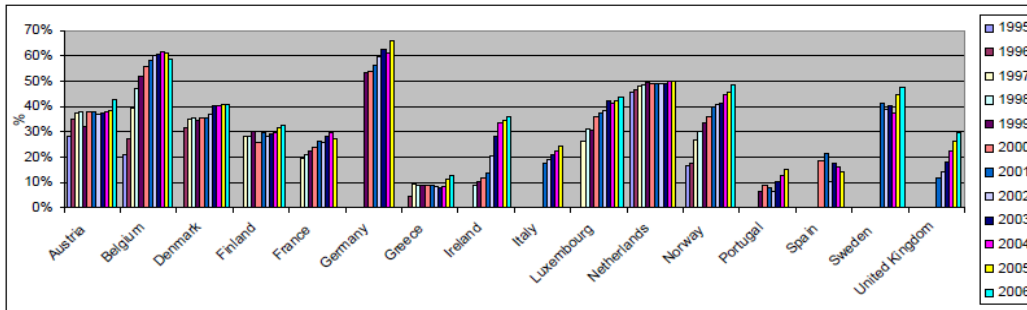


Figure 1: Total municipal waste recycled in percentage of generated amount in the EU-15 and Norway. (Source: ETC/RWM, 2008 based on national reports and statistics)

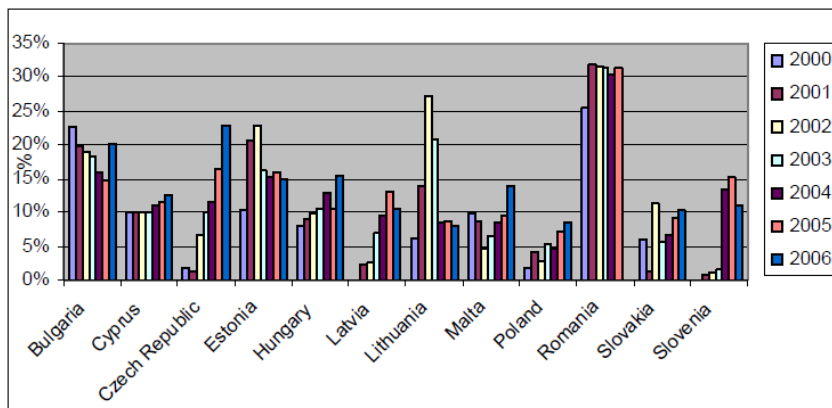


Figure 2: Total municipal waste recycled in percentage of generated amount in the new EU Member States. (Source: ETC/RWM, 2008 based on national reports and statistics and Eurostat for Bulgaria, Hungary, Malta, Romania, Estonia 2000-2003, Lithuania except 2006, Poland except 2004 and Slovakia except 2003)

Table 8: Total amounts of municipal solid waste (MSW) generated and recycled in the EU-27 (derived from (ETC/SCP 2009)³⁰, data from 2005-2006)

	MSW generated	MSW recycled	Recycling rate
Country code	tonnes	tonnes	%
AT	5.101.476	2.198.736	43
BE	4.994.259	2.911.653	58
BG	3.439.047	694.688	20
CY	561.232	71.277	13
CZ	4.586.009	1.045.610	23
DE	46.465.052	30.666.934	66
DK	4.031.074	1.660.802	41
EE	626.913	92.783	15
ES	28.442.863	3.982.001	14
FI	2.555.466	835.637	33
FR	40.548.301	11.150.783	28
GR	4.915.777	634.135	13
HU	4.711.129	725.514	15
IE	3.066.404	1.106.972	36
IT	31.672.733	7.696.474	24
LT	1.176.444	95.292	8
LU	321.010	139.319	43
LV	1.158.222	121.613	11
MT	264.134	36.451	14
NL	10.421.226	5.210.613	50
PL	9.875.944	839.455	9
PT	4.713.467	697.593	15
RO	4.047.627	1.275.003	32
SE	4.476.055	2.117.174	47
SK	602.952	62.104	10
SL	2.309.649	258.681	11
UK	35.501.316	10.508.390	30
EU-27	260.585.780	86.835.685	33

These trends indicate that even the old MS with high baseline rates of recycling (40-50%) show constant increases in recycling amounts since 2000. Data for the new MS are less reliable, but several countries show a yearly increase in recycling levels. Others however show a relatively constant or fluctuating (rather than steadily increasing) recycling level.

³⁰ ETC/SCP working paper 2 (2009) EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU

The report provides inter alia figures on the total amount of municipal waste recycled per capita in each of the MS and on the recycling rates per MS. Based on these data, the total amounts of municipal solid waste (MSW) generated and recycled can be calculated at MS and EU-27 level. An overview of the calculated amounts is presented in Table 8. The calculations are mainly based on data from 2006, gaps were filled with 2005 data. According to these data 86 835 685 tonnes of MSW were recycled in the EU-27 (2006). This figure constitutes about 33% of the total amount of MSW generated.

The EEA State of the Environment Report (SOER) 2010³¹ states that management of waste has improved in the last 15 years due to implementation of EU and national policies, with recycling and composting of municipal waste increasing from 19% to 38% between 1998 and 2007. Projections in the SOER 2010 report suggest that based on current trends, recycling of municipal waste would increase to 49% in 2020.

These figures can be compared to the 50% target of the Waste Framework Directive. From Table 8 it can be concluded that with the data reported for 2006 only 3 MS would reach the recycling targets, which were due to 2007. However, It is worth noting that the inclusion or otherwise of packaging waste in municipal waste statistics can make a significant difference to the results. Different MS appear to include different fractions of packaging waste in their municipal waste recycling figures. Some MS would reach higher recycling levels if more packaging waste were included in their MSW data.

ETC/SCP (2009) also reports on the material composition of the recycling amounts for most MS and at EU level. These data vary significantly between the MS. The level of recycling for each waste fraction varies a lot between the MS and for certain waste streams by a factor of 6 or more. Again, such differences reflect not only different waste policies, but indicate that the published data do not necessarily include the same kind of activities.

The data at EU-25 level (including Norway) are used to calculate the recycled material fractions in Table 9. Since no data are available on the material composition of the generated MSW, the generated material fractions are calculated based on the composition of the recycling amounts. For comparison the DMC per type of material was added in column 5. These DMC values are obtained from the report on the analysis of the evolution of waste reduction and the scope of waste prevention³² (data of 2005).

³¹ European Environmental Agency (2010) European Environment State and Outlook Report 2010

³² Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Table 9: Composition of the MSW recycling amounts and generated amounts, compared to the material flows (DMC) in the EU-27 (based on ETC/SCP (2009) and EC (2010)).

Materials	Material amounts recycled			Amounts generated	Recycling rate
	kg/capita	% of total	ktonnes	ktonnes	%
Glass	18.6	10.6	9 193	27 586	33
Paper and cardboard	35.5	20.2	17 545	52 651	33
Wood	6.0	3.4	2 965	8 899	33
Biowaste	45.1	25.7	22 290	66 889	33
Metals	5.2	3.0	2 569	7 712	33
Plastic	9.8	5.6	4 843	14 535	33
Bulky waste	10.6	6.0	5 239	15 721	33
Other waste	13.5	7.7	6 672	20 022	33
No information about type of recycling	31.4	17.9	15 519	46 570	26
Total	175.7	100.0	86 836	260 586	33

From Table 9 it can be concluded that the recycled amount of glass from MSW represents approximately 0.2% of the minerals input in the EU-27 economy. For paper, cardboard, wood, and biowaste, this figure amounts to 2.6% of the total biomass input. The metals recycled from MSW comprise about 0.9% of the total metal input and the plastics 0.3% of the fossil fuel DMC. However, only 4% of the mineral oil that is imported is used for the production of plastics. In the Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste no data are available on the amount of mineral oil imported in the EU-27. Supposing that 4% of the total amount of fossil fuels is used for the production of plastics, the amount of plastics recycled represents 6.5 % of the DMC (underestimation).

Construction and demolition waste

For construction and demolition waste the Waste Framework Directive has set a reuse, recycling and material recovery (RRR) target of 70% by 2020. In the report “Management of construction and demolition waste in the EU”³³ a reuse, recycling and material recovery rate of 47% is estimated for the EU-27 in 2006. This rate is reported to be a rough estimation with high uncertainty, based on a combination of figures from 1999 to 2006 and a worst case scenario of 0 % reuse, recycling and

³³ BIO Intelligence Service (2010) Study on management of construction and demolition waste in the EU. Commissioned by the European Commission, DG Environment

material recovery rates where data are missing. Based on these data the total RRR amount in the EU-27 is approximately 250 million tonnes. This amount was re-allocated using the composition of C&D waste given in Table 11.

Table 10: Amounts and average reuse, recycling or material recovery rates of C&D waste per Member State (based on BIOIS' own assumptions³⁴ and data reported by (ETC/RWM 2009)³⁵ and (UBA 2008)³⁶)

Country	Arising (million tonnes)	% Reused or recycled
Austria	6.6	60%
Belgium	11.02	68%
Bulgaria	7.8	0%
Cyprus	0.73	1%
Czech Republic	14.7	23%
Denmark	5.27	94%
Estonia	1.51	92%
Finland	5.21	26%
France	85.65	62%
Germany	72.4	86%
Greece	11.04	5%
Hungary	10.12	16%
Ireland	2.54	80%
Italy	46.31	0%
Latvia	2.32	46%
Lithuania	3.45	60%
Luxembourg	0.67	46%
Malta	0.8	0%
Netherlands	23.9	98%
Poland	38.19	28%
Portugal	11.42	5%
Romania	21.71	0%
Slovak Republic	5.38	0%
Slovenia	2	53%
Spain	31.34	14%
Sweden	10.23	0%
UK	99.1	65%
EU 27	531.38	47%

³⁴ BIO Intelligence Service (2010) Study on management of construction and demolition waste in the EU. Commissioned by the European Commission, DG Environment

³⁵ ETC/SCP working paper 2 (2009) EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU

³⁶ Umweltbundesamt (2008) Aggregates Case Study - Final Report

From these calculations it can be concluded that the RRR target is not yet achieved by the EU-27 (Table 12). For comparison the DMC per type of material is given in column 6. These DMC values are obtained from the report on the analysis of the evolution of waste reduction and the scope of waste prevention³⁷ (data of 2005).

The estimations of the generated amounts of C&D waste, the waste composition and the RRR amounts are all based on the figures provided by the report “Management of construction and demolition waste in the EU” and summarised in Table 10.

Table 11: Ranges of composition of C&D waste as reported for some European Member States³⁸ (data from 1996 to 2007)

Ranges	% - min	% - max	tonnes - min	tonnes - max
Concrete and masonry - total ³⁹	40%	84%	212 552 000	446 359 200
<i>Concrete</i>	12%	40%	63 765 600	212 552 000
<i>Masonry</i>	8%	54%	42 510 400	286 945 200
Asphalt	4%	26%	21 255 200	138 158 800
Other mineral waste	2%	9%	10 627 600	47 824 200
Wood	2%	4%	10 627 600	21 255 200
Metal	0.2%	4%	1 062 760	21 255 200
Gypsum	0.2%	0.4%	1 062 760	2 125 520
Plastics	0.1%	2%	531 380	10 627 600
Miscellaneous	2%	36%	10 627 600	191 296 800

³⁷ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

³⁸ EC(2009), Study on Management of construction and demolition waste in the EU

³⁹ The values for the ‘concrete and masonry – total’ category are not to be interpreted as the sum of the values of the ‘concrete’ fraction and the ‘masonry’ fraction. For each of these three C&D categories, the minimum and maximum percentages were extracted independently from the reports of seven European Member States.

Table 12: Overview of the arising amounts of C&D waste and the reused, recycled and recovered materials compared (calculated based on Table 8 and Table 10) to the material input in EU-27⁴⁰, current situation (2006)

Composition C&D waste	Amounts arising		RRR amounts		RRR rate
	ktonnes - min	ktonnes - max	ktonnes - min	ktonnes - max	
Concrete and Masonry - total	212 552	446 359	99 899	209 789	47
<i>Concrete</i>	63 766	212 552	29 970	99 899	47
<i>Masonry</i>	42 510	286 945	19 980	134 864	47
Asphalt	21 255	138 159	9 990	64 935	47
Other mineral waste	10 628	47 824	4 995	22 477	47
Gypsum	1 063	2 126	499	999	47
Wood	10 628	21 255	4 995	9 990	47
Metal	1 063	21 255	499	9 990	47
Plastics	531	10 628	250	4 995	47
Miscellaneous	10 628	191 297	4 995	89 909	47
Total	531 380		249 749		

The reused, recycled and recovered amounts of C&D waste correspond to 3 - 8% of the minerals input, 0.3 - 0.6 % of the biomass input, 0.2 - 4% of the metals input and 0.01 - 0.3% of the fossil fuels input into the EU-27-economy. Supposing that 4% of the total amount of fossil fuels is used for the production of plastics, the RRR amount of plastics represents 0.3-6.7 % of the DMC.

End-of-Life Vehicles (ELV)

Table 13 shows the ELVs collected, reused, recycled and recovered in 25 EU Member States (data for Ireland and Malta are not included) in the year 2006, as reported on Eurostat. For this study the data were extrapolated to the EU-27, multiplying the EU-25 figure per capita by the total number of inhabitants in the EU-27.

The 2006 target for reuse and recycling (80%) was reached by 20 MS, the 2015 target (85%) by 7 MS. The 2006 reuse and recovery target (85%) was achieved by 13 MS, the 2015 target (95 %) has not yet been met by any MS. None of these targets were reached at EU level.

Table 13: Generation of waste from end-of-life vehicles, reuse, recycling and recovery in the year 2006 (as reported on Eurostat)

⁴⁰ Arcadis, VITO, Umweltsundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment.

Country code	ELVs collected		Amounts reused & recycled	Amounts reused & recovered	Reuse & recycling rate	Reuse & recovery rate
	number	tonnes	tonnes	tonnes	%	%
BE	131 043	131 030	114 312	117 300	87	90
BG	45 127	45 127	37 165	39 368	82	87
CZ	56 582	48 094	37 995	40 928	79	85
DK	102 202	99 354	79 226	79 547	80	80
DE	499 756	449 280	389 796	402 311	87	90
EE	11 035	10 637	8 779	8 779	83	83
GR	29 689	23 952	19 714	19 714	82	82
ES	954 715	885 689	675 519	743 582	76	84
FR	930 000	837 000	666 343	677 970	80	81
IT	1 379 000	1 310 050	921 404	952 786	70	73
CY	1 032	918	784	795	85	87
LV	6 288	5 659	4 867	4 867	86	86
LT	13 877	14 057	12 368	12 998	88	92
LU	4 864	4 557	3 879	3 909	85	86
HU	20 976	16 380	13 295	13 349	81	81
NL	192 224	179 883	148 399	153 184	82	85
AT	87 277	69 329	55 350	59 471	80	86
PL	150 987	124 173	105 225	106 538	85	86
PT	25 641	21 692	17 836	18 680	82	86
RO	21 234	17 624	13 592	14 148	77	80
SI	9 000	7 810	5 996	6 215	77	80
SK	15 069	11 907	9 858	9 965	83	84
FI	14 945	14 183	11 698	11 731	82	83
SE	283 450	335 605	279 765	285 179	83	85
UK	995 569	970 582	786 066	798 682	81	82
EU-25	5 981 582	5 634 574	4 419 232	4 581 996	78	81
EU-27	6 038 096	5 687 809	4 460 984	4 625 287	78	81

Table 14: Estimation of ELV treatment under a minimum, market based starting point, based on an average ELV of 1000 kg (GHK and BIO, 2006)⁴¹.

⁴¹ GHK and BIO IS (2006) A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, reuse and recovery under the ELV Directive.

	Reuse	Recycling	Recovery	Landfill	Total
ELV materials	kg	kg	Kg	kg	kg
Ferrous metals	31	597	0	22	650
Non ferrous metals	9	68	0	13	90
Tyres	0	0	5	25	30
Plastics	0	0	0	120	120
Textiles	0	0	0	10	10
Rubber	0	0	0	20	20
Batteries	1	9	0	3	13
Other	0	0	0	20	20
Glass	0	0	0	30	30
Fluids	5	5	0	7	17
Total	46	679	5	270	1 000

Table 15: Estimation of ELV treatment under an advanced dismantling starting point, based on an average ELV of 1000 kg (GHK and BIO, 2006)

	Reuse	Recycling	Recovery	Landfill	Total
ELV materials	kg	kg	Kg	kg	kg
Ferrous metals	31	612	0	7	650
Non ferrous metals	9	79	0	2	90
Tyres	10	10	10	0	30
Plastics	1	11	12	96	120
Textiles	0	1	0	9	10
Rubber	0	5	0	15	20
Batteries	1	12	0	0	13
Other	0	0	0	20	20
Glass	1	14	0	15	30
Fluids	5	12	0	0	17
Total	58	756	22	164	1 000

GHK and BIO (2006)⁴² estimated a typical distribution of the materials present in an ELV over four possible treatment types (reuse, recycling, recovery, landfill) in three different scenarios. The first scenario is based on a minimum market based starting point, where 72.5% of the ELV is reused/recycled (Table 14). This is a typical starting point for many parts of Southern, Central and Eastern Europe. The third scenario is based on MS with advanced standards for ELV treatment and a reuse/recycling rate of more than 80 % (Table 15). These two most extreme scenarios were used for

⁴² GHK and BIO IS (2006) A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, reuse and recovery under the ELV Directive.

obtaining the reused and recycled amounts of Table 16 (the second scenario leads to figures in between the minimum and maximum values of this table). The percentages indicated in column 2 are calculated from the scenarios explained above. The reused and recycled amounts for each of the materials present in an ELV are obtained by combining these percentages with the EU level reused and recycled amount of Table 13.

Table 16: Estimation of the material composition of the reused and recycled ELV amounts (based on GHK and BIO, 2006).

ELV materials	Typical composition of reuse and recycling amounts		Reused and recycled amounts	
	minimum %	advanced %	minimum ktonnes	advanced ktonnes
ferrous metals	86.6	79.0	3 864	3 524
non ferrous metal	10.6	10.8	474	482
tyres	0.0	2.5	0	110
plastics	0.0	1.5	0	66
textiles	0.0	0.1	0	5
rubber	0.0	0.6	0	27
batteries	1.4	1.6	62	71
other	0.0	0.0	0	0
glass	0.0	1.8	0	82
fluids	1.4	2.1	62	93
total	100	100	4 461	4 461

Table 17 compares the RR estimations of the advanced vehicle dismantling scenario in Table 16 to the materials present in the vehicles collected in 2006, to the vehicles registered between 2006 and 2008 and to material input in the EU-27 economy. In 2006-2008 about 14.5-15.5 millions of vehicles were registered at EU level (Eurostat, personal communication). With a typical vehicle weight of one tonne this amounts to about 15 millions of tonnes of vehicles. The percentages in column 2 are based on GHK and BIO (2006), who estimated the typical composition of an ELV over time (2002, 2006 and 2015). 2006 estimates were used. The material flow data (DMC) were obtained from the report on the analysis of the evolution of waste reduction and the scope of waste prevention⁴³ (data of 2005). Due to the estimates made as regards the composition of the recycling amounts and the collected amounts, some of the recycling rates in column 7 exceed 100 %.

Table 17: Comparison of reused and recycled materials in the advanced vehicle dismantling scenario (Table 16) to the estimated amounts of materials present in

⁴³ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment.

vehicles collected in 2006, to the vehicles registered in 2006-2008 and to the material input in EU-27, current situation (2006).

	Typical composition of vehicle in 2006	Material amounts in vehicles registered 2006-2008	Material amounts in vehicles collected in 2006	Reused and recycled amounts	Material reuse and recycling rate vs. vehicles registered 2006-2008	Material reuse and recycling rate vs. vehicles collected in 2006
ELV materials	%	Mt	ktonnes	advanced ktonnes	%	%
ferrous metals	68.0	10.2	3 868	3 524	35	91
non ferrous metal	8.0	1.2	455	482	40	106
batteries	1.3	0.2	74	71	37	96
tyres	3.0	0.5	171	110	24	64
plastics	10.0	1.5	569	66	4	12
textiles	1.0	0.2	57	5	4	10
rubber	2.0	0.3	114	27	9	24
glass	3.0	0.5	171	82	18	48
fluids	1.7	0.3	97	93	37	96
other	2.0	0.3	114	0	0	0
total	100	15.0	5 688	4 461	30	78

The amount of metals reused and recycled from the collected ELVs represents about 1.6 % of the raw metal input in the EU-27 economy (metals present in batteries not included). For reused and recycled glass this figure amounts to 0.002 % of the minerals DMC. Supposing an entirely synthetic composition of plastics, tyres, rubber and textiles, these ELV components represent 0.009% of the fossil fuels input in the EU economy and 0.2% of the amount of fossil fuels used for the production of plastics.

However, Eurostat mentions that in reality more reuse and recycling is performed than reported under the current monitoring scheme. Amounts are expected to be at least a third higher. Data will be presented soon, but are unavailable at this moment.

Waste from Electric and Electronic Equipments (WEEE)

For WEEE a collection target of 4 kg/person (2006) has been set. Table 18 summarises the WEEE collection data based on the data published on the Eurostat EDC waste website (gaps were filled). From this table it can be concluded that the 2006 target is met at EU-27 level, but not at the individual Member State level. 9 out of 18 MS reach a collection rate of more than 4 kg/inhabitant. In COM(2008)810 final⁴⁴ an annual collection rate of 65 %, based on the average amount of EEE placed

⁴⁴ EC (2008), Proposal for a Directive of the European Parliament and of the Council on waste electrical

on the market in the two preceding years, is proposed as a new target. This target is not yet reached by any of the Member States.

Additionally, the WEEE Directive has set recovery and reuse and recycling rates for four different types of WEEE, to be reached in 2006. Table 19 provides an overview of the collection, reuse and recycling data for these 4 different fractions at EU level (2006 data). The medical devices category is not a part of these RRR-target fractions, but is added here since it is included in the collection targets and in the future RRR-targets. All 2006 targets are met at EU-27 level, but not at the individual MS level: only 4 out of 16 MS reach all reuse and recycling targets set. (COM(2008)810 final)⁴⁵ proposes a new set of reuse and recycling targets, to be achieved in 2011. These targets are again all met at EU level, but not in each of the individual MS: only 1 MS reaches all targets set. Moreover, the reuse and recycling targets are specified as a percentage of the collected amounts. If collection rates rise, RR amounts will need to increase accordingly to keep on meeting the targets.

and electronic equipment (WEEE) (Recast)

⁴⁵ European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) (Recast)

**Table 18: Overview of the amount of EEE put on the market and collected in 19 MS
(based on Eurostat EDC waste data, 2006)**

Country code	Total EEE amount placed on the market	Total WEEE amount collected	Collection rate	
	tonnes	tonnes	kg/inh	%
BE	254 571	76 931	7.32	30
DK	173 468	60 245	11.10	35
DE	1 836 912	753 900	9.15	41
EE	18 318	5 855	4.35	32
GR	175 935	11 342	1.02	6
ES	530 076	171 944	3.93	32
FR	1 481 563	15 160	0.24	1
LT	49 798	9 303	2.73	19
LU	7 943	3 848	8.20	48
HU	135 775	24 048	2.39	18
NL	315 199	94 484	5.78	30
AT	156 809	62 629	7.58	40
PL	865 246	17 101	0.45	2
PT	126 114	4 949	0.47	4
RO	146 790	2 631	0.12	2
SI	27 245	-	-	-
SK	51 480	8 583	1.59	17
FI	139 026	39 678	7.55	29
SE	226 615	130 062	14.38	57
EU 19/18	6 718 882	1 492 692	-	-
EU-27	9 512 864	2 125 644	4.31	22

Table 19: Overview of the collected and recycled amounts of the different WEEE fractions at EU-27 level, based on Eurostat data (2006)⁴⁶.

WEEE	Amounts put on market	Collected amounts	Collection rate		Reuse & recycling amounts	Recycling rates	
	ktonnes	ktonnes	%	kg/capita	ktonnes	% of collected	% of put on market
large domestic appliances and automatic dispensers	4 636	1 264	27	2.56	1 084	86	23
small domestic appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment and monitoring and control instruments	1 884	185	10	0.37	140	76	7
medical devices	76	8	11	0.02	6	69	7
IT and telecommunications equipment and consumer equipment	2 782	635	23	1.29	510	80	18
discharge lamps	136	34	25	0.07	32	95	24
total	9 513	2 126	22	4.31	1 773	83	19

Table 20 presents an average composition of WEEE, based on COM (2008) 810 final. These percentages are used to calculate the material fractions present in the reused and recycled WEEE amounts of Table 19 (the maximum value is used for the calculation of the plastic content). Table 21 compares the reused and recycled WEEE materials to the total amount of WEEE materials put on the market and to the material input into the EU-27 economy. The material flow data (DMC) were obtained from the report on the analysis of the evolution of waste reduction and the scope of waste prevention⁴⁷ (data of 2005).

Table 20: Average composition of WEEE, as in COM(2008) 810 final.

Composition	% - Min	% - Max
Ferrous metals	50%	
Non-ferrous metals	5%	
Plastics	20%	25%
Other	25%	20%

⁴⁶ Available at: epp.eurostat.ec.europa.eu/portal/page/portal/waste/data/wastestreams/weee [Accessed online 12/01/2011]

⁴⁷ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Table 21: Comparison of the reused and recycled WEEE materials to the WEEE materials collected, the EEE materials put on the market and to the total material flows into the EU-27 economy (DMC).

	Amount of WEEE materials reused & recycled	Amount of WEEE materials collected	Amount of EEE materials put on market	RR rate vs materials collected	RR rate vs materials put on the market
Materials	ktonnes	ktonnes	ktonnes	%	%
Metals	975	1 169	5 232	83	19
Plastics	443	531	2 378	83	19
Other	355	425	1 903	83	19
Total	1 773	2 126	9 513	83	19

The estimated amount of metals recovered from the collected WEEE represents 0.35% of the raw metal input in the EU-27 economy (DMC). For plastics this figure amounts to only 0.02% of the fossil fuels input. However, when compared to the amount of fossil fuels used for the production of plastics (estimated at 4%), the amount of recycled plastics from WEEE represents 0.6 %.

These data can be compared with a study carried out by the UNU (2007)⁷⁴ reviewing the WEEE Directive. In this study the total amount of EEE put on the EU market in 2005 is estimated at 10.3 Mt per year and the current WEEE arising across the EU27 is between 8.3 and 9.1 Mt per year for 2005. The collection rates of WEEE estimated in this study are roughly in between 25% of the arising WEEE for medium sized appliances until 40% of the arising WEEE for larger appliances. At long term, these collection rates could reach around 75% for the large appliances and 60% for the medium sized appliances.

Waste batteries

The figures in Table 22 provide an overview of the Eurostat waste battery data available at EU level for 2006 (lead-acid batteries, as reported in EEA, 2009). Data about the amounts collected or recycled are not reported. For portable consumer batteries the available data on the amounts sold, collected and recycled are presented in (EEA, 2009, data for 2001/2002). The total amount of waste batteries generated can be approximated by adding up the EU-27 total for lead-acid batteries and the total amount of portable consumer batteries sold in the EU-15, converted to the EU-27 level. For the latter conversion the EU-15 figure per capita is multiplied by the total number of inhabitants in the EU-27. This leads to a total weight of waste batteries in the EU-27 of about 1 833 194 tonnes.

Table 22: Lead-acid battery waste generated in the EU-27 (EEA, 2009⁴⁸, based on Eurostat, EDC Waste data, 2006)

Country code	Amounts generated	
	tonnes	kg/capita
AT	19 318	2.34
BE	62 396	5.94
BG	1 091	0.14
CY	1 808	2.36
CZ	12 232	1.19
DE	301 705	3.66
DK	2 812	0.52
EE	3 532	2.63
ES	126 979	2.90
FI	45 339	8.63
FR	256 610	4.07
GR	43 060	3.87
HU	22 255	2.21
IE	1 449	0.34
IT	196 307	3.34
LT	3 637	1.07
LU	1 589	3.39
LV	4 288	1.87
MT	846	2.09
NL	49 523	3.03
PL	9 946	0.26
PT	197 698	18.70
RO	5 136	0.24
SE	44 862	4.96
SI	2 130	1.06
SK	3 703	0.69
UK	169 773	2.81
EU-27	1 590 024	3.23

⁴⁸ EEA – European Environment Agency (2009), Statistics for Member States for SOER part C waste. Copenhagen. submitted on 10.02.2010

Table 23: Sales, collection and recycling of portable consumer batteries (based on EEA 2009)

		Total sales/onto market	Collected amounts	Collection rate	Recycled amounts	Recycling rate
Country code	Year	tonnes	tonnes	%	tonnes	% of collected
AT	2001	3.263	1.436	44	632	44
BE	2001	3.934	2.361	60	1.416	60
FR	2001	26.291	4.207	16	673	16
DE	2001	33.115	12.915	39	2.196	17
NL	2001	5.795	1.855	32	593	32
SE	2001	3.117	1.714	55	0	
EU-15 + CH + NO	2002	161.572	27.467	17	4.120	15
EU-27		199.544	33.922	17	5.088	15

Collection targets of 25 w% and 45 w% are set for portable batteries and accumulators, to be reached in 2012 and 2016 respectively. For industrial and automotive batteries and accumulators, a 100 w% collection target is specified, which is to be reached in 2009. All collected batteries must be sent to recycling and treatment facilities.

Furthermore, recycling efficiencies are stipulated for the collected batteries (to be reached in 2010): 65 w% for lead-acid batteries, 75 w% for nickel-cadmium batteries and 50 w% for all other battery types (button cells excluded).

Since data on the amounts collected and recycled are not available for each of the battery types, achievement of the targets cannot be verified. Only for portable batteries it can be concluded that neither the collection nor the recycling targets were reached at EU-15 level in 2002 (Table 23). However, a combination of data available in literature allows for a rough estimation of the amounts of materials present in the waste batteries which are sent to recycling facilities. The approach taken for these calculations is discussed in what follows.

In BIO (2003)⁴⁹ the amount of industrial, automotive and portable batteries sold in 2002 is estimated. From these data, the share of these three battery categories in the total amount of batteries sold is calculated and presented Table 24. BIO (2003) provides further data on the share of NiCd and lead-acid batteries and accumulators within the former three battery categories. These data are summarized in Table 24 as well. The share of portable lead-acid batteries in this table is based on UK data for portable batteries presented in a life cycle assessment study of ERM (2006)⁵⁰.

⁴⁹ BIO IS (2003) Impact assessment on selected policy options for revision of the Battery Directive

⁵⁰ ERM (2006) Battery waste management Life Cycle Assessment

Table 24: Share of automotive, industrial and portable batteries in the total amount of batteries sold (based on BIO (2003)). Per battery category the share of NiCd, lead-acid and other battery types is provided (based on BIO (2003) and ERM (2006)).

Batteries category	Share of total batteries sold %	Battery type, share per category		
		NiCd %	Lead acid %	Other %
Automotive	70	0	100	0
Industrial	16	2	97	1
Portable	13	7	2	91

Besides, BIO (2003) estimates the collection rates and percentages of collected batteries treated at recycling facilities for each of the main battery categories (automotive, industrial, portable). The results of the above data, combined with the total amount of waste batteries generated at EU level (1 833 194 tonnes) leads to the estimations presented in Table 25.

Table 25: Estimation of the amounts of battery waste generated, the amounts collected and the amounts treated at recycling facilities in the EU-27 (combination of 2006 data from Eurostat, 2002 data from BIO (2003) and 2003 data from ERM (2006)).

Waste batteries	Amounts generated	Collection rates		Amounts collected		Collected batteries treated at recycling facilities		
	ktonnes	min %	max %	min ktonnes	max ktonnes	%	min ktonnes	max ktonnes
Automotive	1 261	80	95	1 009	1 198	100	1 009	1 198
Industrial	293	80	90	235	264	100	235	264
Portable	235	5	65	12	153	90	11	137
Total	1 790	70	82	1 256	1 474		1 254	1 473

The amount of materials treated at the recycling facilities can be estimated based on a typical material composition of the different battery types, presented in Table 26, and the share of these battery types within the main battery categories (automotive, industrial and portable) of Table 24. The data of Table 26 are based on BIO (2003), ERM (2006) and (COM(2003)723 final)⁵¹.

⁵¹ European Commission (2003) Commission staff working paper. Directive of the European Parliament and of the Council on batteries and accumulators and spent batteries and accumulators. Extended impact assessment

Table 26: Estimated material composition of different battery types, based on BIO, (2003), ERM (2006) and COM(2003)723 final.

Materials	Composition NiCd batteries		Composition lead-acid batteries	Composition other battery types
	portable %	industrial %	%	%
Metals	71	64	69-74	52-72
<i>Cadmium</i>	14	8		
<i>Lead</i>			65-70	
Plastics	10	10	10	0-9
Other	19	26	21	20-44

In Table 27 the results of these calculations (only for the maximum treated amounts of Table 25) are compared with the EU material flow data from the report on the analysis of the evolution of waste reduction and the scope of waste prevention⁵².

Since no information is available on the current recycling efficiencies for each of the battery types, the actual recycled amounts cannot be determined. The estimates of Table 27 assume that all materials entering the recycling facility are effectively recycled. This is equivalent to setting a 100% recycling efficiency, which is of course an overestimate.

For portable batteries however, a recycling rate of 15% of the batteries collected was reported at EU-15 level in 2002 (Table 23). Assuming a similar recycling rate for automotive and industrial batteries, the recycled amounts would be about 85 % less than the amounts treated at recycling facilities (as reported in Table 25 and Table 27). The final results in that case are shown in Table 28. The maximum material amounts in generated battery waste are calculated based on Table 24, Table 25 and Table 26.

⁵² Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Table 27: Amounts of Pb, Cd, metals and plastics treated at recycling facilities compared to the material input in the EU-27 economy (based on Table 24, Table 25, Table 26 and EC (2010)) .

Waste batteries	Max amounts treated	Amounts of Pb		Amounts of Cd	Amounts of metals		Amounts of plastics	
	ktonnes	min ktonnes	max ktonnes	ktonnes	min ktonnes	max ktonnes	min ktonnes	max ktonnes
Automotive	1 198	779	839	0	827	887	120	0
Industrial	264	166	179	0.4	181	195	26	27
Portable	137	2	2	1	74	99	1	12
Total	1 473	947	1 020	1.4	1 082	1 180	147	159
Materials put on EU market (Mt)					metals: 247		fossil fuels: 1 852	

Table 28: Amounts of batteries and Pb, Cd, metals and plastics recycled, compared to the amounts of battery waste generated and the material input in the EU-27 economy assuming recycling rates of 15 % of the batteries collected for all battery categories (based on Table 24, Table 25, Table 26 and EC (2010))

Waste batteries	Max amounts batteries recycled	Amounts of Pb		Amounts of Cd	Amounts of metals		Amounts of plastics	
	ktonnes	min ktonnes	max ktonnes	ktonnes	min ktonnes	max ktonnes	min ktonnes	max ktonnes
Automotive	180	117	126	0	124	133	18	18
Industrial	40	25	27	0.06	27	29	4	4
Portable	23	0.3	0.3	0.2	12	16	0.2	2
Total	221	142	153	0.3	164	179	22	24
Max material amounts generated (ktonnes)		1 086		3	1 319		177	
Recycling rate vs. generated (%)		13	14	10	12	14	13	14
Materials put on EU market (Mt)					metals: 247		fossil fuels: 1 852	

From Table 27 it can be derived that the metals present in the batteries sent for recycling represent about 0.4-0.5% of the metals input in the EU economy. For the plastics fraction, this figure amounts to 0.008 % of the EU-27 fossil fuels DMC.

However, when compared to the amount of fossil fuels used for the production of plastics (estimated at 4%) the amount of plastics from batteries sent for recycling represents approximately 0.2%. If the recycling rates for all waste batteries collected were 15%, then these figures would amount to 0.07% of the metals input into the EU-27 economy and 0.03% of the fossil fuel input used for the production of plastics (Table 28).

Packaging waste

The Packaging Directive defines three separate targets:

- by no later than 31 December 2008, at least 60% by weight of packaging waste to be recovered or incinerated at waste incineration plants with energy recovery;
- between 55 and 80% by weight of packaging waste to be recycled;
- minimum recycling targets per material

The data per type of material used in this study are based on 2006 data published on the Eurostat website⁵³ (gap-filled). An overview of these data for the EU-27 is presented in Table 29. On average, all targets are met at the EU-27 level, but not at the individual Member State level: in only six MS all recycling targets per material are reached. The recycling data of Table 29 are the total recycled amounts, both domestically and exported. The material flow data (DMC) were obtained from the report on the analysis of the evolution of waste reduction and the scope of waste prevention⁵⁴ (data of 2005).

Based on the data in Table 29 it can be calculated that the biomass recycled accounts for 1.7%, the metals recycled for 1.3% and the minerals recycled for 0.3% and the plastics recycled for 0.2% of the total material flows in the EU-27 economy. However, when compared to the amount of fossil fuels used for the production of plastics (estimated at 4%), the amount of plastics recycled from packaging represents 6%.

⁵³ Available at: epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database [Accessed online 12/01/2011]

⁵⁴ Arcadis, VITO, Umweltbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Table 29: Overview of the amount packaging waste collected and recycled (based on Eurostat, data of 2006), the recycling rates and targets, compared to material input in the EU-27, current situation (2006).

	Amounts generated	Amounts recycled	Target 2008	Current recycling rates
Packaging waste	ktonnes	ktonnes	%	%
Paper & board	31 771	23 793	60	75
Wood	12 852	4 883	15	38
Plastic	14 950	3 894	22.5	26
Metals	4 903	3 227	50	66
Glass	16 597	10 003	60	60
Other	233	15		6
Total	81 306	45 814	55-80	56

ASSUMPTIONS AND CALCULATIONS FOR ESTIMATING THE TOTAL CONTRIBUTION OF RECYCLING ASSUMING ALL CURRENT RECYCLING TARGETS ARE FULLY REACHED

Municipal waste

The Waste Framework Directive sets a recycling target of 50% for municipal solid waste. If this target were met by all Member States 130 292 890 tonnes of MSW would be recycled (calculated based on Table 8 and the recycling target). If all recycling targets were met, the recycled amounts of glass would constitute approximately 0.4% of the total mineral input in the EU-27 economy. For biomass, this figure would amount to 3.9%, for metals to 1.4% and for plastics to 9.8% of the total DMC for biomass, metals and fossil fuels used for the production of plastics respectively.

Table 30 provides an overview of the generated and recycled amounts per material fraction and compares these amounts to the material input into the EU-27 economy (DMC)⁵⁵.

If all recycling targets were met, the recycled amounts of glass would constitute approximately 0.4% of the total mineral input in the EU-27 economy. For biomass, this figure would amount to 3.9%, for metals to 1.4% and for plastics to 9.8% of the

⁵⁵ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

total DMC for biomass, metals and fossil fuels used for the production of plastics respectively.

Table 30: Composition of the MSW recycling amounts, compared to the material flows (DMC) in the EU-27 (based on ETC/SCP (2009)⁵⁶, EC (2010) and the recycling target)

Materials	Material amounts recycled		Amounts generated	Recycling rate
	% of total	ktonnes	ktonnes	%
Glass	10.6	13 793	27 586	50
Paper and cardboard	20.2	26 326	52 651	50
Wood	3.4	4 449	8 899	50
Biowaste	25.7	33 445	66 889	50
Metals	3.0	3 856	7 712	50
Plastics	5.6	7 267	14 535	50
Bulky waste	6.0	7 861	15 721	50
Other waste	7.7	10 011	20 022	50
No information about type of recycling	17.9	23 285	46 570	50
Total	100.0	130 293		

Construction and demolition waste

The C&D waste reuse, recycling and material recovery target amounts to 392 million tonnes. As stated before, this target amount is calculated based on the assumption that all Member States which already reach or exceed the target set at EU level (in this case Denmark, Estonia, Germany, Ireland and the Netherlands, see Table 8), keep their current reuse, recycling and recovery rate constant.

Table 31 presents the RRR amounts of C&D waste if the current targets for the reuse, recycling and recovery of C&D waste would be met by all MS. The RRR amounts would represent 4.7- 12% of the mineral input 0.5 - 1% of the biomass input, 0.3 – 6.4% of the metals input, 0.02 – 0.4% of the fossil fuels input and 0.5- 10.6% of the fossil fuels input used for the production of plastics into the EU-27 economy.

Table 31: Overview of the arising amounts of C&D waste and the reused, recycled and recovered materials (calculated based on Table 8 and the recycling target)

⁵⁶ ETC/SCP working paper 2 (2009) EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU

compared to the material input in EU-27 (DMC)⁵⁷, when the current reuse, recycling and recovery targets are fully reached.

Composition C&D waste	Amounts arising		RRR amounts		RRR rate
	ktonnes - min	ktonnes - max	ktonnes - min	ktonnes - max	%
concrete and masonry - total	212 552	446 359	156 846	329 376	74
<i>concrete</i>	63 766	212 552	47 054	156 846	74
<i>masonry</i>	42 510	286 945	31 369	211 742	74
asphalt	21 255	138 159	15 685	101 950	74
other mineral waste	10 628	47 824	7 842	35 290	74
gypsum	1 063	2 126	784	1 568	74
wood	10 628	21 255	7 842	15 685	74
metals	1 063	21 255	784	15 684	74
plastics	531	10 628	392	7 842	74
miscellaneous	10 628	191 297	7 842	141 161	74
Total		531 380		392 114	74

End-of-Life Vehicles (ELV)

From the ELV collection data and the recycling rates in Table 13, it can be derived that if recycling target were met by all Member States (85% of the ELVs collected), 4 846 075 tonnes of ELVs would be reused and recycled. This target amount is again calculated assuming that all Member States which already reach or exceed the target set at EU level, keep their current reuse and recycling rate constant.

With this target amount in mind, and based on the typical composition of reused and recycled amounts of the advanced vehicle dismantling scenario in Table 16, the reused and recycled amounts of materials present in ELVs can be determined. Table 32 provides an overview of the reused and recycled amounts of ELVs when the 2015 reuse and recycling target is fully reached. These amounts are compared to the material amounts in vehicles collected in 2006, in vehicles registered between 2006 and 2008 (as calculated in Table 17) and to the material input in the EU-27 economy (EC, 2010). Due to the estimates made as regards the composition of the recycling amounts and the collected amounts and to the changes in composition over time some of the recycling rates in column 7 exceed 100 %.

Table 32: Estimated composition of the reused and recycled materials in ELVs (GHK and BIO, 2006)⁵⁸, based on the currently collected amounts in the EU-27 (Eurostat, 2006), assuming that the 2015 reuse and recycling target is met.

⁵⁷ Arcadis, VITO, Umweltbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

⁵⁸ GHK and BIO IS (2006), A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, reuse and recovery under the ELV Directive

Comparison is made with the materials present in the vehicles collected in 2006, with the vehicles registered in 2006-2008 (based on GHK and BIO, 2006 and Eurostat, personal communication), and with the material input in the EU-27 economy (DMC)⁵⁹.

	Typical composition of reuse and recycling amounts	Reused and recycled amounts	Material amounts in vehicles registered 2006-2008	Material amounts in vehicles collected in 2006	Material reuse and recycling rate vs. vehicles registered 2006-2008	Material reuse and recycling rate vs. vehicles collected in 2006
ELV materials	advanced (%)	ktonnes	Mt	ktonnes	%	%
ferrous metals	79.0	3 828	10.2	3 868	38	99
non ferrous metals	10.8	524	1.2	455	44	115
batteries	1.6	77	0.2	74	40	105
tyres	2.5	119	0.5	171	26	70
plastics	1.5	71	1.5	569	5	13
textiles	0.1	6	0.2	57	4	10
rubber	0.6	30	0.3	114	10	26
glass	1.8	89	0.5	171	20	52
fluids	2.1	101	0.3	97	40	105
other	0.0	0	0.3	114	0	0
total	100.0	4 846	15.0	5 688	32	85

If the 2015 target for the reuse and recycling of ELVs were met by all MS, the RR amounts would represent 1.8% of the metal input into the EU-27 economy (metals present in batteries not included). For rubber, tyres, plastics and textiles, supposing an entirely synthetic composition of these fractions, this figure would amount to 0.2% of the fossil fuels used for the production of plastics. The reused and recycled amounts of glass would represent only 0.002% of the minerals input into the EU-27 economy.

Waste from Electric and Electronic Equipments (WEEE)

Table 33 presents the total amounts of WEEE which would be collected and recycled if the collection target of 4 kg/inhabitant/year and the 2006 recycling targets for the different WEEE types were achieved by each of the EU-27 Member States. The overall EU-27 collection rate in that case would amount to 5.36 kg/inhabitant and the reused and recycled amount would reach approximately 2 093 k tonnes.

⁵⁹ Arcadis, VITO, Umweltsundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

As for other waste categories, it is assumed that MS, which already reach or exceed the collection and/or recycling targets, keep their collection and/or recycling rates constant. For MS that have not yet reached the collection target, the amount of WEEE, which remains to be collected is allocated to the different WEEE categories in proportion to the amounts currently collected. When the collected amounts obtained in this way exceed the amounts put on the market, the excess amount is redistributed proportionally over the other WEEE categories. Data gaps are filled with the reported value per capita at EU level, multiplied by the number of inhabitants of the data gap country.

Table 33: Overview of the collected and recycled amounts of the different WEEE fractions at EU-27 level, if 2006 collection and recycling targets were met by all Member States. Amounts put on the market are based on Eurostat data (2006).⁶⁰

WEEE	Amounts put on market	Collected amounts	Collection rate		Reuse & recycling amounts	Recycling rates	
	ktonnes	ktonnes	%	kg/capita	ktonnes	% of collected	% of put on market
large domestic appliances and automatic dispensers	4 636	1 444	31	2.93	1 197	83	26
small domestic appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment and monitoring and control instruments	1 884	245	13	0.50	171	70	9
medical devices	76	16	21	0.03	8	51	11
IT and telecommunications equipment and consumer equipment	2 782	883	32	1.79	663	75	24
discharge lamps	136	56	41	0.11	54	96	40
total	9 513	2 643	28	5.36	2 093	79	22

Similar calculations were carried out for the 2011 targets and the results are shown in Table 34. The 65 % collection target was assumed to be reached in all WEEE categories separately. In this case the collection rate would amount to 12,5 kg/inhabitant and about 4,840 ktonnes of WEEE would be reused and recycled.

Table 34: Overview of the collected and recycled amounts of the different WEEE fractions at EU-27 level, if 2011 collection and recycling targets were met by all Member States. Amounts put on the market are based on Eurostat data (2006)

⁶⁰ Available at: epp.eurostat.ec.europa.eu/portal/page/portal/waste/data/wastestreams/weee [Accessed online 12/01/2011]

WEEE	Amounts put on market	Collected amounts	Collection rate		Reuse & recycling amounts	Recycling rates	
	ktonnes	ktonnes	%	kg/capita	ktonnes	% of collected	% of put on market
large domestic appliances and automatic dispensers	4 636	3 013	65	6.11	2 511	83	54
small domestic appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment and monitoring and control instruments	1 884	1 225	65	2.48	836	68	44
medical devices	76	49	65	0.10	33	68	44
IT and telecommunications equipment and consumer equipment	2 782	1 808	65	3.67	1 377	76	49
discharge lamps	136	88	65	0.18	83	94	61
total	9 513	6 183	65	12.54	4 840	78	51

From the reuse and recycling data of Table 33 and Table 34, the reused and recycled amounts per material fraction are calculated, based on the average WEEE composition of Table 20. Table 35 compares the resulting RR amounts to the amounts of EEE materials placed on the EU-27 market and to the total material flows into the EU-27 economy.

Table 35: Comparison of the reused and recycled WEEE materials to the WEEE materials collected and to the total material flows into the EU-27 economy (DMC)⁶¹.

	Amount of WEEE materials reused & recycled, 2006 targets reached	Amount of WEEE materials reused & recycled, 2011 targets reached	Amount of EEE materials collected if 2006 targets reached	Amount of EEE materials collected if 2011 targets reached	Reuse and recycling rate, 2006 targets reached	Reuse and recycling rate, 2011 targets reached
Materials	ktonnes	ktonnes	ktonnes	ktonnes	%	%
Metals	1 151	2 662	1 454	3 401	79	78
Plastics	523	1 210	661	1 546	79	78
Other	419	968	529	1 237	79	78
Total	2 093	4 840	2 643	6 183	79	78

Table 35 shows that, if the collection targets of 2006 were fully met, the RR amounts would represent approximately 0.4% of the raw metals input and 0.7 % of the fossil fuels input used for plastics in the EU-27 economy. As for the 2011 targets, these figures would amount to 1.0% of the metals and 1.6 % of the fossil fuels used for plastics in the EU-27 material flows (DMC).

Waste batteries

Table 36 provides an overview of the battery waste generated and the amounts collected and recycled if all collection and recycling efficiency targets were fully reached. An estimated material composition of different battery types (Table 26), and the estimated share of these battery types within the three main battery categories (automotive, industrial, portable)(Table 24) is used to calculate the approximate amounts of Pb, Cd, metals and plastics recycled. In Table 37 these

⁶¹ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

amounts are compared to the maximum material amounts in generated battery waste and to the total material flows entering the EU-27 economy (2005 data)⁶².

Table 36: Battery waste generated and the amounts collected and recycled assuming that all collection and recycling targets are fully reached (based on Table 22, Table 23, Table 24, Table 25 and the collection/recycling targets).

	Amounts generated	Collection & treatment targets	Amounts collected & treated if targets reached	Amounts recycled if recycling efficiency targets reached
Waste batteries	ktonnes	%	ktonnes	ktonnes
Automotive	1 261	100	1 261	820
Industrial	293	100	293	191
Portable	235	45	106	55
Total	1 790	0	1 660	1 066

Table 37: Amounts of Pb, Cd, metals and plastics recycled when all collection and recycling targets are fully reached (based on Table 24, Table 25 and Table 26). These amounts are compared to the amounts of battery waste generated (Table 13) and the material input in the EU-27 economy (EC (2010)).

Waste batteries	Amounts of Pb recycled		Amounts of Cd recycled	Amounts of metals recycled		Amounts of plastics recycled	
	min ktonnes	max ktonnes	ktonnes	min ktonnes	max ktonnes	min ktonnes	max ktonnes
Automotive	533	574	0	566	607	82	82
Industrial	120	130	0.3	131	141	19	19
Portable	0.7	0.8	0.5	29	40	0.5	5
Total	654	704	0.8	726	787	102	106
Max material amounts generated (ktonnes)	1 086		2.8	1 319		177	
Recycling rate vs. generated (%)	60	65	30	55	60	57	60
Materials put on EU market (Mt)				metals: 247		fossil fuels: 1 852	

When all collection targets and recycling efficiencies stipulated are reached, the amount of metals recycled would represent about 0.3% of the metals input into the EU-27 economy. For plastics this figure would amount to approximately 0.1% of the fossil fuel input used for the production of plastics.

⁶² Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Packaging waste

Table 38 provides an overview of the recycling figures as compared to the material flows into the EU economy, if the current recycling targets for packaging waste were met by all MS. As before, it is assumed that recycling rates are kept constant in Member States which have already reached or exceeded the targets in 2006.

Table 38: Overview of the amount packaging waste generated and recycled (Table 15) and the recycling rates and targets, when all targets are fully reached by each MS. These data are compared to material input in the EU-27 (DMC⁶³).

	Amounts generated	Amounts recycled	Target	Recycling rates
Packaging waste	ktonnes	ktonnes	%	%
Paper & board	31 771	23 975	60	75
Wood	12 852	4 936	15	38
Plastic	14 950	4 091	22.5	27
Metals	4 903	3 275	50	67
Glass	16 597	11 059	60	67
Other	233	15		6
Total	81 306	47 351	55-80	58

The contribution of the recycled amounts of packaging waste to the material flows into the EU-27 economy is basically the same as in the current situation (2006) presented in Table 29: the recycled biomass accounts for 2%, the recycled metals for 1.3% and the recycled glass for 0.3 % of the total material input. Recycled plastics account for 6% of the fossil fuels input used for the production of plastics.

⁶³ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

ASSUMPTIONS AND CALCULATIONS FOR ESTIMATING THE POTENTIAL CONTRIBUTION OF RECYCLING ASSUMING BEST PRACTICES ARE FULLY IMPLEMENTED

Municipal waste

The available data on the recycling of municipal waste suffers from important flaws as to data comparability between the MS, and should thus be interpreted with caution. A more stringent and more coherent approach to reporting would ensure accurate data, enabling more detailed and correct comparisons to be made between the Member States' performances. This would also help to identify good practices, which could stimulate less well performing Member States to improve their recycling activities.

Detailed impact assessment studies evaluating the current recycling targets set in the Waste Framework Directive are not available. From the previous calculations in this project on municipal waste recycling it can be derived that in 2006 the highest recycling rates were obtained in Germany (66%), Belgium (58%) and the Netherlands (50%), all complying with or exceeding the 50% target set out in the Waste Framework Directive. Recycling levels in these MS are reported to be still increasing (>0.25 percent/year), although at a slower pace than in all other European Member States (ETC/SCP, 2009)⁶⁴. Collection schemes and recycling practices/techniques are continuously improving in all Member States. Projections in the SOER 2010 report⁶⁵ suggest that, based on current trends, recycling of municipal waste would increase to 49% in 2020. Hence, the 50% target set out in the Waste Framework Directive appears to be feasible at EU level.

A modelling exercise of waste management trends towards 2030 in (EC, 2010)⁶⁶ suggests that the recycling of MSW fractions will stabilise after a shorter period of continued increase, driven by the recycling targets for specific waste streams. Composting, however, affects a larger fraction of generated MSW and is likely to increase considerably as a cheap and effective method for landfill diversion of MSW.

It is believed that the average composition of generated MSW will remain rather stable at the level of the EU-27.

The information compiled in the previous sections suggests that on a longer term an EU-wide MSW recycling rate of approximately 65% (more or less the level of the current best practices) can be achieved. The calculations were therefore reiterated

⁶⁴ ETC/SCP working paper 2 (2009), EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU

⁶⁵ European Environmental Agency (2010), European Environment State and Outlook Report 2010.

⁶⁶ BIO Intelligence Service, IEEP, Ecologic, Umweltbundesamt, Arcadis, VITO (2010) Preparatory study for the review of the Thematic Strategy on the Prevention and Recycling of Waste. Study commissioned by the European Commission, DG Environment

based on a 65% recycling level for all Member States (66% for Germany). The mean EU-25 material composition of recycled MSW in 2006 was used for obtaining the recycling figures in Table 39. It should however be noted that this composition varies significantly between Member States, and is expected to change in accordance with the trends and developments in collection and recycling techniques. Besides, calculations are based on the MSW amounts generated in 2006. The EC (2010) report however concludes that, for the EU-27 as a whole, the total generation of MSW will go through a phase of intense increase until 2016, driven by both demographic and economic changes, and will keep on rising at a slower pace afterwards.

Table 39: Recycled and generated amounts of MSW materials, compared to the material flows (DMC) in the EU-27 if a 65% recycling target were achieved by all MS (based on ETC/SCP (2009)⁶⁷ and EC (2010)⁶⁸)

Materials	Material amounts recycled		Amounts generated	Recycling rate
	% of total	ktonnes	ktonnes	%
Glass	10.6	17 931	27 586	65
Paper and cardboard	20.2	34 223	52 651	65
Wood	3.4	5 784	8 899	65
Biowaste	25.7	43 478	66 889	65
Metals	3.0	5 013	7 712	65
Plastic	5.6	9 448	14 535	65
Bulky waste	6.0	10 219	15 721	65
Other waste	7.7	13 014	20 022	65
No information about type of recycling	17.9	30 271	46 570	65
Total	100.0	169 381	260 586	65

If all MS achieved a 65% MSW recycling rate, the recycled amounts of glass would represent 0.5% of the minerals input into the EU-27 economy. Recycled paper, cardboard, wood and biowaste together would constitute 5.1% of the biomass DMC. For metals this figure would amount to about 1.8% and for plastics to 12.7% of the input of fossil fuels, used for the production of plastics into the EU-27 economy.

⁶⁷ ETC/SCP working paper 2 (2009), EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU

⁶⁸ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Construction and demolition waste

The data obtained from the study on management of construction and demolition waste in the EU⁶⁹ provides for only very rough and uncertain estimates. This is owing to unequal levels of control and reporting of C&D waste in MS, as well as differences in definitions and reporting mechanisms. Data quality is therefore an important issue. A harmonisation of reporting mechanisms and definitions should be undertaken, and, in particular, excavation material should be systematically distinguished from the “core” C&D waste.

As 5 MS already achieve the target of 70% reuse, recycling and material recovery of C&D waste, some of them very comfortably (with RRR rates over 80%), the objective set in the Waste Framework Directive seems feasible. MS with very low recycling rates (less than 40%) will certainly face a challenge in reaching this target, as it will be necessary to develop the appropriate infrastructure.

According to the EC (2010) report on C&D waste, the mineral fraction should easily find applications as aggregates in e.g. road construction and structural concrete, as long as the quality of the secondary materials is ensured, through early decontamination of the waste and quality certification. Focusing on this stony fraction should, in most cases, guarantee a recycling rate close to, and above 70%. Moreover, as the recovery of mineral waste requires selective demolition and the appropriate sorting of C&D waste, this is likely to drive the recycling of the smaller fractions. However, some countries such as e.g. Finland report relatively low shares of mineral waste compared to wood waste. These countries might face more difficulties in reaching the target, as energy recovery of wood waste is encouraged by European and national policies as a renewable source of energy and is not included in the Waste Framework Directive target.

The EC (2010) report on C&D waste further states that the best practices in Europe show that RRR rates over 80% or 90% are feasible, which means that an increase in the WFD target to 90% should be possible on the longer term.

The previous calculations were reiterated taking account of a RRR rate of 90% for most Member States and the current RRR rates for Member States already exceeding the 90% recycling level. The results are summarized in Table 31. Again, it is worth noting that the calculated RRR amounts are based on the amounts of C&D waste arising in 2006. However, according to the EC (2010) report on C&D waste, it is likely that the quantities of C&D waste arising will keep on increasing, at least as fast as the economy. The composition of the (reused, recycled or recovered) C&D waste is believed to remain similar in the coming years.

⁶⁹ EC (2010) Study on Management of construction and demolition waste in the EU

Table 40: Overview of the arising amounts of C&D waste and the reused recycled and recovered materials (based on Table 10 and the recycling target) compared to the material input in EU-27 (DMC)⁷⁰, if a 90% recycling target were fully reached.

Composition C&D waste	Amounts arising		RRR amounts		RRR rate
	ktonnes - min	ktonnes - max	ktonnes - min	ktonnes - max	%
concrete and masonry - total	212 552	446 359	192 169	403 554	90
<i>concrete</i>	63 766	212 552	57 651	192 169	90
<i>masonry</i>	42 510	286 945	38 434	259 428	90
asphalt	21 255	138 159	19 217	124 910	90
other mineral waste	10 628	47 824	9 608	43 238	90
gypsum	1 063	2 126	961	1 922	90
wood	10 628	21 255	9 608	19 217	90
metals	1 063	21 255	961	19 217	90
plastics	531	10 628	480	9 608	90
miscellaneous	10 628	191 297	9 608	172 952	90
Total	531 380		480 422		90

If all MS would reach a 90% recycling rate for construction and demolition waste, the RRR amounts of concrete and masonry, asphalt, gypsum and other mineral waste would together represent 5.8 to 14.9 % of the minerals input into the EU-27 economy. Recycled wood would constitute about 0.6 to 1.2% of the biomass DMC, recycled metals 0.4 to 7.8% of the metals DMC and recycled C&D plastics approximately 0.6 to 13.0% of the EU-27 DMC of fossil fuels, used for the production of plastics.

End-of-Life Vehicles (ELV)

GHK and BIO (2006)⁷¹ examined the feasibility of different reuse, recycling and recovery targets for ELVs in 2015. They concluded that the 95% RRR target set in the ELV Directive should be retained, since it would bring about environmental benefits at a modest or zero cost.

The scrap value of parts and metals is sufficient to ensure that left to the market at least 75% of the ELV is recycled. With some efforts to increase recycling and the requirement for depollution, current practice achieves about 80% of reuse and recycling. This level can be reached without the use of new techniques. The introduction of recently developed Post Shredder Technologies (PSTs) would entail recycling or recovery efficiencies of at least 75%. Given the baseline rates of

⁷⁰ Arcadis, VITO, Umweltbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

⁷¹ GHK and BIO IS (2006) A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, reuse and recovery under the ELV Directive

recycling and recovery of around 80% per ELV, these new technologies are capable of treating the remaining 20%, enabling an overall recycling and recovery rate of 95%.

Recycling would be the most environmentally beneficial treatment, especially at lower levels of recycling, due to the benefits of metal recycling. At present it also appears to be cheaper than thermal treatment. It would therefore make sense to confirm the 95% target as a target for reuse and recycling rather than recovery. At higher recycling levels however, the balance of environmental benefits between recycling and recovery options is less certain, since the volume of plastics requiring treatment increases. Hence, the marginal benefits, although positive, decline, due to the treatment of more difficult resins with lower substitution rates of virgin material. Furthermore, adoption of the 95% target as a reuse and recycling target would undermine the development of PSTs based on thermal treatment and the potential benefits this technology might deliver. The GHK and BIO (2006) study therefore suggests to keep the reuse, recycling and recovery targets for 2015 as is, and add a clear set of environmental criteria against which to assess different PST options.

On a longer term however, both mechanical treatment and thermal treatment PSTs are expected to further develop. The reuse, recycling and recovery potential of materials is believed to become a more important criterion for vehicle design under influence of, among other things, the design requirements set in legislation: currently vehicle design must allow for 95% recovery and 85% reuse and recycling, in accordance with the 2015 RRR-targets set in the ELV Directive.

A reuse and recycling target of 90% (88% is the current best practice) might therefore be feasible in the future. Hence, the ELV reuse and recycling amounts calculated in previous sections were recalculated based on a 95% recycling rate (Table 41). The recycled material fractions were again determined according to the advanced vehicle dismantling scenario described by GHK and BIO (2006). The introduction of PSTs however, will probably lead to a different composition of the RRR fractions. Furthermore it must be noted that the figures of Table 41 are derived from the currently collected amounts of ELVs (2006). These amounts are expected to increase, as more vehicles are put on the market and better enforcement of the ELV Directive will lead to higher reported numbers of ELVs collected.

Due to the estimates made as regards the composition of the recycling amounts and the collected amounts and to the changes in composition over time some of the recycling rates in column 7 of Table 28 exceed 100 %.

Table 41: Estimated composition of the reused and recycled materials in ELVs (GHK and BIO, 2006), based on the currently collected amounts in the EU-27 (Eurostat, 2006), if a 90% reuse and recycling target were reached. Comparison is made with the materials present in the vehicles collected in 2006, with vehicles registered in

2006-2008 (based on GHK and BIO, 2006 and Eurostat, personal communication), and with the material input in the EU-27 economy (DMC)⁷².

	Typical composition of reuse and recycling amounts	Reused and recycled amounts	Material amounts in vehicles registered 2006-2008	Material amounts in vehicles collected in 2006	Material reuse and recycling rate vs. vehicles registered 2006-2008	Material reuse and recycling rate vs. vehicles collected in 2006
ELV materials	advanced (%)	ktonnes	Mt	ktonnes	%	%
ferrous metals	79.0	4 044	10.2	3 868	40	105
non ferrous metals	10.8	553	1.2	455	46	122
batteries	1.6	82	0.2	74	42	111
tyres	2.5	126	0.5	171	28	74
plastics	1.5	75	1.5	569	5	13
textiles	0.1	6	0.2	57	4	11
rubber	0.6	31	0.3	114	10	28
glass	1.8	94	0.5	171	21	55
fluids	2.1	107	0.3	97	42	111
other	0.0	0	0.3	114	0	0
total	100.0	5 119	15.0	5 688	34	90

Under the above assumptions, the amount of metals recovered from ELVs (excluding batteries) represents about 1.9 % of the total metal input into the EU-27 economy. For tyres, plastics, rubber and textiles (supposing an entirely synthetic composition) this figure amounts to 0.2 % of the fossil fuel input used for the production of plastics. The reused and recycled amounts of glass would constitute about 0.002% of the mineral DMC at EU-27 level.

Waste from Electric and Electronic Equipments (WEEE)

The WEEE Directive is in co-decision in Parliament and Council at the time this report is written, based on a proposal, an impact assessment, and underlying studies prepared by and for the Commission. Further policy suggestions, as outlined below, should therefore be understood as considerations for further assessment to be undertaken when the next review of the Directive starts.

The findings in previous sections suggest that in 2006 only 22% of the EEE put on the market was collected at EU-27 level. A serious effort would thus be required from all

⁷² Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Member States in order to reach the 65% collection target set out in the proposal for a WEEE Directive recast. However, the impact assessment study preceding this proposal⁷³, states that currently approximately 65% of the EEE placed on the market is separately collected, but less than half of it is reported (and treated) according to the requirements of the Directive. Since the levels of WEEE arising are about 80% of the EEE sold in the previous year, a collection rate of 65% of the EEE put on the market matches a collection rate of about 85% of the WEEE arising.

According to EC(2008) the separately collected 85% of WEEE arising includes nearly all the large and medium size WEEE, which is economic to collect. It is expected that very high collection rates approaching the maximum of 100% of the WEEE arising would entail disproportionate costs. This would be due to, for example, the necessity to extract small WEEE from unsorted municipal waste. In particular small WEEE with a weight below 1kg is currently hardly handed in by consumers and this would explain at least 11% of the not separately collected WEEE. The option of setting a 100% collection target for the most environmentally harmful equipment only was discarded, although environmentally beneficial and economically feasible. This option would be less effective at avoiding waste treatment under bad conditions in developing countries, with a significant proportion of the 29% of all WEEE arising not being covered by the collection target likely to go for illegal treatment. The option of setting a 100% collection target for the most environmentally harmful appliances in addition to the other targets set, was not discussed, probably due to the high associated cost. However, this option could bring about important environmental benefits.

UNU (2007)⁷⁴ states that from an environmental perspective, increasing weight based collection and recycling targets is not always the preferred option. E.g. for CFC containing fridges, CFC removal and control is crucial and should be prioritized over high recycling percentages, for plastic dominated products, the focus should be directed to increasing plastic recycling instead of setting a weight based recycling target, for LCD screens and gas discharge lamps, mercury recovery should be prioritized over recycling etc. According to the UNU study, the diversity in environmental priorities over the various treatment categories should therefore be addressed in much more detail instead of setting general collection and recycling targets for very diverse EEE categories.

Studies show that 5 to 10% of collected equipment is found to be reusable. Therefore in the WEEE recast, the inclusion of reuse of whole appliances in the targets, is accompanied with a 5% increase of the current reuse/recycling targets in order to keep the same level of environmental ambition. However, older appliances tend to consume more energy than new products and continued use of old products

⁷³ EC (2008) Commission staff working paper accompanying the proposal for a directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) (recast). Impact Assessment

⁷⁴ United Nations University (2007), 2008 Review of Directive 2002/96 on waste electrical and electronic equipment (WEEE) – final report

where they would not have been used, or where they would have been replaced by newer products, will increase energy use. With a 5% target increase, corresponding to what the market now allows (5 to 10%), there is low risk that the tradeoffs between reuse and replacement would be distorted.

With the above arguments in mind and taking account of the fact that the collection data discussed in this report appears to be of a very poor quality and shows many data gaps, no further future collection targets are suggested. The targets set in the proposal for a WEEE Directive recast are assumed to be the potential targets.

The data for the WEEE recycling figures are very incomplete and projections towards EU-27 level are quite rough. However, Table 19 shows that the recycling rates achieved with the currently collected amounts, on the whole exceed the target rates proposed by the WEEE recast. The data of Table 19 are a summary of the calculations at a more detailed EEE category level, as presented in Table 42.

Table 42: Overview of the current reuse and recycling amounts and rates of WEEE at EU-27 level (based on Eurostat data, 2006, converted to EU-27 level).

	Reuse and recycling amounts	Reuse and recycling rate vs. collected	2011 recycling targets
WEEE	ktonnes	%	%
Large household appliances	1 073	86	80
Small household appliances	93	77	55
IT & Telecommunication	233	76	70
Consumer equipment	278	84	70
Lighting equipment	15	77	55
<i>Gas discharge lamps</i>	32	95	85
Electrical & electronic tools	24	84	55
Toys, leisure & sports equipment	7	53	55
Medical devices	6	69	55
Monitor & control instruments	2	55	55
Automatic dispensers	10	72	80
Total	1 773	83	

Table 42 compares the current reuse and recycling rates to the target recycling rates for 2011. The highest rates for each WEEE category are selected (shaded) and further used as potential future targets. The figures of Table 43 are calculated based on these potential targets and keeping the 2011 collection target of 65%.

Table 43: Collection, reuse and recycling of WEEE if a 65% collection rate was reached, and if 2011 recycling targets were replaced by the target rates of Table 42 (shaded).

	Collected amounts	Reuse and recycling amounts	Reuse and recycling rate vs. collected
WEEE	ktonnes	ktonnes	%
Large household appliances	2 973	2 561	86
Small household appliances	495	385	78
IT & Telecommunication	917	708	77
Consumer equipment	891	753	84
Lighting equipment	262	207	79
<i>Gas discharge lamps</i>	88	84	96
Electrical & electronic tools	321	272	85
Toys, leisure & sports equipment	98	58	59
Medical devices	49	35	71
Monitor & control instruments	48	28	59
Automatic dispensers	41	33	80
Total	6 183	5 125	83

Table 44 shows the above data, converted to the category level at which the recycling targets of the WEEE Directive are set.

Table 44: Amounts of WEEE currently put on the market (Eurostat, 2006), collected and reused/recycled under the assumptions of Table 43.

WEEE	Amounts put on market	Collected amounts	Reuse & recycling amounts	Recycling rates	
	ktonnes	ktonnes	ktonnes	% of collected	% of put on market
large domestic appliances and automatic dispensers	4 636	3 013	2 594	86	56
small domestic appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment and monitoring and control instruments	1 884	1 225	951	78	50
medical devices	76	49	35	71	46
IT and telecommunications equipment and consumer equipment	2 782	1 808	1 461	81	53
discharge lamps	136	88	84	96	62
total	9 513	6 183	5 125	83	54

Using a typical WEEE composition (Table 20), these data can be compared to the total material flows in the EU-27 economy⁷⁵ (Table 45).

Table 45: Comparison of the WEEE material amounts reused and recycled to the EEE amounts collected in 2011 and to the material input in the EU-27 economy, under the assumptions of Table 20.

	Amount of WEEE materials reused & recycled, potential targets reached	Amount of WEEE materials collected in 2011	Reuse and recycling rate
Materials	ktonnes	ktonnes	%
Metals	2 819	3 401	83
Plastics	1 281	1 546	83
Other	1 025	1 237	83
Total	5 125	6 183	83

Based on the data in Table 45 it can be calculated that with a 65% collection rate for all MS and recycling rates as in Table 42 (shaded), the metals recycled account for 1.0% of the total material flows in the EU-27 economy. For the plastics, this figure amounts to 0.07% of the total fossil fuels input and to 1.7% of the fossil fuels used for the production of plastics. It must however be stressed that these calculations are based on inaccurate data, on the current amounts of EEE put on the market (2006) and on an estimated material composition. The amounts put on the market are expected to increase and the composition is expected to change on the longer term.

Moreover, technological advances stimulated by the ELV Directive will have a role to play in treatment and recycling of WEEE materials. Approximately half of the shredder residue treated with Post Shredder Technologies (PSTs) is derived from WEEE materials. Technological development in PSTs will lead to more advanced recycling and recovery techniques, which of course influence the feasibility of the suggested recycling targets. However, at present the available data do not allow for substantiated statements to be made in that sense.

Waste batteries

Data on recycling and on the material fractions present in the recycled amounts of waste batteries are scarce. Therefore, the figures calculated for waste batteries in previous sections are based on very rough assumptions and generalisations. Again, this leads to the conclusion that in the first place emphasis should be placed on accurate reporting, in order to enable a substantiated evaluation of the targets set.

In EC (2008)⁷⁶ it is reported that lack of enforcement of the WEEE Directive is an important aspect hindering high battery collection and recycling rates. The WEEE

⁷⁵ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

Directive demands to dismantle appliances and to separate batteries before any mechanical treatment can destroy hazardous components (like batteries). Despite the legal requirements many treatment techniques are not able to separate batteries from the other material streams. Therefore, many batteries are shredded within the treatment process of WEEE, with most battery-specific materials not separated afterwards. A better enforcement of the WEEE stipulations would thus be recommended in order to foster optimal battery recycling.

Besides, the EC (2008) report states that ambitious recycling targets for batteries would give an additional incentive for more and better recycling. Furthermore, the introduction of public collection schemes for batteries and battery-containing small appliances seems necessary in order to guarantee easy access for the public to dispose of them correctly.

A case study in EC (2008) reveals that the collection rate of waste portable batteries in Flanders amounted to 88.5% in 2005 and is still increasing. It is believed that the high effectiveness of this portable battery collection system is owing to the combination of eco-tax legislation and a legally imposed acceptance obligation, the high density of the collection system as well as the continuous public awareness campaigns. However, in order to put the collection rates in perspective, one should keep in mind that Flanders is a very small and densely populated region. The associated costs are also reported to be very high.

Recycling of these portable batteries in Flanders is carried out by different companies. One of the companies which are appointed for treatment of all portable battery types other than button cells and lead-acid batteries, claims that new technology investments allow for achieving recycling efficiencies of about 70%.

With respect to recycling efficiencies, the study COM(2003)723 final⁷⁷ also states that up to 70% of the metals present in portable general-purpose batteries can be recycled. For industrial and automotive lead-acid batteries the report mentions metal recycling efficiencies of about 65%. For nickel-cadmium batteries a minimum recycling efficiency of 75% by average weight is reported. The study stresses that it is particularly important to recover the lead and cadmium from batteries, given that the production of lead-acid batteries and nickel-cadmium batteries uses approximately 70 % of the global production of lead and cadmium.

EC (2008)⁷⁸ reports that due to the present high prices of lead, selective collection and recycling of lead acid batteries is currently organised profitably by the private sector. As for portable batteries, the current metal prices cover the operational costs

⁷⁶ European Commission (2008) Optimising markets for recycling – final report 07/13105/LF. November 2008

⁷⁷ European Commission (2003) Commission staff working paper, Directive of the European Parliament and of the Council on batteries and accumulators and spent batteries and accumulators – extended impact assessment. COM(2003)723 final

⁷⁸ European Commission (2008) Optimising markets for recycling – final report 07/13105/LF. November 2008

for recycling of nickel-cadmium, nickel-metal-hydrate and lithium ion batteries. For the latter battery types it would thus be sufficient to impose selective collection to create a viable market for recycling. However, since there is no certainty that the current metal prices will last, collection as well as recycling targets are still advisable. For zinc and manganese containing batteries, the revenues from sales do not cover the operational costs for recycling and explicit binding recycling objectives are always necessary on top of collection targets.

Based on the arguments above, a collection target of 80% is suggested as a long term objective for portable batteries. The recycling efficiency targets for nickel-cadmium and lead-acid batteries appear to be close to their potential value at present. For other battery types, increasing the current recycling efficiency target from 50% to about 70% seems feasible on the longer term. When the potential collection targets and recycling efficiencies suggested in this section are reached, the amount of metals recycled would represent about 0.3% of the metals input into the EU-27 economy. For plastics this figure would amount to approximately 0.1-0.2% of the fossil fuel input used for the production of plastics. It must be noted that these figures are only valid under the assumptions of chapter 3 in the report. Furthermore, they are based on the amount of battery waste generated in 2006, while a future increase in battery waste generation is to be expected. Table 46 and Table 47 present the results of reiterating the previous calculations based on the potential collection and recycling identified in this section.

Table 46: Battery waste generated and the amounts collected and recycled assuming that all potential collection and recycling targets are fully reached (based on Table 22, Table 23, Table 24, Table 25, and the collection/recycling targets).

	Amounts generated	Collection & treatment targets	Amounts collected & treated if targets reached	Amounts recycled if recycling efficiency targets reached
Waste batteries	ktonnes	%	ktonnes	ktonnes
Automotive	1 261	100	1 261	820
Industrial	293	100	293	191
Portable	235	80	188	132
Total	1 790		1 743	1 143

Table 47: Amounts of Pb, Cd, metals and plastics recycled when all potential collection and recycling targets are fully reached (based on Table 24, Table 25 and Table 26). These amounts are compared to the amounts of battery waste generated (Table 27) and the material input in the EU-27 economy (EC (2010))⁷⁹.

Waste batteries	Amounts of Pb recycled		Amounts of Cd recycled	Amounts of metals recycled		Amounts of plastics recycled	
	min ktonnes	max ktonnes	ktonnes	min ktonnes	max ktonnes	min ktonnes	max ktonnes
Automotive	533	574	0	566	607	82	82
Industrial	121	130	0.3	132	141	19	19
Portable	2	2	1.3	71	95	1	12
Total	655	706	1.6	768	843	102	113
Max material amounts generated (ktonnes)	1 086		2.8	1 319		177	
Recycling rate vs. generated (%)	60	65	57	58	64	58	64
Materials put on EU market (Mt)				metals: 247		fossil fuels: 1 852	

Packaging waste

In principle the present recycling targets of the Packaging Waste directive were derived – among others – based on the results of the RDC/Pira 2003 study⁸⁰. Higher recycling targets are not necessarily better from an economic and environmental point of view.

The optimum recycling target per packaging material depends on multiple parameters⁸⁰:

- The collection method of household packaging waste: kerbside separate collection, separate collection based on bring-systems or no separate collection at all. The optimum collection method for each packaging material depends on the population density.
- The alternative waste treatment method. In the study the costs and benefits of recycling were compared with the alternative treatment options land and incineration (with energy recovery). For specific types of packaging (e.g. metals), the recovery of materials from incineration ashes was considered.

⁷⁹ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

⁸⁰ RDC & Pira (2003) Evaluation of costs and benefits for the achievement of reuse and recycling targets for the different packaging materials in the frame of the Packaging and Packaging Waste Directive 94/62/EC, Final Consolidated Report, March 2003

- The amounts of household and industrial packaging.

Therefore the recycling rates achievable with “optimum systems” are different for each Member State (MS).

For this reason the Packaging Directive also includes a maximum recycling rate (cf. Art. 6.1.(d)):

- (d) No later than 31 December 2008 between 55% as a minimum and 80% as a maximum by weight of packaging waste will be recycled;

This is based on the consideration that incineration with energy recovery may be better than recycling in some cases, based on cost-benefit analysis. This is recognised by Article 6.3 of the Packaging Directive :

Member States shall, where appropriate, encourage energy recovery, where it is preferable to material-recycling for environmental and cost-benefit reasons. This could be done by considering a sufficient margin between national recycling and recovery targets.

Since all the above parameters could not be analysed in the framework of this study, a pragmatic analysis was adopted, based on today’s recycling results of the individual Member States. Afterward the results were compared with the RDC/Pira 2003 study.

In previous sections it was demonstrated that many Member States already meet the 2008 recycling rate (RR) targets for many materials, and that the EU on average meets the 2008 RR targets. The overall RR for all materials combined equals 56%, which is just within the 55 – 80 % target range.

The overall RR was calculated in previous sections for all materials combined under the assumption that all non-compliant MS would meet the target (the compliant ones remaining unchanged). This overall RR equals 58%, which is not very different from the present 56% and still at the low end of the 55 – 80 % target range. This seems to indicate that there is room for improvement. A calculation was made based on the assumption the all non-compliant MS would meet recycling rates per material that are equal to the weighted average of the MS that are compliant today (the compliant ones remaining unchanged). The results are shown in Table 48.

Table 48 : Overview of the amount packaging waste generated, the recycling rates and targets, compared to material input in the EU-27 (DMC)⁸¹, based on weighted average recycling rate of compliant MS

	Amounts generated	Amounts recycled	Target	Recycling rates
Packaging waste	ktonnes	ktonnes	%	%
Paper & board	31 771	24 346	77%	77%
Wood	12 852	5 066	39%	39%
Plastic	14 950	4 854	32%	32%
Metals	4 903	3 382	69%	69%
Glass	16 597	13 777	83%	83%
Other	233	15		6%
Total	81 306	51 440	55-80	63%

This overall RR now equals 63%, which is still at the low end of the 55 – 80 % target range. Another scenario was calculated based on the assumption the all non-compliant MS would meet recycling rates per material that are equal to the weighted average recycling rate of the top 3 performing MS per material (the top 3 performing MS per material remaining unchanged). The overall RR now equals 79%, which is at the top end of the 55 – 80 % target range. To check if these recycling rates are realistic, they were compared to the recycling rates achievable with the “optimum systems” that were presented in the RDC/Pira 2003 study⁸².

⁸¹ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

⁸² RDC & Pira (2003) Evaluation of costs and benefits for the achievement of reuse and recycling targets for the different packaging materials in the frame of the packaging and packaging waste directive 94/62/EC, Final Consolidated Report, March 2003

Table 49: Comparison of recycling rates in order to determine most plausible improvement level (marked in green).

Packaging waste	RDC/Pira study		Our assumptions	
	Min. Recycling rate %	Max. Recycling rate %	Weighted average recycling rate of compliant MS %	Weighted average recycling rate of top 3 performing MS %
Paper & board	60	74	77	91
Wood	47	65	39	73
Plastic	28	38	32	43
Metals (Aluminium/Steel)	(25 / 60)	(31 / 65)	69	88
Glass	53	87	83	93

The shaded areas are the most plausible improvement level of the recycling target, which were used as a basis for a new calculation. The results thereof are presented in Table 50.

Table 50 : Overview of the amount packaging waste generated, the recycling rates and targets, compared to material input in the EU-27 (DMC)⁸³, based on the most plausible RR improvement level.

	Amounts generated	Amounts recycled	Target	Recycling rates
Packaging waste	ktonnes	ktonnes	%	%
Paper & board	31 771	24 346	77	77
Wood	12 852	9 335	73	73
Plastic	14 950	6 501	43	43
Metals	4 903	3 382	69	69
Glass	16 597	15 532	93	94
Other	233	15		6
Total	81 306	59 112	55-80	73

Based on the data in Table 50 it can be calculated that the biomass recycled accounts for 2.1%, the metals recycled for 1.4% and the minerals and the plastics recycled both for approximately 0.4% of the total material flows in the EU-27

⁸³ Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment

economy. For plastics, the recycled amounts represent about 8.8% of the fossil fuels input used for the production of plastics.

It is worth noticing that these figures are calculated based on the amount of packaging waste generated in 2006. Since future packaging generation is expected to increase, the calculated recycling amounts represent a lower limit of the potential contribution from recycling.

ANNEX D: WASTE PREVENTION

1. WASTE PREVENTION RELATED POLICIES

This section studies policies that provide criteria for waste prevention and/or require the establishment of regulations for waste prevention as defined in chapter 4 in the report. A preliminary assessment of their impacts on material use through waste prevention is carried out.

1.1 ELV DIRECTIVE⁸⁴

The End-of-Life Vehicles (ELV) Directive aims to prevent the waste from vehicles at their end-of-life and to promote the reuse, recycling and recovery of ELVs and their components. As seen in the previous chapter, the Directive sets specific targets for reuse, recycling and recovery to be achieved in 2006 with a 5% - 10% increase in 2015.

In order to assess the potential contributions of the ELV Directive to material savings through waste prevention, a clear distinction between reuse and recycling targets would be necessary. However, the way they were defined in the ELV Directive does not lead to a clear distinction between both, leaving the option to achieve the targets by either reusing or recycling, without prioritising any of the approaches. Although a number of vehicle parts are currently reconditioned and reused, e.g. batteries, radios, used tyres for retreading, etc., the mix of recycling and reuse stimulates target achievement by recycling. This is the least difficult waste management option, and therefore undermines the advantages of reuse (as a means of waste prevention). From previous studies on the assessment of benefits of the implementation of the ELV Directive, it is clear that this has been the case. Since the implementation of the policy, there has been an increase in vehicles sent to treatment facilities and in the level of treatment for different materials has been reported. A report from the Commission on the targets contained in the Directive⁸⁵ states that there is evidence that the ELV Directive has stimulated technological development related to waste treatment, but this has not yet been sufficiently commercialised.

It is estimated that for an average ELV of 1000 kg, up to 31 kg of ferrous metal, 9 kg of non-ferrous metals, 1 kg of batteries, 5 kg of fluids, 10 kg of tyres, 1 kg of glass

⁸⁴ Directive 2000/53/EC on End-of-Life Vehicles (ELV Directive)

⁸⁵ European Commission (2007) 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. COM(2007)5.

and 1 kg of plastics can be reused (corresponding to under 6% of the vehicle)⁸⁶. As the amounts of recycling and reuse are reported in total, the material savings from reuse have already been accounted for in the previous chapter on the contributions from recycling.

In the latest report from the Commission on the implementation of the ELV Directive⁸⁷ all MS have taken measures to ensure manufacturers use component and material coding, and provide information on dismantling, which is thought to support greater reuse. Furthermore in the report ten MS have indicated that waste prevention measures had been taken, but there is no information about the effectiveness of these.

Contribution to material productivity

The potential contribution of the ELV Directive to material savings due to waste prevention (particularly reuse of components) is considered to be limited under current policy implementation. Nonetheless, in this study the amounts of material saved due to reuse have already been accounted for in the recycling data.

1.1. WEEE DIRECTIVE

The Waste Electrical and Electronic Equipment (WEEE) Directive aims at regulating and reducing the production and management of this type of waste. It provides rules concerning the design, collection, treatment, recovery, financing, information on and control of WEEE. When the WEEE Directive was adopted the prevention of WEEE was listed as a first priority⁸⁸ with reuse, recycling and other forms of recovery as secondary options. The key element of the WEEE Directive is the introduction of the producer responsibility principle. This principle requires the manufacturer of electrical and electronic products to be responsible for financing its labelling, collection, treatment, recovery, disposal and for providing information on its disposal. By putting the burden of financing waste management on manufacturers, this is thought to create an incentive to reduce the quantity of waste of their products - the less waste there is, the less money they will need to finance its treatment. However the WEEE Directive does not provide explicit waste prevention measures to guide producer responsibility, and instead provides rules concerning the separate collection of WEEE in order to encourage sorting and recovery, as well as the financial responsibility of WEEE management.

⁸⁶ GHK, BIO Intelligence Service (2006) A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, re-use and recovery under the ELV Directive.

⁸⁷ European Commission (2009) Report from the Commission to the Council, the European Parliament, the European Economic and Social Committee, and the Committee of Regions on the Implementation of Directive 2000/53/EC on the End-of-Life Vehicles for the period 2005-2008. COM(2009) 635.

⁸⁸ Article 1 of Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), OJ L 37/24, 13.02.2003.

Contribution to material productivity

Similar to the ELV Directive, there is no distinction in the WEEE targets between reuse (including the reuse of whole appliances) and recycling. The result is a limited amount of WEEE being prevented. In this study, the current material savings from the reuse of products and components have been already included in WEEE's contribution to recycling.

1.2. PACKAGING AND PACKAGING WASTE DIRECTIVE

The Packaging and Packaging Waste Directive (94/62/EC) establishes common rules for packaging. Member States must ensure that packaging complies with the following three requirements:

- limit the weight and volume of the packaging to a minimum
- reduce the content of hazardous substances and materials
- design reusable or recoverable packaging

Although all of these requirements could be seen as waste prevention measures, in the context of this study they are considered measures related to improving product design. The contributions to material savings from reducing the material intensity of packaging, reducing the use of hazardous substances and creating packaging that can be reused or recycled is considered in the next chapter. In this chapter only the amounts of material savings due to reducing the need for packaging and the increased reuse of packaging is considered.

The potential contribution of the Directive to quantitatively prevent waste could be significant as packaging waste accounts for about a third of municipal solid waste (by weight). However, the potential for waste prevention to contribute to material savings is far from being fully exploited. This is mainly due to the fact that prevention of packaging at the source is regarded as a complex process. The second reason is that recycling is the most popular option for achieving the targets in packaging waste. Finally, although there is some decoupling of packaging waste from GDP growth, the total amounts of packaging waste generated is increasing⁸⁹ and has by far outweighed any savings achieved. The result of this is that the actual contributions to material savings from waste prevention through the implementation of the packaging Directive have not been significant. Even though MS have taken different approaches to implement waste prevention instruments, the increasing patterns of packaging waste generation are similar in all MS. There is no evidence that waste prevention measures implemented by MS have had a significant effect. This could be due to the effectiveness of the measures, but also simply because no clear indicators and targets exist for waste prevention. None of

⁸⁹ European Commission (2006) Report from the Commission to the Council and the European Parliament on the implementation of Directive 94/62/EC on packaging and packaging waste and its impacts on the environment, as well as on the functioning of the internal market. COM(2006) 767.

the MS have any specific waste prevention targets at the moment, as they have been regarded as difficult to establish especially since they could create disadvantages among packaging materials.

The Packaging Directive has however been successful in reducing the use of hazardous substances in packaging to a minimum (qualitative waste prevention/product design). According to a Commission report: *“there are no indications that the current levels of heavy metals and other hazardous substances present in packaging pose any particular risks to health and the environment. Therefore, it appears unlikely that a further reduction of heavy metal limits would result in significant health and environmental benefits”*⁹⁰.

Contribution to material productivity

From the above, it follows that the main contribution of the Packaging and Packaging Waste Directive to material productivity is attributed to the recycling of packaging waste. No separate data exists on the amount of packaging reused. The material savings from limiting the weight and volume of packaging will be considered in the next chapter on the contributions of improvements in design. Other contributions to material savings in the form of waste prevention are considered insignificant on an EU level under the current state of policy implementation.

1.2 ROHS DIRECTIVE

The Restriction of the use of certain Hazardous Substances in electrical and electronic equipments – or simply the RoHS - Directive aims at restricting the use of six hazardous substances in electronic and electrical equipment (EEE)⁹¹. The main objective is to contribute to the protection of human health and the environmentally sound recovery and disposal of so-called “e-waste”. The RoHS Directive complements the WEEE Directive in that it focuses on the qualitative aspects of waste prevention and deals with the toxicity of e-waste⁹². The RoHS Directive allows only low levels of six hazardous substances to be present in EEE (with exceptions for certain products, e.g. batteries): lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE).

⁹⁰ European Commission (2006) Report from the Commission to the Council and the European Parliament on the implementation of Directive 94/62/EC on packaging and packaging waste and its impacts on the environment, as well as on the functioning of the internal market. COM(2006) 767

⁹¹ Although RoHS actually addresses the design of products, it is included as a waste prevention measure in this report as it is often linked with the WEEE Directive.

⁹² European Commission (2008) Impact Assessment – Commission staff working paper accompanying the Proposal for a Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) (recast). COM(2008) 810

Contribution to material productivity

The RoHS Directive seems to have been effective in removing these substances from WEEE. According to a 2008 study⁹³ the RoHS Directive has resulted in reducing the quantities of the banned substances being disposed of and potentially released into the environment by 89 800 tonnes of lead, 4 300 tonnes of cadmium, 537 tonnes of hexavalent chromium, 22 tonnes of mercury, and 12 600 tonnes of octa-BDE per year⁹⁴. It is however not clear whether the reduction in using these substances actually results in a net reduction of resources. It is not known what amounts of other materials are needed to substitute the hazardous substances in the production of EEE.

The Commission's impact assessment of the WEEE Directive estimates that there is potential for the scope of the RoHS Directive to be expanded further, to also include: non-reacted TBBPA⁹⁵, HBCDD⁹⁶, DEHP⁹⁷ and beryllium oxide. Here, it is estimated that 40 000 tonnes of non-reacted TBBPA, 210 tonnes of HBCDD, 29 000 tonnes of DEHP and 1.5 tonnes of beryllium oxide could be annually removed from EEE. The levels of presence of the current list of hazardous substances could also be reduced further. The impact assessment mentions that 50 000 tonnes of lead in cathode ray tubes, 4.3 tonnes of mercury in lamps and 2.8 tonnes of mercury in LCD panels are still put on the market every year. The Commission currently considers the substitution of these to be *"technically or scientifically impracticable or the positive impacts of substitution outweigh the benefits"* of banning them.

1.3 EMAS (ECO-MANAGEMENT AND AUDIT SCHEME)

The EMAS is a management tool for companies and other organisations to assess, report and improve their environmental performance. The voluntary scheme was launched in 1995 for manufacturing companies to participate in. Originally limited to companies in the industrial sector, it was opened in 2001 to all economic sectors (including the public and private services). In 2009 the EMAS Regulation was modified for the second time and is now referred to as the "EMAS III Regulation"⁹⁸.

EMAS registered sites are classified according to NACE codes, which represent the statistical classification of economic activities within the European Community. It is also interesting to note that every enterprise which has been certified with ISO 14 001 receives an EMAS certificate if it publishes an environmental declaration

⁹³ Arcadis Ecolas and RPA (2008) Study on RoHS and WEEE Directives. Study commissioned by the European Commission – DG ENTR.

⁹⁴ European Commission (2008) Impact Assessment – Commission staff working paper accompanying the Proposal for a Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) (recast). COM(2008) 810.

⁹⁵ Tetrabromobisphenol-A, a flame retardant

⁹⁶ Hexabromocyclododecane, a flame retardant

⁹⁷ Bis(2-ethylhexylphthalate), a PVC (poly-vinyl chloride) plasticiser

⁹⁸ Available at the website of the European Commission on EMAS: ec.europa.eu/environment/emas/index_en.htm

complying with EMAS criteria. EMAS integrates entirely the ISO 14 001 standard, but is more transparent as there is an obligation to communicate objectives and results.

Before certifying a company, an audit is carried out, assessing the organisation's environmental policy and actions taken under EMAS. The certification is awarded only if the organisation demonstrates that environmental impacts are considered through a global approach: from purchase to transportation, including products or services and sub-contractors and suppliers. This approach is notably interesting from a waste prevention point of view.

Contribution to material productivity

EMAS does contribute to resource efficiency. For example, the guidance on environmental reporting provides core indicators for environmental performance in the areas of energy efficiency, material efficiency, water, waste, biodiversity (land use) and emissions⁹⁹. Relevant to this study is material efficiency, which is a core indicator defined as the *“annual mass-flow of different materials used (excluding energy carriers and water), expressed in tonnes”*. Waste concerns both the *“total annual generation of waste, broken down by type”*, and the *“total annual generation of hazardous waste”* - both expressed by weight. As *“what gets measured, gets managed”*, demanding such quantified data raises awareness in organisations. EMAS certified organisations are motivated to reduce their environmental impacts and obtain better environmental performance each year. According to a study on the cost and benefits of EMAS to registered organisations¹⁰⁰, the most positive impact of EMAS registration was energy and resource savings. Across the range of different organisation sizes, it was estimated that 2% - 10% material¹⁰¹ savings were achieved with EMAS through more efficient use of resources and more efficient production techniques.

1.4 ETAP (ENVIRONMENTAL TECHNOLOGIES ACTION PLAN)

The Environmental Technologies Action Plan (ETAP)¹⁰² was adopted by the European Commission in January 2004 to boost eco-innovation, growth and sustainable development. The rationale was to overcome the numerous barriers that hinder the development of eco-technologies to foster their use and improve European competitiveness in this area. This is being achieved through a series of measures to promote eco-innovation and the take-up of environmental technologies.

Three areas are given priority: getting from research to markets, improving market conditions, and acting globally. ETAP is meant to support the EU environmental

⁹⁹ EMAS Regulation, Annex 4, C), 2), a), iv), p. 37

¹⁰⁰ Milieu & RPA (2009) Study on the Costs and Benefits of EMAS to Registered Organisations. Study commissioned by the European Commission, DG Environment.

¹⁰¹ Estimates of energy savings were provided separately in the report, so the stated resource savings is assumed to be material savings.

¹⁰² ETAP website: ec.europa.eu/environment/etap/index_en.html

objectives including those related to waste and resource efficiency. Although recycling dominates when it comes to environmental technologies related to waste and resource efficiency, waste prevention and reuse are also included in the scope of ETAP. This can also be observed in the Commission's Lead Market Initiative¹⁰³, where recycling has been identified as one of six important sectors, where actions should be made to lower barriers to bring innovative products and services to the market. Here again waste prevention and reuse is included in the scope, but they play a minor role compared to recycling.

Contribution to material productivity

Reports on the progress of ETAP¹⁰⁴ and the Lead Market Initiative¹⁰⁵ do state the potential for developing and diffusing resource efficiency technologies, but no concrete or qualitative evidence is provided. Eco-innovation and eco-technologies can therefore be regarded as indirect ways of achieving waste prevention; however no specific contributions to waste prevention have been identified.

1.5 WASTE PREVENTION POLICIES IN MS

There are many waste prevention policies and initiatives in EU member states¹⁰⁶, hereafter are summarised two illustrative examples:

France's Grenelle I Law

In addition to EU policies, different MS have taken steps to include specific waste prevention measures in their national legislation. The law derived from France's Grenelle de l'environnement is an example of such a measure¹⁰⁷. The Grenelle I law was introduced in July 2010, outlining specific targets for waste recovery and prevention. Within this new law, a specific objective of 7% reduction of Municipal Solid Waste (MSW) per inhabitant was set, to be achieved in 5 years. As MSW is often composed of varied material types, this policy could lead to the reduction of waste in various streams. To consider the potential reduction by material type, the composition of MSW must first be considered.

UK Waste Strategy

In 2007, the UK government introduced the National Waste Strategy which proposes specific targets for waste prevention. The strategy calls for the amount of household

¹⁰³ Lead Market Initiative: Website: ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative/index_en.htm#h2-1

¹⁰⁴ European Commission (2007) Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Report of the Environmental Technologies Action Plan (2005-2006), COM(2007) 162.

¹⁰⁵ European Commission (2009) Lead Market Initiative for Europe - Mid-term progress report. Commission staff working document. SEC (2009) 1198.

¹⁰⁶ ec.europa.eu/environment/waste/prevention/practices.htm;
scp.eionet.europa.eu/facts/factsheets_waste/2009_edition/wasteprevention

¹⁰⁷ LOI n° 2009-967 du 3 août 2009 de programmation relative à la mise en œuvre du Grenelle de l'environnement (1)

waste not re-used, recycled or composted, to be reduced from over 22.2 Mt in 2000 to:

- 15.8 Mt by 2010 (29%)
- 12.2 Mt by 2020 (45%)

If these targets are reached, this would be equivalent to a fall of 50% of waste produced per person by 2020 (from 450kg to 225kg). It is not clear at present whether 2010 targets have been reached.

It is worth noting that the UK's per capita production of waste is much higher than that of France, at 786 kg per capita and 401 kg per capita, respectively. As France's per capita production of waste is much closer to that of the European average (417 kg per capita), it has been assumed that the scaling up the 7% reduction figure of MSW would be feasible across Europe. Applying this figure amounts to total savings of 18.2 Mt of materials.¹⁰⁸

1.6 VOLUNTARY WASTE PREVENTION AGREEMENTS

A voluntary agreement is a common agreement among industry actors (manufacturers, distributors, retailers, consumers, etc.) to achieve a certain objective. As an alternative or complementary to legislation, they can be an effective measure to directly influence the quantity and the nature of waste generated and the pressure caused by it.

Courtauld Commitment, UK

The Courtauld Commitment¹⁰⁹ in the UK is an example of a successful voluntary agreement that has had an enormous impact on waste prevention. This voluntary agreement was made between manufacturers, retailers and packaging associations led by WRAP (Waste & Resources Action Programme) in order to improve resource efficiency and reduce the wider environmental impact of the grocery retail sector. Over 40 major retailers, brand owners, manufacturers and suppliers have signed the agreement since its launch in July 2005. The retailers represent 92% of the UK's grocery supermarkets. In a first phase from 2005 to 2009, the Courtauld Commitment set itself three targets:

- to reduce packaging waste growth by 2008;
- to help reduce the amount of food the nation's householders throw away by 155,000 t by 2010, against a 2008 baseline; and,
- to deliver absolute reductions in packaging waste by 2010.

¹⁰⁸ Estimates of amounts and composition based on Arcadis, VITO, Umweltsbundesamt, BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study commissioned by the European Commission, DG Environment.

¹⁰⁹ www.wrap.org.uk/retail/courtauld_commitment/

The first two targets were achieved: zero growth of packaging waste was achieved in 2008, and there was a reduction of 270,000 t less food waste in 2009/10 than in 2007/08. The target to reduce the amount of packaging waste over the same period was not achieved. Total amounts of packaging in the UK remained at approximately 2.9 Mt between 2006 and 2009. The main reason behind this was a 6.4% increase in grocery sales volumes since the agreement began in 2005. In total during the Commitment's first phase from 2005 to 2009, 670,000 t of food waste and 520,000 t of packaging have been prevented across the UK.

It is remarkable that the participants in the Commitment noted that there were only positive effects, as no loss of quality or protection nor economic detrimental effect (sales either remained the same, or they even increased) were observed. Furthermore, life-cycle benefits emerged in terms of carbon emissions reduction due to the fact that more products were transported at the same time and thus less transport was needed. The Phase 2 of the Courtauld Commitment sets new targets for 2012:

- to reduce the weight, increase recycling rates and increase the recycled content of all grocery packaging, as appropriate. Through these measures the aim is to reduce the carbon impact of this grocery packaging by 10%.
- to reduce UK household food and drink waste by 4%.
- to reduce traditional grocery product and packaging waste in the grocery supply chain by 5% - including both solid and liquid wastes.

Nevertheless, the efficiency of these measures needs to be carefully considered. Rebound effects must be taken into account. The savings from less transport could induce retailers to sell and transport more. On the other hand participants have a financial interest in using less material to produce packaging, as this translates into less production costs.

“No thank you to adverts and free papers”, Denmark

In Denmark, the industry actors and the Danish Consumer Agency agreed to respect a “No thank you to adverts and free papers” scheme.¹¹⁰ Consumers can register themselves at the post office and by putting an official “No thank you” sticker on their letterbox, distributors agreed not to deliver ‘unaddressed’ adverts and newspapers to registered households. So far more than 570,000 households¹¹¹ have registered themselves under the scheme (in 2007 this corresponded to over 16% of the population)¹¹². Although there are still cases of unwanted adverts and newspapers delivered, there is a general satisfaction of the scheme among consumers according to a recent poll¹¹³. It has been such a success that a large

¹¹⁰ www.forbrug.dk/Artikler/Dine-rettigheder/Forbrugerguides/Reklamer-og-gratisavisser/generelt?tc=95DF6769B9D041129773A5AC53308CA2

¹¹¹ ulrikhorneman.dk/Reklamer%20NEJ%20TAK%20Udredende%20artikel.pdf

¹¹² www.dr.dk/Nyheder/Penge/2007/07/11/060820.htm

¹¹³ www.forbrugeraadet.dk/nyheder-alle/evaluering-af-ordningen-nej-tak-til-adresselorsendelser/

portion of consumers think that all households should by default not receive unwanted adverts and newspapers, but register only if they want to receive them.

The influences of policies and voluntary agreements on the prevention of waste generation can be radically different at each phase of the life cycle of a product (raw material extraction, production, distribution, consumption and end-of-life). To assess the effectiveness of waste prevention measures in each phase and thus on material productivity, it is necessary to break the analysis of waste generation factors down into key elements of the supply chain. In the following section, the main types of waste prevention measures are presented and existing studies are reviewed in order to assess their contribution in terms of material savings. It must nevertheless be kept in mind that all these different approaches to waste prevention are often closely linked, and that the effectiveness of each of them depends on the others.

2. THE POTENTIAL OF WASTE PREVENTION APPROACHES

2.1 LEAN PRODUCTION

The main idea of Lean Production (or Lean Manufacturing)¹¹⁴ is the systematic elimination of waste by focusing on production costs, product quality, delivery, and employee involvement.

Effects of industrial case studies

There are several case studies¹¹⁵ that show that lean production approaches has resulted in dramatic raw material savings, e.g. decreased scrap and defect rates, elimination of lubricants, less packaging needed, etc.

Examples of the effects of lean production

In the UK, the Toyota Motor Corporation has taken concrete steps towards the reduction of waste in vehicle production. Toyota UK (TMUK) has demonstrated a 60% reduction of waste produced per vehicle¹¹⁶. In this case, it is not clear exactly what waste types may have been prevented, or how this has been achieved.

Under the term 'Resource Management' 50 of General Motors' (GM) plants have realised a 20% reduction in overall waste generation (30,000 tonnes), a 60% decrease in disposal, and a 30% decrease in waste management costs. Individual assembly plants have reported greater than 25% reduction in waste per vehicle.¹¹⁷

¹¹⁴ US EPA (2000) Pursuing Perfection: Case Studies Examining Lean Manufacturing Strategies, Pollution Prevention, and Environmental Regulatory Management Implications.

¹¹⁵ Mollenkopf, D., Stolze, H., Tate, W.L. & Ueltschy, M. (2010) Green, lean, and global supply chains, International Journal of Physical Distribution & Logistics Management, Vol. 40 No. 1/2.

¹¹⁶ University of Cambridge (2008) Towards a sustainable industrial systems

¹¹⁷ US EPA (2009) "Green Servicizing" for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

A recent study on regional efforts of increasing resource efficiency in manufacturing firms in North Rhine-Westfalia, Germany estimated that approximately 5-10% material savings could be made in the metal processing industry¹¹⁸.

Estimates of material productivity potential for lean production approaches

In the “quick win scenario” - “defined as being relatively easy to implement as they do not require additional costs or major technology and or cultural shifts” - in the WRAP study¹¹⁹ on resource efficiency strategies, it was estimated that lean production could lead to 15% decrease in material requirement to produce the same good. Furthermore, considering the 2-10% material savings achievable through environmental management systems such as EMAS, and the 5-10% estimated in the North Rhine-Westfalia case study, it would seem feasible that both the manufacturing and construction industries have the potential to reduce its waste production with at least 10% without reducing the quality or quantity of its output. As lean production is already best practice in many manufacturing companies, it is assumed that it already contributes to approximately 2% waste reduction.

2.2 REUSE

Reuse and the related strategies are often mentioned as waste prevention approaches. These are different from recycling because they involve preserving the whole or parts of products. **Example of the effects of refurbishment**

Green-Works¹²⁰ in the UK refurbishes and repairs unwanted furniture and then resells or donates the furniture to charities and social organisations. According to the company’s website, it has so far diverted over 60,000 t of furniture (including recycling) from the landfill.

Charity recycling has grown into a sizeable business. In 2006, mobile phone recyclers and remanufacturers estimated that they received about 1% of the phones that were discarded globally.¹²¹

Example of the effects of remanufacturing

A study¹²² on Fuji Xerox claims that their take-back and remanufacturing system has resulted in material savings of 25% for a certain type of non-modular (not designed for disassembly and remanufacture) photocopier and 49% in a modular (designed

¹¹⁸ COWI (2010) Economic Analysis of Resource Efficiency Policies. Study commissioned by the European Commission, DG Environment.

¹¹⁹ WRAP (2009) Meeting the UK climate change challenge: The contribution of resource efficiency. WRAP Project EVA128. Report prepared by Stockholm Environment Institute and University of Durham Business School.

¹²⁰ Green-Works. www.green-works.co.uk/pages/what-we-do-and-why.html

¹²¹ US EPA (2009) “Green Servicizing” for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

¹²² Kerr, W. & Ryan (2001) Eco-efficiency gains from remanufacturing - A case study of photocopier remanufacturing at Fuji Xerox Australia. Journal of Cleaner Production. Vol 9, pp. 75–81.

for disassembly and remanufacture) model. In the study the types of materials were not specified.

In the US, an estimated 14 Mt of raw material (unspecified) are saved annually through remanufacturing, whilst costing 30-50% of the product's new price¹²³. A single company managed to save 60,000 t of discarded auto parts by remanufacturing in 2009. One specific example of remanufacturing in the auto industry is the re-treading of used tires.¹²⁴ According to the European Tyre and Rubber Manufacturers' Association (ETRMA)¹²⁵, 95% of end-of-life tyres are recovered with about 11% being retreaded.

Examples of the potential of reuse in the construction industry

Regarding the construction industry, there are claims that the 'deconstruction' or the reuse of salvaged materials, could reuse up to 37% of materials embodied in end-of-life structures.¹²⁶ One study has estimated that in the UK, of the 120 Mt of waste generated annually, at least 10 Mt could be reused¹²⁷. This amounts to 8.3% potential waste prevention.

More specifically, recent research by WRAP puts the volume of waste timber generated annually in the UK at around 4.5 to 4.6 Mt. Of this amount, approximately 1.8 Mt of waste timber is currently being diverted from the waste stream (approximately 40%). Some figures show that around 10% of the timber waste coming out of the building industry is reusable – that could be as much as 460,000 t every year in the UK alone¹²⁸.

As a special case of reuse, communal programs such as bicycle sharing schemes (e.g. JCDecaux¹²⁹) and car-sharing systems (e.g. Streetcar¹³⁰) are good examples of how sharing can lead to the need for fewer products and ultimately less waste generated. If communal use deters individuals from purchasing their own products, demand for new products falls, and thus the need for materials is lowered on a general scale. Less need for related infrastructure (e.g. roads, parking spaces, etc.) also has an effect on the wider need for other materials, besides the fact that users of sharing transport systems also tend to use public transport options more.

¹²³ Cardone (2010) The best kept secret to US economic growth: Remanufacturing.

www.cardone.com/English/Club/employee/upload/Best%20Kept%20Secret_07.pdf

¹²⁴ US EPA (2009) "Green Servicizing" for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

¹²⁵ www.etrma.org/public/activitiesoflftrenf.asp

¹²⁶ US EPA (2009) "Green Servicizing" for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

¹²⁷ Bioregional (2008) Pushing Reuse : Towards a low-carbon construction industry

¹²⁸ www.communitywoodrecycling.org.uk/woodwaste.htm

¹²⁹ JCDecaux - Cyclocity® installed in 67 cities including Paris (Vélib') and Brussels (Villo!):

www.jcdecaux.com/en/Innovation-Design/Cyclocity-R

¹³⁰ Streetcar – a self-service pay-as-you-go car in the UK: www.streetcar.co.uk/

Example of the effects of car sharing

According to a study from the US EPA¹³¹, every car in a car sharing systems ‘remove’ between 6 and 23 vehicles from the road (Streetcar claims that one shared car fulfils the need of 26 users) as users tend to sell their own car or choose not to buy one. One car sharing system, Flexcar, estimated that as of 2005, it had ‘removed’ 7,000 vehicles from the road and eliminated the need for 21,000 parking spots (corresponding to 70,000 t of concrete).

It is assumed that with less vehicles being produced, the number of vehicles sent for disposal or reprocessing also is also reduced. However, sharing can have the negative effect of potentially accelerating product deterioration (and therefore the need for extra maintenance or repair). Ownership can lead to increased maintenance and responsible use of items, as the costs of repair fall directly upon the owner, providing an incentive to keep equipment in good working order. The renting and leasing of goods (e.g. DIY tools, professional equipment, skis, etc.) are also examples of communal use which could lead to lowered material consumption. Similar to other sharing schemes, however, deterioration can occur at a faster rate, leading to increased need for repair, or earlier replacement.

In order to prolong product life, preventive maintenance can reduce deterioration over time and prolong a product’s life. Preventive maintenance refers to servicing products regularly by monitoring product performance, in order to determine and repair faults at an earlier stage to ensure it stays in good working condition and that it is used appropriately. A good example of this is wood products, which require repainting or refinishing at regular intervals to prevent moisture or ultraviolet damage and wear.

Reuse through leasing, preventive maintenance and remanufacture can also be combined to create new business models for offering services instead of products. This is seen in diverse areas, such as office equipment¹³², construction equipment¹³³ and airplane engines¹³⁴. Under the terms ‘servicising’ or ‘product/service-systems (PSS)’¹³⁵, these approaches refer to the provision of services and the performance of products rather than the ownership of goods.

Such approaches are even applicable in the chemical industry, where ‘chemical management systems (CMS)’ have shown the potential to provide a more efficient use of chemicals, paints and lubricants. CMS is a *“strategic, long-term relationship in which a customer contracts with a service provider to supply and manage the*

¹³¹ US EPA (2009) “Green Servicizing” for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

¹³² Steelcase - Office furniture through leasing and management services: www.steelcase.co.uk/en/services/pages/ecoservices.aspx

¹³³ Caterpillar – equipment rental and remanufactured products www.cat.com/cda/layout?m=94942&x=7

¹³⁴ Rolls-Royce – complete engine management: www.rolls-royce.com/civil/services/corporatecare/index.jsp

¹³⁵ Tukker, A. & Tischner, U. (eds) (2006) New Business for Old Europe. Product-Service Development, Competitiveness and Sustainability. Greenleaf Publishing.

customer's chemicals and related services. Under a CMS contract, the provider's compensation is tied primarily to quantity and quality of services delivered not chemical volume. CMS goes beyond invoicing and delivering product to optimizing processes, continuously reducing chemical lifecycle costs and risk, and reducing environmental impact.”¹³⁶ Several case studies^{137,138} have shown that CMS can achieve material savings such as those listed in the following box:

Examples of savings achieved through CMS¹³⁹

- Extending the lifetime of fluids and reducing fluid waste with 90% (Houghton)
- 30% reduction of costs, 54% reduction in quantity of purge solvent, 77% reduction in quantity of paint stripper, 80% reduction in quantity of solvent masking and 75% reduction of emissions of VOC (GM Oshawa & Haas Corp.)
- 50% reduction in quantity of annual chemical consumption, reduction of hazardous waste 8% in 2 years (Nortel)
- 10–20% net savings in costs the first 2 years, reduction in scrap rates by 250%, 71% reduction in paint waste (Raytheon Systems Company/Radian International LLC)
- coolant use reduction by >50% of quantity, coolant waste reduction by 90% (Navistar engine plant/Castrol Industrial North America)
- over USD 1 million in savings, 8% decrease in chemical costs per vehicle, 50% reduction in quantity of paint use, 78% reduction in paint inventory (General Motors Truck and Bus Plant/BetzDearborn)
- Net savings in excess of USD 2.5 million, 30% reduction in chemical costs, eliminated inventory waste, generating \$250,000 annual savings, shelf-life-related losses reduced by 75% (Delta Air Lines and Interface LLC)
- 35–40% reduction of chemical quantity in finishing operation, reduction of VOC emissions by 50% (Ford-DuPont CPU program)

Estimates of material productivity potential for reuse strategies

Through the examples of reuse strategies – including second hand sales, remanufacturing and servicing – provided above, it would seem that some of these practices are already common and widespread. Although hard to quantify, a conservative estimate could be that already 2% of the waste from manufacturing is currently avoided due reuse in some or another form and reduces the need for new materials.

According to the WRAP study on resource efficiency, a third of all products thrown away are still in working order. For the “quick win” scenario, the WRAP study estimates that the discard rate for products can be reduced by a third (lifetime optimisation) and by increasing the durability of products households may reduce

¹³⁶ CMS Forum website, www.cmsforum.org

¹³⁷ US EPA (2009) “Green Servicizing” for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

¹³⁸ COWI (2008) Promoting Innovative Business Models with Environmental Benefits. Study commissioned by the European Commission, DG Environment.

¹³⁹ US EPA (2009) “Green Servicizing” for a More Sustainable US Economy: Key concepts, tools and analyses to inform policy engagement.

their consumption on non-consumable goods by 10% (restorative economy). Furthermore, 15% of the raw materials that become waste in industry and commerce can be eliminated (waste reduction) and 10-20% reduction of products are possible through servicising (goods to services).

2.3 SUSTAINABLE CONSUMPTION BEHAVIOUR

Sustainable behaviour orients individual consumption not just towards more environmentally efficient solutions, but also towards sufficiency. In 2008, the public waste agency of Flanders (OVAM) presented the results of a study¹⁴⁰ on innovative instruments towards environmentally responsible production and consumption. Table 51: sums up the instruments and instruments packets studied and their indicative assessment. Among these instruments, those which have been identified as economic instruments (discount coupon campaigns, promotional campaigns, internalisation of environmental costs, green means of payment, and savings cards) appear to be the most relevant in terms of effectiveness and cost effectiveness (see instruments 7 to 11).

Table 51: Summary of indicative assessments (scores) according to OVAM study¹⁴⁰

Instruments (1 to 14) and instrument packets (15 to 18)	Effectiveness	Cost-effectiveness	Degree of experience
1 Environmental info – labelling and EPD	+ + - - -	+ + - - -	+ + + - -
2 Quality marks	+ + - - -	+ + - - -	+ + + + -
3 In store marketing, publicity and lead system	+ + + - -	+ + + - -	+ + + + +
4 Marketing, publicity and sensibilisation outside the store	+ + - - -	+ + - - -	+ + + + +
5 Theme stores	+ + + - -	+ + + - -	+ + + + -
6 Facilitating self-regulation by consumers	+ + + - -	+ + - - -	+ + + - -
7 Discount coupon campaigns	+ + + + -	+ + + - -	+ + + + -
8 Savings card	+ + + - -	+ + - - -	+ + - - -
9 Promotional campaigns	+ + + - -	+ + + - -	+ + + + +
10 Internalisation of environmental costs	+ + + - -	+ + + + -	+ + - - -
11 Green means of payment	+ + + + -	+ + + + -	+ + - - -
12 Covenants between government and distribution	+ + + + -	+ + - - -	+ + - - -
13 Collective consumer agreements	Too recent	Too recent	+ - - - -

¹⁴⁰ OVAM (2008) Analysis of innovative environmental policy instruments towards the realisation of environmentally responsible production and consumption.

Instruments (1 to 14) and instrument packets (15 to 18)	Effectiveness	Cost-effectiveness	Degree of experience
14 Facilitating self-regulation by businesses	++++-	+++--	+++--
15 Energy label	++++-	++---	0
16 Achats futés, déchets limités (Thoughtful purchases-Limited waste))	+++--	++---	0
17 Milieu op de Kaart (savings card)	+++--	++---	0
18 Covenant market development biological farming	+++--	++---	0

As these instruments incite consumers to consume less and do it in a greener way, they do have an impact in terms of qualitative waste prevention through the use of more environmentally friendly products and in terms of quantitative waste prevention through a life-cycle approach. From the analysis of policy instruments it seems that it is easier to achieve waste prevention through financial dissuasive instruments on non-environmentally-friendly products (internalisation of environmental costs, etc.) than through financial incentives (which incite to purchase cleaner products rather than discourage consumption) .

Experiences with limiting the consumption of plastic bags

Denmark has had a weight-based levy on plastic carrier bags since 1994 (and also on disposable tableware since 1988)¹⁴¹. Before the levy was introduced the Danes used over 700 million plastic bags each year, this was drastically reduced to 300 million (approx. 55% reduction) with the levy, but it has since increased to 450 million (approx. 35% reduction) in 2007¹⁴².

In Ireland, a fee for the use of plastic bags, known as the Plastax, was introduced in 2002. Under the scheme, individuals must pay a fee of 15c per plastic bag consumed at check out. This scheme has since been very successful, resulting in a 90% drop in consumption, and approximately one billion fewer bags consumed annually¹⁴³.

Communication instruments can have an impact on all life phases of products and can support both qualitative and quantitative waste prevention. Nevertheless, they should not operate on their own: it is a supportive and horizontal instrument that needs to be linked to other policies to be fully effective¹⁴⁴. For example, being informed that a certain substance is hazardous is not useful, as long as it is

¹⁴¹ Danish EPA (2009) Regerings Affaldstrategi 2009-12. 1. delstrategi.

¹⁴² www.politiken.dk/tjek/tjekmad/tjekmadartikler/ECE653682/vi-oedsler-med-plastikposer;www.greenstyle.dk/shop/cms-1.html

¹⁴³ Reuseit. The PlasTax - Ireland's Plastic Bag Fee. Available at : www.reuseit.com/learn-more/top-facts/about-irelands-plastax

¹⁴⁴ Defra (2010) Understanding and influencing behaviours : a review of social research, economics and policy making in Defra. Draft paper for discussion.

impossible to verify the presence of this substance in the packaging of a product. It is important that the actions are followed through.

Moreover, these two communication tools do not have the same impact according to the targeted audience. When influencing the producers (and more generally all economical actors), financial arguments are more likely to lead to greater waste prevention oriented behaviour. Making SMEs aware of the real amount of money they could save by choosing prevention, for example by emphasising ‘hidden costs’, is particularly efficient. Alternatively, awareness raising and educational measures have various impacts on the consumers.

Education seems to have more impacts than raising awareness as it mainly applies to education at school and seminars, where people that receive the information are interested in applying it as well. Contrarily it appears that awareness campaigns have little impact - at least when not reiterated frequently - as consumers often have habits which are hard to change. Moreover, the sensitisation campaigns dealing with waste prevention often put more stress on reuse and quantitative waste prevention than on qualitative waste prevention.

Case: “Love Food, Hate Waste” waste reduction campaign

An example of a successful waste reduction awareness campaign is the WRAP’s ‘Love Food, Hate Waste’ campaign. WRAP worked with the UK grocery sector, food industry, government and organisations such as the Food Standards Agency, to develop practical solutions and improved communications to make it easier for consumers to get the most from the food they buy, and to waste less of it. The practical advice provided included: a meal planner and a portion calculator; tips for good storage of food; and, recipes for cooking with leftovers. Since its launch in 2008, the campaign claims to have prevented 137,000 tonnes of food waste, thereby achieving a nearly 3% reduction in avoidable household food waste (or 1.8% of total food waste) throughout the UK over a one year period¹⁴⁵.

In some cases however, the effectiveness of awareness campaigns has not been clearly demonstrated as experienced in the WRAP study on the “Choose to reuse” trial in UK¹⁴⁶. In an effort to cut down on the number of free carry bags used at the check-out, this campaign aimed at encouraging people to take a bag with them when they went shopping. The study was carried out in order to see whether consumers could be persuaded to use fewer free carry bags on their shopping trips by encouraging them to reuse bags instead. The campaign was inconclusive regarding whether such techniques, used over the timeframe of only 10 weeks, could be sufficient to change significantly consumer habits. It appears that the success of awareness campaign is dependent on its frequency.

¹⁴⁵ Love Food Hate Waste: www.lovefoodhatewaste.com; WRAP (2009) *Household Food and Drink Waste in the UK*, United Kingdom

¹⁴⁶ WRAP, Research Report: *The “Choose to Reuse” trial – testing an approach to reducing carrier bag waste*, June 2006, www.wrap.org.uk/retail/case_studies_research/report_choose_to.html

Estimates of material productivity potential for sustainable consumption behaviour

Given the case study examples provided above, there seems to be evidence that material savings can be achieved through changing consumption behaviour. According to WRAP's 2009 report on "Household Food and Drink Waste in the UK"¹⁴⁷, the amount of food¹⁴⁸ wasted per year is 25% of that purchased (by weight). A similar US study found that on average 14% of household purchases becomes food waste.¹⁴⁹ An Austrian study¹⁵⁰ on food waste estimated that about 8% of food waste in Austria can be prevented, and by reducing the (over)consumption of food a further 8% of the food produced could be avoided. While food wasted as a percentage of food purchased could vary across MS, WRAP's data appears to provide the most robust estimation of this value for the EU. WRAP estimates that of the food waste generated in the UK, 19% is 'truly avoidable', and 61% is 'avoidable'.¹⁵¹ Another WRAP study¹⁵² estimates that it is possible to halve edible food waste from households in the UK between 2010 and 2020, while dietary changes can reduce meat and dairy consumption by 25% by 2020.

Food waste

Table 52: Food waste generation in manufacturing, household, wholesale/retail and food service sectors: Best estimate for all sectors using available data¹⁵³

Sector	Food waste tonnes/yr in EU-27	Food waste ¹⁵⁴
Manufacturing	34 800 000	37 300 000
Households	37 700 000	35 520 000
Retail/Wholesale	3 800 000	
Food Service	12 300 000	
Total	89 000 000	

Source: based on EUROSTAT 2006 data and national data from 2006, 2007, 2008, 2009

¹⁴⁷ WRAP (2008) The food we waste - A study of the amount, types and nature of the food we throw away in UK households.

¹⁴⁸ Including liquid and solid foods but excluding drink

¹⁴⁹ Foodproductiondaily.com, 'Half of US food goes to waste': www.foodproductiondaily.com/Supply-Chain/Half-of-US-food-goes-to-waste

¹⁵⁰ Lackner, M. (2008) Sozialökologische Dimensionen der österreichischen Ernährung. Eine Szenarienanalyse; Social Ecology Working Paper 103, Vienna.

¹⁵¹ WRAP (2009) Household Food and Drink Waste in the UK

¹⁵² WRAP (2009) Meeting the UK climate change challenge: The contribution of resource efficiency. Report prepared by Stockholm Environment Institute and University of Durham Business School.

¹⁵³ BIO Intelligence Service, AEA, Umweltsbundesamt (2010) Preparatory study on food waste across EU-27. Study commissioned by the European Commission, DG Environment.

¹⁵⁴ Arcadis, VITO, Umweltsbundesamt, BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study commissioned by the European Commission, DG Environment.

Composition of MSW waste

Table 53: Composition of Municipal Solid Waste and Household Waste¹⁵⁵

Material type	Municipal Solid Waste composition ¹⁵⁶	Municipal Solid Waste composition ¹⁵⁷	Household waste composition ¹⁵⁸	UK, municipal waste ¹⁵⁹	Composition of MSW of specified groups of Member States ¹⁶⁰		
Food	30%	25%	29%	17.84%	36 %	36%	33%
Garden waste	7%			14.08%			
Other organic				1.73%			
Paper and board	20%	35%	26%	22.69%	18 %	17%	10%
Plastics	13%	11%	9%	9.99%	6%	7%	9%
Glass	6%	6%	7%	6.64%	6%	4%	8%
Metals	4%	2% ferrous, 1% aluminium	4%	4.30%	2%	4%	2%
Nappies and what they contain/Sanitary	4%			2.51%			
Textiles	3%	2%	5%	2.83%	2%	3%	4%
Wood				3.73%			
WEEE				2.19%			
Hazardous				0.53%			
Furniture				1.34%			
Mattresses				0.25%			
Other combustible	3%			2.37%			
Rubble and non-combustible	3%			2.82%	14 %	17%	21%
Soil				0.18%			
Specials			1%				
Composites			1%				
Other	7%	18%	18%	3.98%	16 %	12%	13%

¹⁵⁵ BIO Intelligence Service, AEA, Umweltsundesamt (2010) Preparatory study on food waste across EU-27. Study commissioned by the European Commission, DG Environment.

¹⁵⁶ Parfitt, J. (2009) Taking out the rubbish: Municipal waste composition, trends & futures.

¹⁵⁷ Laetitia Reynaud, L. (2010) The performances of collection and recycling of organic waste in Europe. European Federation of Waste Management and Environmental Services

¹⁵⁸ Association of Cities and Regions for Recycling and sustainable Resource management (ACR+)

¹⁵⁹ Resource Futures (2009) Municipal Waste Composition: A review of Municipal Waste Component Analyses. Report for Defra, UK.

¹⁶⁰ Arcadis, VITO, Umweltsundesamt, BIO Intelligence Service (2010) Analysis of the evolution of waste reduction and the scope of waste prevention. Study commissioned by the European Commission, DG Environment.

A 2009 Arcadis study¹⁶¹ reports that in countries as different as Belgium and Bulgaria the share of bio-waste in municipal waste is as similar as 35.9% and 33.5%, respectively. The study also claims that on the basis of the data gathered from the Member States, food waste constitutes a significant proportion of the household and municipal waste streams. In very few cases is the proportion of food waste less than 20% of the total.

The recent study on food waste prevention suggests that a minimum scenario of food waste in municipal waste is 8.375%.¹⁶²

Table 54: Percentage of food wastes and by-products in different processes

Production process	% of wastes and by-products
Fish canning	30-65
Fish filleting, curing, salting and smoking	50-75
Crustaceans processing	50-60
Molluscs processing	20-50
Beef slaughtering	40-52
Pig slaughtering	35
Poultry slaughtering	31-38
Milk, butter and cream production	Negligible
Yoghurt production	2-6
Fresh, soft and cooked cheese production	85-90
White wine production	20-30
Red wine production	20-30
Fruit and vegetables juice production	30-50
Fruit and vegetables processing and preservation	5-30
Vegetable oil production	40-70
Corn starch production	41-43
Potato starch production	80
Wheat starch production	50
Sugar production from sugar beet	86

Source: Fuentes et. al. (2004) AWARENET: Agro-Food Wastes Minimisation and Reduction Network

¹⁶¹ Arcadis (2009) Assessment of the options to improve the management of bio-waste in the European Union.

¹⁶² BIO Intelligence Service, AEA, Umweltsbundesamt (2010) Preparatory study on food waste across EU-27. Study commissioned by the European Commission, DG Environment.

ANNEX E: ECODESIGN

1. ECODESIGN RELATED POLICIES

The following are the product groups that were studied for each policy:

Ecodesign product groups (Lots)

2006: 14 lots from DG TREN

- lot 1 Boilers and combi-boilers (*preparatory study completed*)
- lot 2 Water heaters (*preparatory study completed*)
- lot 3 Personal computers (*preparatory study completed*)
- lot 4 Imaging equipment (*preparatory study completed*)
- lot 5 Consumer electronics (TV) (*implementing measures in place*)
- lot 6 Standby and off-mode losses (*implementing measures in place*)
- lot 7 Battery chargers and external power supplies (*implementing measures in place*)
- lot 8 Office lighting (*implementing measures in place*)
- lot 9 (Public) street lighting (*implementing measures in place*)
- lot 10 Residential room conditioning appliances (*preparatory study completed*)
- lot 11 Electric motors 1-150 kW, pumps, circulators, fans (*implementing measures in place*)
- lot 12 Commercial refrigerators and freezers (*preparatory study completed*)
- lot 13 Domestic refrigerators and freezers (*implementing measures in place*)
- lot 14 Domestic dishwashers and washing machines (*preparatory study completed*)

2007: 6 lots from DG TREN

- lot 15 Solid fuel small combustion installations (*preparatory study completed*)
- lot 16 Laundry dryers (*preparatory study completed*)
- lot 17 Vacuum cleaners (*preparatory study completed*)
- lot 18 Complex set-top boxes (*preparatory study completed*)
- lot 19 Domestic lighting (*preparatory study completed*)
- + Simple set-top boxes (*implementing measures in place*)

2008: 7 lots from DG ENER

- lot 20 individual room heating
- lot 21 central heating (hot air)
- lot 22 ovens
- lot 23 hobs and grills
- lot 24 professional washing machines, etc.
- lot 25 coffee machines
- lot 26 network standby

2008: 3 lots from DG ENTR

- lot1 commercial refrigerators and freezers
- lot 2 transformers (power and distribution)
- lot 3 DVD players, video projectors, etc.

2009: 3 lots from DG ENTR

- lot 4 industrial furnaces and ovens
- lot 5 machine tools
- lot 6 air-conditioning and ventilation systems

Ecolabel

Table 55 provides the ecolabel criteria that were studied.

Table 55: Ecolabel criteria

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
Cleaning	All purpose cleaners and cleaners for sanitary facilities	Quaternary ammonium salts that are not readily biodegradable shall not be used	Packaging requirement: If the primary packaging is made of recycled material, any indication of this on the packaging shall be in conformity with the ISO 14021 standard	n.a.
	Detergents for dishwashing machines	The quantity of phosphonates that are not readily biodegradable (aerobically) shall not exceed 0.2 g/wash	Packaging: Cardboard primary packaging shall consist of at least 80 % recycled material.	n.a.
	Hand dishwashing detergents	Quaternary ammonium salts that are not readily biodegradable shall not be used	Packaging: The primary packaging, except for the cap, shall have a volumetric coefficient of packaging (VCP) less than or equal to 1.9. This criterion does not apply if the primary packaging is made up of 50 % or more recycled material. If the primary packaging is made of recycled material, any indication of this on the packaging shall be in conformity with the ISO 14021 standard	n.a.
	Laundry detergents	Quaternary ammonium salts that are not readily biodegradable shall not be used. Phosphonates (not readily biodegradable aerobically) shall not exceed 0.5 g/wash	Packaging: The cardboard packaging shall consist of at least 80 % recycled material.	n.a.
	Soaps, shampoos and hair conditioners	Packaging: must not contain additives based on Cd or Hg		n.a.
Clothing	Textile Products	n.a.	Textile fibre: The criteria set in this section for a given	n.a.

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
			<p>fibre-type need not be met if that fibre contributes to less than 5 % of the total weight of the textile fibres in the product. Similarly they need not be met if the fibres are of recycled origin.</p> <p>Processes and chemical: It accepted that recycled fibres may contain some of the dyes or other substances excluded by these criteria, but only if they were applied in the previous life-cycle of the fibres.</p> <p>Auxiliaries: At least 95 % (by dry weight) of the component substances applied to yarns shall be sufficiently biodegradable, or else shall be recycled.</p>	
	Footwear	There shall be no arsenic, cadmium and lead in the materials used for the product assembly or in the final product.	<p>Packaging: cardboard boxes used for packaging of footwear, shall be made of 100 % recycled material. Plastic bags used for the packaging of footwear shall be made of, at least, 75 % recycled material or they shall be biodegradable or compostable (as per EN 13432).</p> <p>User instruction: The following information (or equivalent text) shall be supplied with the product: - "When disposing of footwear, please use appropriate local recycling facilities where these are available."</p>	n.a.
Do it yourself	Paints and varnishes (indoor)	The following heavy metals or their compounds shall not be used as an ingredient of the product or tint (if applicable) (whether as a substance or as part of any preparation used): cadmium, lead, chromium VI, mercury, arsenic, barium (excluding	n.a.	n.a.

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
		barium sulphate), selenium, antimony. It is accepted that ingredients may contain traces of these metals up to 0.01 % (m/m) deriving from impurities in the raw materials.		
	Paints and varnishes (outdoor)	The following heavy metals or their compounds shall not be used as an ingredient of the product or tint (as applicable) (whether as a substance or as part of any preparation used): cadmium, lead, chromium VI, mercury, arsenic, barium (excluding barium sulphate), selenium, antimony. It is accepted that ingredients may contain traces of these metals up to 0.01 % (m/m) deriving from impurities in the raw materials.		n.a.
Electronic equipment	Personal computers	Plastic parts shall have no lead or cadmium intentionally added. Batteries shall not contain more than 0.0001 % of mercury, 0.001 % of cadmium or 0.01 % of lead by weight of the battery. The background lighting of the LCD monitor shall not contain more than 3 mg of mercury on average per lamp. Hazardous materials shall be separable.	Packaging shall meet the following requirements: (a) all packaging components shall be easily separable by hand into individual materials to facilitate recycling. (b) where used, cardboard packaging shall consist of at least 80 % recycled material. 90 % (by weight) of the plastic and metal materials in the housing and chassis shall be technically recyclable.	n.a.
	Portable computers	Criteria same as for "personal computers". In addition, the display of a personal data assistant (PDA) shall contain no mercury.	Criteria same as for "personal computers".	n.a.

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
	Televisions	<p>The total amount of mercury (Hg), in all lamps, per screen, shall be no greater than 75 mg for screens with a visible screen diagonal of up to and including 40 inches (101 cm). The total amount of mercury (Hg), in all lamps, per screen, shall be no greater than 99 mg for screens with a visible screen diagonal of greater than 40 inches (101 cm).</p> <p>Cadmium, lead, mercury, chromium 6 + or poly-brominated biphenyl (PBB) or poly-brominated diphenyl ether (PBDE) flame retardants, as listed in Article 4(1) of Directive 2002/95/EC of the European Parliament and of the Council [3], shall not be used in the television unless the applications of those substances are listed in the Annex to that Directive as exempted from the requirements of Article 4(1) of that Directive or unless their maximum concentration value is equal to or lower than the threshold specified in that same Annex. Regarding the Annex, for PBBs and PBDEs, the maximum concentration value shall be < 0.1 %.</p>	To facilitate dismantling: Plastic parts shall be of one polymer or be of compatible polymers for recycling and have the relevant ISO11469 marking if greater than 25 g in mass.	n.a.
Floor coverings	Wooden coverings	The product must not contain halogenated organic binding agents, azidirin and polyaziridins as well as pigments and additives based on:	Packaging must be made out of one of the following: <ul style="list-style-type: none"> - easily recyclable material, - materials taken from renewable resources, 	n.a.

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
		- lead, cadmium, chrome (VI), mercury and their compounds, arsenic, boron and copper, organic tin.	- materials intended to be reusable. Post-consumer wood, chips or fibres applied in the production of wood-based materials (input), shall at least comply with the provisions in the EPF industry standard.	
	Textile coverings	The concentrations of the following metals shall not exceed the following values: Hurdle value for the substance (in ppm): Antimony (0.5), Arsenic (0.5), Lead (0.5), Cadmium (0.1), Chromium (1.0), Cobalt (0.5), Copper (2.0), Nickel (1.0), Mercury (0.02), Dyes and pigments containing lead (Pb), cadmium (Cd), mercury (Hg) or chromium (chromium total) or Cr(VI) as ingredients of the dyeing component must not be used to dye the materials: The limit value for the total heavy metal content of a fitted carpet is 100 mg/kg.	n.a.	n.a.
	Hard floor coverings	Where lead, cadmium and antimony (or any of their compounds) are used in the glazes, their content shall not exceed the following specific limits (% in weight of the glazes): Lead (0.5), Cadmium (0.1), Antimony (0.25)	Raw material extraction: there shall be a waste water recovery closed system for avoiding sawing waste dispersion to the environment and to feed the recycling loop. After clearing, water shall be recycled. Production process: The waste water produced by the processes included in the production chain shall reach a recycling ratio of at least 90 %. Packaging: Paperboard used for the packaging of the final	n.a.

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
			product should be designed for reuse or be made out of 70 % recycled materials.	
Furniture	Wooden furniture	<p>Criteria same as for “Wooden coverings”.</p> <p>Also, the limit values of elements and substances allowed in recycled wood fibres for the production of wood-based materials include (in mg/kg recycled wood-based material) as Arsenic (25), Cadmium (50), Chromium (25), Copper (40), Lead (90), Mercury (25), Fluorine (100), Chlorine (1000), Pentachlorophenol (5) and Tar oils (0.5).</p>	<p>The product must be easily recyclable. A detailed description of the best ways to dispose of the product (reuse, recycling, take back initiative by the applicant, energy production) shall be given to the consumer, ranking them according to their impact on the environment. Packaging must fulfil the following requirements:</p> <p>(i) Made out of one of the following:</p> <ul style="list-style-type: none"> - easily recyclable material; - materials taken from renewable resources; - materials intended to be reusable, such as textile coverings. <p>(ii) All materials shall be easily separable by hand in recyclable parts consisting of one material (e.g. cardboard, paper, plastic, textiles).</p>	n.a.
Gardening	Growing media	<p>In the organic growing medium constituents, the content of the following elements shall be lower than the values shown below, measured in terms of dry weight (mg/kg):</p> <p>Zn (300), Cu (100), Ni (50), Cd (1), Pb (100), Hg (1), Cr (100), Mo (2), Se (1.5), As (10) and F (200) Note: These limit values are valid unless national legislation is more strict.</p>	The applicant shall demonstrate that at least 50 % by volume of the growing media waste is recycled after use.	These criteria aim in particular at promoting the use of renewable materials and/or recycling of organic matter derived from the collection and/or processing of waste material and the minimisation of environmental impact in retrieval and production of non-renewable

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
				materials.
	Soil improvers	In the final product, the content of the following elements shall be lower than the values shown below, measured in terms of dry weight (mg/kg dry weight): Zn (300), Cu (100), Ni (50), Cd (1), Pb (100), Hg (1), Cr (100), NB: These limit values are valid unless national legislation is more strict.	n.a.	These criteria aim in particular at promoting the use of renewable materials and/or recycling of organic matter derived from the collection and/or processing of waste material
House hold appliances	Light bulbs	Mercury content of the light bulbs: • Single-ended: Hg < 4 mg. • Double-ended: Normal life (Hg < 5 mg) and Long life (Hg < 8 mg)	For single-ended light bulbs, all cardboard packaging must contain a minimum of 65 % recycled material (by weight). For double-ended light bulbs, all cardboard packaging must contain a minimum of 80 % recycled material (by weight).	n.a
	Heat pumps	Cadmium, lead, mercury, chromium 6+ or the flame retardants, i.e. poly-brominated biphenyl (PBB) or poly-brominated diphenyl ether (PBDE) flame retardants as listed in Article 4 of Directive 2002/95/EC, may not be used in the heat pump or system, considering the tolerances specified in Commission Decision 2005/618/EC.	n.a.	n.a
Lubricants	Lubricants	n.a.	n.a.	The product shall have a carbon content derived from renewable materials: ≥ 50 % (m/m) for hydraulic oils, ≥

Product group	Product category	Criteria for hazardous materials	Criteria for recycled materials	Criteria for promotion of certain materials
				45 % (m/m) for greases, \geq 70 % (m/m) for chainsaw oils, concrete release agents and other total loss lubricants, and \geq 50 % (m/m) for two-stroke oils.
Other house hold items	Mattresses	The concentrations of the following metals shall not exceed the following values (in ppm): Antimony (0.5), Arsenic (0.5), Lead (0.5), Cadmium (0.1), Chromium (1.0), Cobalt (0.5), Copper (2.0), Nickel (1.0), Mercury (0.02)	The packaging used shall be made from recyclable material	n.a.
Paper	Copying and graphic paper	The levels of ionic impurities in the dye stuffs used shall not exceed the following: Ag 100 ppm; As 50 ppm; Ba 100 ppm; Cd 20 ppm; Co 500 ppm; Cr 100 ppm; Cu 250 ppm; Fe 2500 ppm; Hg 4 ppm; Mn 1000 ppm; Ni 200 ppm; Pb 100 ppm; Se 20 ppm; Sb 50 ppm; Sn 250 ppm; Zn 1500 ppm.	n.a.	n.a.
	Tissue paper	n.a.	The fibre raw material in the paper may be recycled or virgin fibre. 50 % of any virgin fibre must, however, originate from sustainably managed forests	n.a.
Services	Campsite services	n.a.	Recycled water shall be collected and used for non-sanitary and non-drinking purposes.	n.a.
	Tourist accommodation service	n.a.	Recycled water shall be collected and used for non-sanitary and non-drinking purposes.	n.a.

1.1 ECODESIGN DIRECTIVE

The aim of the Ecodesign Directive is to improve the environmental performance of (energy-using and energy-related) products put on the market in the EU by setting certain requirements to their design. The Ecodesign Directive identified parameters, such as raw materials selection, packaging, and possibilities for reuse, recycling and recovery, which could be considered. These parameters could have significant impacts on resource savings if considered within the implementing measures¹⁶³. However, actual contributions of this Directive to resource use and efficiency have not been significant for two main reasons: 1) the first implementing measures with ecodesign requirements were only approved of in 2008, and 2) the methodology for assessing products focuses on energy efficiency.

The Directive entered into force in 2005 and the preparatory studies for the first product groups to be considered for ecodesign requirements were launched in 2006/2007. So far only nine of these launched lots have resulted in implementing measures. Most of the requirements from current regulations derived from the Directive are related to energy-using products, which unsurprisingly focus on energy efficiency as the energy consumption during the use phase, which by far is the greatest generator of environmental impacts. Although each preparatory study considers the materials used in extraction, production, distribution, use and end-of-life, the environmental impacts of these are seen as minor compared to energy efficiency. As a result none of the implementing measures relate to material efficiency¹⁶⁴. However in the case of domestic lighting (light bulbs), impact assessments¹⁶⁵ do show that although the energy-efficient light bulbs require more material (more glass as well as a plastic housing and electronic print board) per product, as they last ten times there is an overall reduction of material use. Compact fluorescent lamps (CFLs) also contain small amounts of mercury compared to traditional incandescent lamps, but as they are much more energy efficient, over the product's life less mercury is emitted from electricity production.

Contribution to material productivity

Besides domestic lighting (light bulbs), the regulations that have entered into force show no direct contributions to material savings (since only non-energy carriers' materials are considered in this study). Out of the remaining 11 product groups where consultation processes are still going on, there is one that could be an exception if a final agreement is achieved with the industry. This is a draft voluntary agreement currently under discussion with the imaging (i.e. copiers, faxes, printers,

¹⁶³ BIO Intelligence Service (2010) Technical support to identify product categories with significant environmental impact and with potential for improvement by making use of ecodesign measures. Study commissioned by the European Commission, DG Environment.

¹⁶⁴ Helena Mälkki, H., Vanhanen, H., Heiskanen, J. (2010) Product specific EuP studies of LOTs 15 to 18 relevancy of other environmental aspects besides the use phase energy consumption of products. Norden.

¹⁶⁵ MTP (2008) Impact Assessment of EuP Implementing Measures of Domestic Lighting. Defra, UK.

scanners, multifunctional devices, etc.) industry. If accepted, the voluntary agreement will require consumables of the equipment to be designed to enable their channelling to either reuse or recycling¹⁶⁶. However, no targets are included in this agreement.

Possible contributions from this Directive in the future could be important and measurable when more regulations enter into force. Findings from the preparatory studies or consultation process could also motivate the industry to establish voluntary agreements on their own. These contributions are assessed in the next section. Product categories that are not included in the Ecodesign Directive, mainly related to business-to-business and inter-sector spending products, can hide important contributions to resource use and also to resource efficiency. The packaging industry, being one of these hidden sectors, is studied next.

1.2 EU ECOLABEL

The 'EU-Ecolabel' is the voluntary certification scheme which aims at helping European consumers to identify more environmentally friendly products and services (e.g. shoes, textiles, tissue paper, detergents, and tourist accommodation services). Established in 1992, the Ecolabel is now part of the action plan on Sustainable Consumption and Production and Sustainable Industrial Policy. At present around 25 types of products and services fall under the Ecolabel, with further groups being continuously added. These include cleaning products, household appliances, electronic equipment, paper products, textiles, home and garden products, lubricants, and services such as tourist accommodation.

The direct benefits to the environment that can be obtained by using Ecolabelled products have been measured in terms of resource savings, such as lower energy, water and raw materials needed for their production and use phase¹⁶⁷. The corresponding reduced effects on the environment, such as pollution to water, to air and hazardous wastes, among others, have also been quantified. It is considered that the Ecolabel has created a shift in production process, product composition and design, which is the ultimate goal of any ecodesign policy.

Contribution to material productivity

The criteria for EU Ecolabel products and services that are related to material productivity can be categorised in three groups related to ecodesign (see Annex E):

- Limits for the use or content of hazardous materials
- Amount of recycled material

¹⁶⁶ Draft Industry Voluntary Agreement to improve the environmental performance of imaging equipment placed on the European market. Version 2.5. 19 February 2010

¹⁶⁷ AEAT (2004) The Direct and Indirect Benefits of the European Ecolabel – Final Report. Study produced for the European Commission, DG Environment.

- Criteria for certain types of materials to be used (e.g. use of renewable materials)

The contribution of the Ecolabel to material savings, however, cannot be measured only in terms of the environmental benefits of an individual product over a non-labelled one, but should be based on the aggregated effect of the products sold on the market. Consequently, a key indicator to assess the possible contributions of the Ecolabel is the success of Ecolabelled products in the overall market share, quantified in the market penetration. To measure the current contributions and the future possible contributions, it is therefore necessary to know the current and forecast market share of Ecolabelled products.

A 2004 study evaluating the direct environmental benefits of the Ecolabel estimated the potential savings that could be obtained if Ecolabelled products achieved 5, 20 or 50% market share¹⁶⁸. In the study the environmental performance and savings of 21 Ecolabel product groups was assessed including the use of harmful substances and savings from raw material extraction. The methodology in the study quantifies the difference between the performance of Ecolabelled products and average market products, where relevant criteria from the previous list are applicable. From all the categories studied, only the product groups in Table 56 were found to have a measurable and direct impact on raw materials extraction or material savings.

Table 56: Examples of design criteria in Ecolabelled products compared with conventional products

Product group	Material related criteria
Cleaners for sanitary facilities	<ul style="list-style-type: none"> • VOC content: < 10% by weight (conventional product about double the amount) • Total phosphorous content: < 1g/100g (conventional product 2g/100g)
All purpose cleaners	<ul style="list-style-type: none"> • VOC content: < 10% by weight (conventional product about double the amount) • Total phosphorous content: < 0.02g/100g (conventional product 0.04g/100g)
Detergents for dishwashers	<ul style="list-style-type: none"> • Total phosphorous per wash: < 10g (conventional product 16g) • Total chemical content per wash: < 22.5g (conventional product 40g) • Hazardous ingredients per wash: < 0.2g (conventional product 1.0g)
Hand dishwashing detergents	<ul style="list-style-type: none"> • Total chemical content per wash: < 1.3g (conventional product 2.0g) • Hazardous ingredients per wash: < 0.4g (conventional product 0.6g)
Laundry detergents	<ul style="list-style-type: none"> • Total phosphorous per wash: < 25g (conventional product 37.5g) • Total chemical content per wash: < 100g (conventional product 150g) • Hazardous ingredients per wash: < 0.5g (conventional product 1.0g)
Personal	<ul style="list-style-type: none"> • Hazardous substances per machine: < 2g (conventional product 5g)

¹⁶⁸ AEAT (2004) The Direct and Indirect Benefits of the European Ecolabel – Final Report. Study produced for the European Commission, DG Environment

Product group	Material related criteria
computers	
Laptop computers	<ul style="list-style-type: none"> Hazardous substances per machine: < 3g (conventional product 10g)
Lightbulbs	<ul style="list-style-type: none"> Change from tungsten filament to compact fluorescent lamps (estimated to saved 73g of materials per year per lamp)
Footwear	<ul style="list-style-type: none"> Hazardous substances in final product: < 112g (conventional product 250g)
Indoor paint and varnishes	<ul style="list-style-type: none"> Hazardous substance content: < 50g/L (conventional product 100g/L) White pigment content (paints only) : <38g/m2 (conventional product 60g/m2)
Hardfloor coverings	<ul style="list-style-type: none"> Block recovery (40% recovery rate, conventional 20% recovery rate)
Soil improvers	<ul style="list-style-type: none"> Only processing or reuse of waste material, i.e. no peat allowed Threshold values on heavy metals
Textiles	<ul style="list-style-type: none"> No pesticide usage in cotton production (standard textiles 0.025 tonnes/tonnes of cotton) Fertiliser usage in cotton production (standard textiles 0.72 tonnes/tonnes of cotton) VOC content: < 1.2 g/kg (standard textiles 40 g/kg)

Most of the Ecolabel criteria deal with the threshold values for the content of chemicals and hazardous substances. Although these materials do not constitute large quantities at an EU-level, they do have significant environmental impacts. As discussed in Chapter 3 under the analysis of RoHS, it is not known whether the restriction of these materials have actually resulted in material productivity as it is not known which substances are used to replace them.

An ongoing study at BIOIS has estimated that Ecolabelled products in France had an average market share of about 1% (5 product categories considered) in 2007, 2.5% in 2008 (8 product categories considered) and 3% in 2009 (only 1 product category considered), but it is thought that the market share of Ecolabelled products are higher in most other Member States. To calculate the possible contributions of the Ecolabel to material use and productivity, a scenario of 5% market penetration of Ecolabelled products was used. The total material savings during a year were calculated using the product sales during 2004. Table 57 presents total material savings (in tonnes) for the various material streams identified for the 5% market penetration scenario.

Table 57: Total estimated materials saved (in ktonnes) due to EU Ecolabel¹⁶⁹

Material stream	Ecolabelled products market share (5%), in ktonnes
Reduced use of hazardous substances	13.80
Material savings	

¹⁶⁹ AEAT, 2004. The direct and indirect benefits of the European Ecolabel.

Material stream	Ecolabelled products market share (5%), in ktonnes
Pesticide	1.58
Fertiliser	45.41
Granite	233.81
Peat	113.30
Titanium dioxide	25.11
Others	111.49
Total materials saved	530.70

Environmental labels in MS

In addition to the EU Ecolabel, several Member States have their own eco-labels that specify environmental (including material use) criteria for a wider range of products and services, e.g. NF Environnement (FR), Blue Angel (DE), Milieukeur (NL), Nordic Swan (Nordic countries), etc. Sweden is the Member State with one of the highest levels of market penetration for the environmentally labelled products. In general ecolabelled products cover between 30 – 70% of the market share per product category in Sweden.¹⁷⁰

As part of an ongoing study at BIOIS, it is estimated that in France the average market share of NF Environment marked products is in the range of 20% (however this estimate is considered to be an overestimate by most of the experts as this figure only takes into account four product categories covered by the NF Environment mark).

1.3 WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT DIRECTIVE

The WEEE Directive was one of the first environmental policies that took an integrated life cycle approach by linking the design phase with the end-of-life phase. Although its implementation focuses on the collection and recycling of electrical and electronic equipment (EEE), the Directive was originally seen as a means to “encourage the design and production of electrical and electronic equipment which take into full account and facilitate their repair, possible upgrading, reuse, disassembly and recycling.” Article 4 of the Directive specifically addresses product design. It clearly states that producers should not prevent through design features WEEE from being reused, unless specific features have overriding advantages with regard to safety or the environment. According to the European Topic Centre on Sustainable Consumption and Production¹⁷¹, 14 MS have introduced material

¹⁷⁰ www.nedlac.org.za/research/fridge-studies/ecolabels2/impact.aspx

¹⁷¹ ETC-SCP (2010) Europe as a Recycling Society. Recycling policies for selected waste streams in EEA member countries. European Environmental Agency.

restrictions and ecodesign requirements to EEE. As there is no commonly agreed metric to measure recyclability, or other method to verify that the aforementioned conditions have been fulfilled, MS have focused their efforts on collection and recycling of WEEE.

Contribution to material productivity

Although there are on-going efforts to increase the recycling of electrical and electronic products through design approaches, e.g. UNEP's *"Solving the E-Waste Problem (StEP)"*¹⁷², there is no quantification on recyclability of EEE. In any case, the contribution of the WEEE Directive to material productivity has already been accounted for under recycling in Chapter 3.

1.4 PACKAGING AND PACKAGING WASTE DIRECTIVE

The Packaging Directive is relevant to product design as the essential requirements (Annex II) lists that manufacturers should:

- limit the volume and weight of the packaging to a minimum adequate amount, maintaining safety, hygiene and acceptance levels.
- design packaging to permit its reuse or recovery, including recycling,
- minimise the presence of noxious and other hazardous substances and materials
- if biodegradable, be capable of undergoing physical, chemical, thermal or biological decomposition such that most of the finished compost ultimately decomposes into carbon dioxide, biomass and water, and not hinder the separate collection and the composting process or activity

This can only be achieved by optimising the design of the packaging through a better design that will reduce the use of materials while still being able to fulfil its purpose¹⁷³. According to the European Topic Centre on Sustainable Consumption and Production¹⁷⁴, 14 MS have introduced material restrictions and ecodesign requirements to packaging products. Besides some labels in Germany, no requirements for minimum recycled materials content were identified.

Nevertheless, the implementation of the Directive in MS has given more weight to other requirements in the Directive, such as the recycling or recovery of packaging materials. Consequently the effects derived from these measures have had a more important impact, which is being reported and quantified¹⁷⁵. Specific targets have been set to measure the increase of recycling or (energy) recovery rates and to

¹⁷² www.step-initiative.org/

¹⁷³ To preserve the goods or deliver the product to the consumer in perfect condition.

¹⁷⁴ ETC-SCP (2010) Europe as a Recycling Society. Recycling policies for selected waste streams in EEA member countries. European Environmental Agency.

¹⁷⁵ Report from the Commission to The Council and the European Parliament on the implementation of Directive 94/62/EC on packaging and packaging waste and its impact on the environment, as well as on the functioning of the internal market. Brussels, 6.12.2006

reduce environmental impacts of GHG emissions or energy consumption. A reduction of packaging waste in general has not been assessed as it has not been required in targets set by MS. Since there are no other indicators to measure impacts on resource use besides those previously mentioned that measure energy carriers, there are no actual indications that the Directive has had a direct impact on resource savings through design.

According to a Commission report¹⁷⁶ the EU has achieved absolute decoupling of packaging waste disposal from GDP growth. However the actual quantity of packaging waste is still increasing. The non-wood packaging on the other hand still has only relative decoupling from GDP as presented in Figure 3.

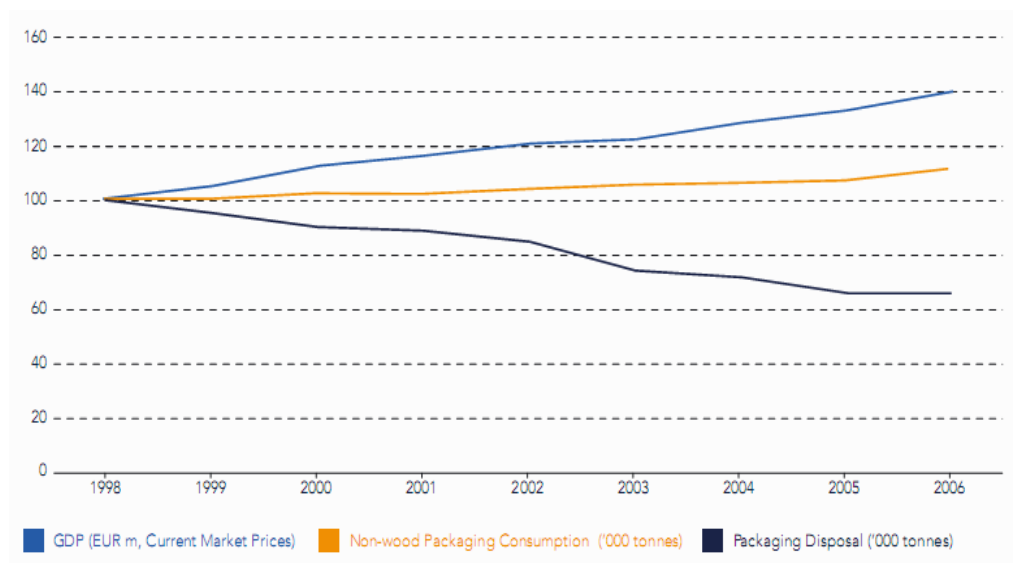


Figure 3: Trends in GDP, non-wood packaging consumption and packaging disposal in EU-15¹⁷⁷, 1998 - 2006¹⁷⁸

The decoupling of packaging waste disposal and GDP could be attributed to an increase in the reuse/recycling rates and/or a reduction in packaging materials consumption. If the effect of the latter was important, an absolute decoupling of material consumption from GDP would also be present. Figure 3 shows that it is not entirely the case for non-wood packaging consumption and that it is slightly following the GDP growing trend. In other terms, the reduction in packaging waste disposal cannot be attributed to product design but only to the effectiveness of increased reuse and/or recycling rates that are diverting packaging waste from being disposed.

¹⁷⁶ Report from the Commission to The Council and the European Parliament on the implementation of Directive 94/62/EC on packaging and packaging waste and its impact on the environment, as well as on the functioning of the internal market. Brussels, 6.12.2006

¹⁷⁷ EU-15: AT, BE, DE, DK, EL, ES, FI, FR, IE, IT, LU, NL, PT, SE, UK.

¹⁷⁸ EUROPEAN COMMISSION (2009) Packaging in the Sustainability Agenda: A Guide for Corporate Decision Makers.

Contribution to material productivity

Although there is relative decoupling of packaging waste disposal and GDP, Figure 4 and Figure 5 show that the amount of packaging consumed has not decreased in the EU-15 in the period 1998 – 2006. Any effect that the Directive could have had on material use would have been measurable during this period as the Directive was adopted in 1994, but instead an 11% increase has been observed. The data presented corresponds to per capita consumption rates, derived from the material consumption in weight as reported by the EU-15 MS and the EUROSTAT population figures for each year¹⁷⁹. Figure 4 presents the total resources consumption (metal, wood, plastic, glass, paper and board) for packaging for the period 1998 – 2006 and for non-wood packaging resources.

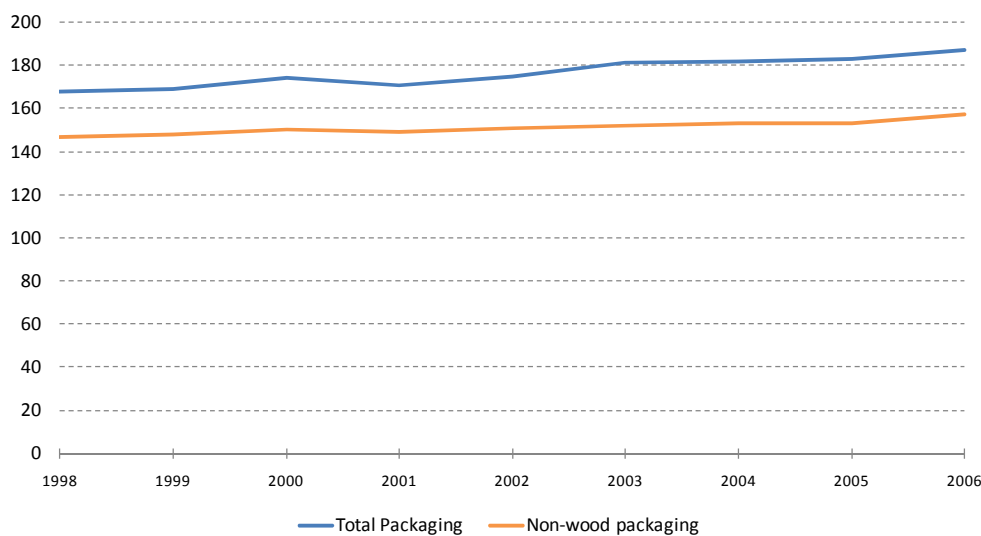


Figure 4: Total packaging per capita consumption (kg) in EU-15, 1998 – 2006

Figure 5 presents the consumption for each material category. Per capita consumption of metals for packaging has been constant with a slight decrease in the last two years under study. Wood was only required to be reported after 2003 which can explain the sudden increase after 2002; since then consumption has been constant. There is a reduction in per capita consumption of glass, while plastics, paper and board consumption has increased 27% and 10% respectively. Plastics and paper/board packaging could be replacing glass packaging, accounting for the reduced consumption of the latter, but they are growing in a larger proportion which accounts for the overall increase in the total consumption of packaging materials.

¹⁷⁹ EUROPEAN; Packaging and Packaging Waste Statistics 1998 – 2006.

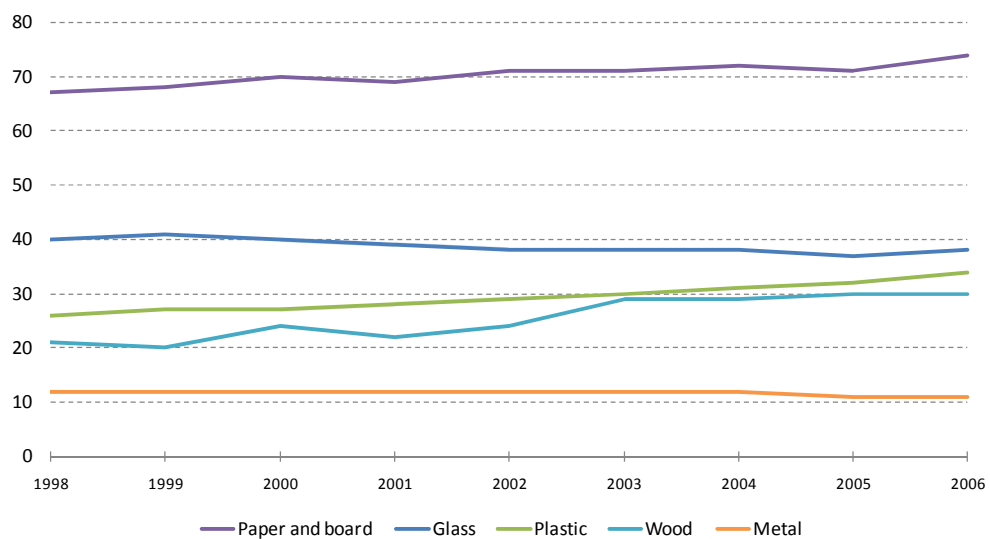


Figure 5: Packaging per capita consumption rates of different materials (kg) in EU-15, 1998 – 2006

Although the previous analysis shows that there is no actual reduction in packaging materials consumption, there is evidence that there has been an increase in the material efficiency over the same period as more packaged products were sold in the same period, representing greater material efficiency. Evidence from the packaging industry has shown that considerable reductions in weight have been introduced since the 1990s, as presented in Table 58.

Table 58: Evolution of packaging weight¹⁸⁰

Type of packaging	1950s	1960s	1970s	1990s	2000	2008	Per cent change ¹⁸¹
Washing-up liquid bottle (1 litre)	–	–	120g	67g	50g	43g	64%
Soup can (400g)	90g	–	69g	57g	55g	49g	46%
Yoghurt pot (165g)	–	12g	7g	5g	–	4g	67%
Plastics fizzy drinks bottle (2 litre)	–	–	58g	–	43g	40g	31%
Metal drinks can (330ml)	–	60g	–	21g	15g	14g	77%
Glass beer bottle (275g)	–	–	450g	–	325g	176g	61%
Glass milk bottle (1 pint)	538g	–	397g	230g	–	186g	65%

It was seen that in early stages (i.e. in the 1960s) material weight reductions were significant, and changes of more than 50% in the weight of some packaging materials was achieved. It would seem that the technical limits of packaging have been reached as the weight reductions have been less in the later years. There is however still a potential for further weight reduction by substituting material, e.g.

¹⁸⁰ EUROOPEN; Packaging and Packaging Waste Statistics 1998 – 2006

¹⁸¹ The per cent change measures the weight reduction in 2008 compared with the first year of data reporting for the product in the table

from glass bottles to plastic or carton.¹⁸² A study conducted by PlasticsEurope claims that the use of plastic for packaging helps in reducing the overall material consumption of alternative packaging material by almost 4 times (by weight)¹⁸³. For example, by changing the material of their beer bottles, Carlsberg reduced the weight of a beer bottle from 260 g (glass bottle) to 38 g (plastic bottle).¹⁸⁴

It has not been possible to determine the extent that packaging manufacturers use more recycled material in their products, but it has been observed that higher amounts of packaging waste are being recycled¹⁸⁵. Regardless, the effects of packaging recycling have already been accounted for under recycling in Chapter 3.

1.5 END-OF-LIFE VEHICLE DIRECTIVE

The End-of-Life Vehicles Directive (2000/53/EC) sets up binding targets in the EU for vehicle recovery and recycling. The initial target for the year 2006 was for 85% of recovery, of which 80% recycled or reused, rising to 95% and 85% respectively by 2015. To achieve this, the Directive stipulates the vehicle producers to integrate the recyclability and dismantling aspects during the design phase. Article 4 of the Directive¹⁸⁶ states that MS should encourage:

- a) vehicle manufacturers, in liaison with material and equipment manufacturers, to **limit the use of hazardous substances** in vehicles and to reduce them as far as possible from the conception of the vehicle onwards, so as in particular to prevent their release into the environment, make recycling easier, and avoid the need to dispose of hazardous waste;
- b) the design and production of new vehicles which **take into full account and facilitate the dismantling, reuse and recovery, in particular the recycling**, of end-of life vehicles, their components and materials;
- c) vehicle manufacturers, in liaison with material and equipment manufacturers, to **integrate an increasing quantity of recycled material** in vehicles and other products, in order to develop the markets for recycled materials.

Furthermore materials and components of vehicles put on the market after 1 July 2003 should not contain lead, mercury, cadmium or hexavalent chromium other than in some specific cases. Finally MS should require *'the relevant economic operators'* to publish information on the design of vehicles and their components

¹⁸² www.tetrapak.com/us/Documents/tetrapak_consumerminbrochure.pdf

¹⁸³ Denkstatt AG (2010) The impacts of plastics on life-cycle energy consumption and greenhouse gas emissions in Europe.

¹⁸⁴ www.carlsbergdanmark.dk/omol/AtVide/Emballager/Pages/Flasker.aspx

¹⁸⁵ Treatment of packaging waste in the EU-27, Packaging waste 2007, EUROSTAT, Environmental Data Centre on waste.

¹⁸⁶ In the ELV Directive this is mentioned as waste prevention, but in the context of this study it relates more to design issues.

with a view to their recoverability and recyclability. According to the European Topic Centre on Sustainable Consumption and Production¹⁸⁷, 12 MS have introduced mandatory ecodesign requirements (10 MS have voluntary agreements) for vehicles. Likewise 12 MS have mandatory policies for the increased use of recycled material (11 MS do this on a voluntary basis).

Contribution to material productivity

Chapter 3 of this report estimated the current RRR share for ELV to be approximately 78%. However, by incorporating dismantling and recyclability aspects in the design of the cars, it would be possible to achieve an even higher recycling and reuse rate. For example with car seats it is possible to achieve as much as 86% recycling and reducing disposed Automobile Shredder Residue (ASR) for ELVs by up to 42%¹⁸⁸. The headrest is a critical part of the car seat. By simply modifying joining techniques through design, it is easier to dismantle before shredding and recovering the textile from it. It is also possible through design for recyclability to achieve easier removal of bumpers, fuel tanks, tyres and glass that could lead to 84% overall recycling of vehicles.

According to the Commissions' last report on the implementation of the ELV Directive¹⁸⁹, several MS have reported that they have taken measures to ensure that producers use component and material coding standards as well as provide information on dismantling, storage and testing of components for recycling facilities. Automobile and automobile component manufacturers must provide dismantling information for each type of new vehicle put on the market. The IDIS system (International Dismantling Information System) is regularly updated with this information.

The report also mentions that the amount of recycled material used in vehicles has increased, but this was dependent on the market availability and on the price and quality level of recycled material. According to specialists in the metals industry, an incorporation of more than 40% of recycled metal in vehicles is difficult. The integration of recycled plastic in vehicles was lower than for metals, but this was due to the trade-off between the use of recycled conventional plastics and innovative new lightweight plastics.

¹⁸⁷ ETC-SCP (2010) Europe as a Recycling Society. Recycling policies for selected waste streams in EEA member countries. European Environmental Agency.

¹⁸⁸ Passarini et al. (2010) Assessment of Ecodesign potential in reaching new recycling targets, Resources, Conservation and Recycling Journal, pp. 1128–1134

¹⁸⁹ EC (2009) Report from the Commission to the Council, the European Parliament, the European Economic and Social Committee, and the Committee of Regions on the Implementation of Directive 2000/53/EC on End-of-Life Vehicles for the period 2005-2008. COM(2009) 635 final.

2. THE POTENTIAL OF ECODESIGN APPROACHES

2.1 DESIGN FOR RECYCLABILITY

The methods and approaches found for this option are mainly related to using materials that can be recycled, using recycled materials, minimising number of parts, minimising the number of different types of material, marking parts for easier identification, eliminating labels or product components that have to be removed before recycling, and making the product easy to disassemble.

Examples of design for recyclability

- **Ford** is making greener vehicles by increasing the use of recyclable and renewable materials in the design phase¹⁹⁰:
 - These vehicles are 85% recyclable by weight; the 2010 Ford Taurus uses eco-friendly bio-based seat cushions
 - In 2009, Ford saved approximately \$4.5 million by using recycled materials
- **Lafarge** substituted up to 60% of the clay in clinker in UK by using recycled pulverised-fuel ash¹⁹¹. The total share of slag, fly ash and pozzolan that Lafarge uses in their cement is about 15% (which means 15% less clinker) hence improving the resource productivity.
- Zurich based **Freitag** manufactures bags and accessories for women and men since 1993. Freitag manufactures its bags using only recycled materials which include truck tarpaulins, unravelled seat belts, bicycle inner tubes beyond repair, and recycled airbags. Normally these materials are costly to dispose of but, the superlative design of Freitag bags allows them to be used as an important raw material¹⁹².
- **Green Toys** in San Francisco makes children's toys entirely out of recycled milk jugs from local recycling facilities. All of the Green Toys products are both recycled and recyclable¹⁹³.

Estimates of material savings potential for design for recycling

Design for recycling is key to achieving higher recycling rates. As a strategy it allows products to be more easily recycled (creating supply), but also increases the demand for recycled material by using recycled material instead of virgin raw material.

¹⁹⁰ www.ford.com/about-ford/news-announcements/press-releases/press-releases-detail/pr-ford-is-making-greener-vehicles-32474

¹⁹¹ www.lafarge.co.uk/wps/portal/uk/2_2_2-Industrial_ecology

¹⁹² www.freitag.ch/

¹⁹³ www.lunar.com/docs/the_designers_field_guide_to_sustainability_v1.pdf

2.2 PRODUCT LIGHTWEIGHTING

The main idea of lightweighting is to reduce the weight of products during design whilst considering the environmental impacts throughout its entire lifecycle.¹⁹⁴

Table 59: presents examples of products that have undergone redesign processes in order to use less material. A short description of the initiatives is presented with a quantification of the material savings, as reported by the industry.

Table 59: Concrete results of industry initiatives to encourage ecodesign of products¹⁹⁵

Type of product	Description	Material savings
Dairy products	Packaging was redesign to allow better placement in pallets and to reduce product waste due to stability problems	87 tons/year cardboard
Cat food	Can thickness was redesign from 0.14 to 0.13mm	1500 tons / year metal
Shampoo	Three models of bottle caps were reduced by 1, 2.8 and 6.7g	85 tonnes / year plastics
Detergent	A new formula allows to include functions that were performed by different products in one: 1/3 of the chemical components were reduced	4700 tonnes / year chemicals
Fruit juice	The glass bottle weight was reduced from 480 to 450g	148 tonnes / year glass
Mobile phone	Packaging change from having a volume of product / volume of packaging ratio from 18 to 25%	236 tonnes / year plastics and cardboard
Golf balls	Material replacement, the package change from being a PVC box to a plastic net that could be reused as a bag	7 tonnes / year PVC
Fruit juice	The plastic PET bottle weight was reduced from 54 to 36g	36 tonnes / year PET
Wine	The handle of the "bag in box" to keep the wine was suppressed by a better design of the cardboard box, thus it went from being a two materials package to be solely made from cardboard	3.4 tonnes / year plastic

According to the packaging manufacturer Tetra Pak¹⁹⁶ packaging weight in relation to the product's weight can be drastically reduced by choosing a carton instead of a glass bottle or can. A glass bottle is 67% of the total weight of the product, whilst the same content for a can is only 14% and 4% for a carton. Furthermore rectangle cartons are more space efficient than bottles or cans during transport.

A special case of lightweighting by dematerialisation is the provision of products as services through digitalisation.

¹⁹⁴ Oakdene Hollins & Cranfield University (2007) Product Lightweighting. A strategy to deliver a sustainable economy? Resource Efficiency Knowledge Transfer Network, DTI, UK.

¹⁹⁵ Database at: www.conseil-emballage.org/web/c_fiche.asp

¹⁹⁶ www.tetrapak.com/us/Documents/tetrapak_consumerminbrochure.pdf

Example of digitalisation

One article¹⁹⁷ has stated that the production of an e-reader requires the extraction of 15 kg of minerals including rare metals (compared to 0.3 kg of minerals for a book made of recycled paper). With respect to fossil fuels, water use and mineral consumption, the impact of one e-reader payback equals roughly 40 to 50 paper books.

One aspect of dematerialisation is that the change in use of materials shifts the environmental impacts. For instance, an ongoing BIOIS study estimates that the transmission of a 1 Mb (approximately 20 pages) document by USB leads to 2.4 times less depletion of metals and almost 17 times less depletion of natural resources when compared to the transmission of the same document in paper format. On the other hand, another study carried out by BIOIS estimates that electronic invoicing has almost two times more impact on metal depletion than paper invoicing.

The electronics industry also has several examples of achieving the production of its products by consuming less material. As an example, Daishinku Corporation has succeeded in reducing material consumption for the production of its crystal oscillators (e.g. its latest DSX 211A crystal weighs only 0.0045 g which is less than 1/100th the weight of the earlier version of this crystal oscillator DSX 151 GA)¹⁹⁸.

Ecodesign has become common practice in most leading manufacturing firms. The effects of these can be seen with the material intensity of each new generation of product being improved. Examples of the magnitude of material savings or amount of recycled material can be seen in Table 60.

Table 60: Material savings achieved according to Apple¹⁹⁹

Apple product	Material reductions
27 inch (new version) iMac - Packaging	25% less material compared to 15 inch (old version) iMac <i>19% less material compared to 15 inch (old version) iMac</i>
21.5 inch (new version) iMac - Packaging	50% less material compared to 15 inch (old version) iMac <i>46% less material compared to 15 inch (old version) iMac</i>
Mac Pro	1.8 m less internal cables compared to previous version
Mac Mini - Packaging	68% less plastic <i>35% less volume, 50% recycled content</i>
Snow Leopard Server - Packaging	68% less plastic <i>15% less volume, 50% recycled content</i>
17 inch MacBook Pro - Packaging	<i>34% less volume than original version</i>

¹⁹⁷ D. Goleman, and Norris G, 2010, How Green Is My iPad?
Available at: www.nytimes.com/interactive/2010/04/04/opinion/04opchart.html

¹⁹⁸ www.kds.info/html/environment_conservation/report/consideration_en.htm

¹⁹⁹ www.apple.com/environment/reports/

Apple product	Material reductions
iPhone 4 - Packaging	14% lighter, 14% less volume compared to previous version
iPod Touch packaging	14% less plastic, 17% less volume, 16% lighter
iPod nano - Packaging	48% less plastic, 45% less volume, 46% lighter compared to previous version

A study performed by BIOIS to compare the relative impact of lightweighting of mailing envelopes on material consumption. It estimates that for 1000 mailing packages, a 54 g envelope made from high density polyethylene fibres (avoids over packaging) has 1.5 times less impact on material consumption as compared to traditional 150µm LDPE envelope (230mm x 330mm) and 3.6 times less impact when compared to a cardboard box (330mm x 250mm x 120mm) used for the same application.

Estimates of material productivity potential for lightweighting

Given the above evidence, it seems economically feasible that packaging, electronic and electrical equipment (EEE) and vehicles could be redesigned using less materials and/or substituting materials with less environmental impacts. Packaging has already seen large weight reductions per unit of about 50% on average, but it would still seem possible to further reduce the weight of packaging by at least 5%. Likewise for EEE, miniaturisation and digitalisation has resulted in products which on average are estimated to require half the amount of materials compared with earlier generations of the same product. From the achievements of individual firms on material savings through ecodesign, it is assumed that a further 10% of materials could be saved and still provides the same value. Finally, the evidence shows that although lightweighting has occurred in the automotive industry, these savings have been outweighed by the increase in size and features of the average car sold on the market. If consumers accept smaller cars (which seems to be the case with the popularity of cars such as BMW Mini, Fiat 500, Smart fortwo), it would seem plausible that vehicles could be designed with as much as 30% less materials .

It must be pointed that the above mentioned estimates assume that consumers are willing to accept these changes to products and that these material savings do not entail rebound effects in terms of increased consumption.

2.3 DESIGN FOR LONGEVITY

The methods and approaches under this option are normally related to increasing the lifetime of products by making them more durable, repairable and upgradable. This supports waste prevention measures for reusing/ refurbishment/ repair/ remanufacturing.

Example of designing for longevity

The 606 Universal Shelving System of Vitsoe²⁰⁰, created in 1960, is a revolutionary way of building shelves - a modular system that can be used for one shelf or an entire library. It's adjustable and extendable without tools and is fabricated in metal with simple, clean lines. Customers can add to their system slowly and seamlessly – a shelf at a time if they wish – depending on changing needs. Vitsoe claims that their products help people live better with less, that lasts longer. So far their strategy seems to work as customers stay loyal to the company (half of Vitsoe's business is from existing customers) and the products sold as second-hand retain much of their original value.

Material saving impacts through design for longevity

Design for longevity supports various strategies to prolong product life including waste prevention strategies such as reuse, repair, remanufacture, etc. The effects of these have already been accounted for in the previous chapter on waste prevention.

3. MATERIAL SAVINGS OF LIGHT BULBS FROM ECODSIGN DIRECTIVE

Table 61: Material compositions of different lighting technologies²⁰¹

Lamp type	Power rating	Weight (g)					
		Total	Glass	Aluminium	Electronics	Plastics	Balance
GLS	60W	33	30	3	-	-	0.01
Halogen	35W	2.5	2	0.5	-	-	0.01
CFL-integral	11W	120	65	4	25	25	1

Note: Balance includes lamp envelope additives including electrodes, capping paste and ceramic parts

Source: European Lamp Companies Federation www.elcfd.org/2_lighting_composition.html, 2008

Table 62: Estimated annual sales of light bulbs (in million units) - the difference between 2007 and 2000 is used to represent the current situation²⁰²

Lamp type	EU sales 2000	EU sales 2007	EU future
GLS + GLS-R	2538	1899	
Halogen	283	342	
CFL-integral	68	483	600

²⁰⁰ www.vitsoe.com/en/gb/about/60s-606-is-50

²⁰¹ Helena Mälkki, H., Vanhanen, H., Heiskanen, J. (2010) Product specific EuP studies of LOTs 15 to 18 relevancy of other environmental aspects besides the use phase energy consumption of products. Norden.

²⁰² OECD/IEA (2010) Phase Out of Incandescent Lamps.

Table 63: Changes in annual material consumption (in tonnes) for lighting between 2000 and 2007

	Sales (million units)	Glass	Aluminium	Electronics	Plastics	Other
GLS	-639	-19170	-1917			-6.39
Halogen	59	118	29.5			0.59
CFL-integral	415	26975	1660	10375	10375	415
Net savings		7923	-227.5	10375	10375	409.2

Table 64: Changes in annual material consumption for lighting between 2000 and future scenario

	Sales (million units)	Glass	Aluminium	Electronics	Plastics	Other
GLS	-2538	-76140	-7614			-25.38
Halogen	-283	-566	-141.5			-2.83
CFL-integral	532	34580	2128	13300	13300	532
Net savings		-42126	-5627.5	13300	13300	503.79

ANNEX F: OVERALL SAVINGS

MATERIAL SAVINGS FROM RECYCLING

Table 65: Detailed material savings for major material categories in the EU-27 for the scenarios: no recycling, current situation, targets fully reached, potential recycling and 100% recycling, all values in million metric tonnes (Mt)

Material categories	current		targets		potential		100%	
	Mt	Share %	Mt	Share %	Mt	Share %	Mt	Share%
Metals								
Iron	25.5	8.1%	33.6	7.2%	42.0	7.2%	48.2	6.9%
Aluminium	4.3	1.4%	5.4	1.2%	6.5	1.1%	8.4	1.2%
Copper	4.0	1.3%	4.3	0.9%	4.9	0.8%	6.6	0.9%
Lead	1.3	0.4%	5.9	1.3%	5.9	1.0%	9.1	1.3%
Non-metallic metals								
Glass	19.3	6.1%	24.9	5.4%	33.6	5.8%	44.4	6.3%
Aggregates	187.5	59.8%	294.4	63.2%	360.7	62.2%	399.2	57.1%
Fossil fuels								
Plastics	11.8	3.8%	16.1	3.4%	22.3	3.8%	36.7	5.3%
Biomass								
Paper	21.1	6.7%	25.1	5.4%	28.6	4.9%	38.5	5.5%
Wood	16.6	5.3%	22.9	4.9%	32.0	5.5%	41.0	5.9%
Biowaste	22.3	7.1%	33.4	7.2%	43.5	7.5%	67.1	9.6%
Sum	313.8	100%	466.0	100%	579.8	100%	699.2	100%

In the current scenario, the recycling of 13.9 Mt iron replaces the need for of 25.5 Mt iron ore. When the targets are fully achieved, the savings will be 33.6 Mt. If the full feasible potential for recycling can be obtained, 42 Mt of iron ore will be saved. In 100% recycling scenario 48.2 Mt of iron ore would be saved. In the current scenario the 25.5 Mt of iron ore represents 8.1% of the total material savings due to recycling.

Metals

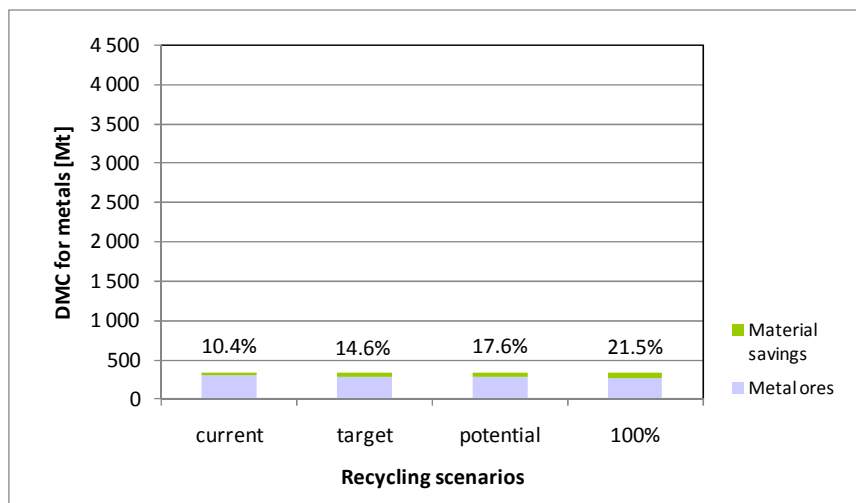


Figure 6: DMC for metals and relevant material savings due to metal recycling in EU-27 based on waste statistics for current situation, targets reached, potential and 100% recycling, in million metric tonnes (Mt) and material savings as a percentage

In the current scenario the recycling of metals reduces the domestic material consumption of the ‘no recycling’ scenario (DMC₀) for metals by 10.4%. It can be seen that increasing recycling can reduce the relevant DMC for metals up to 15 - 20%.

Non-metallic minerals

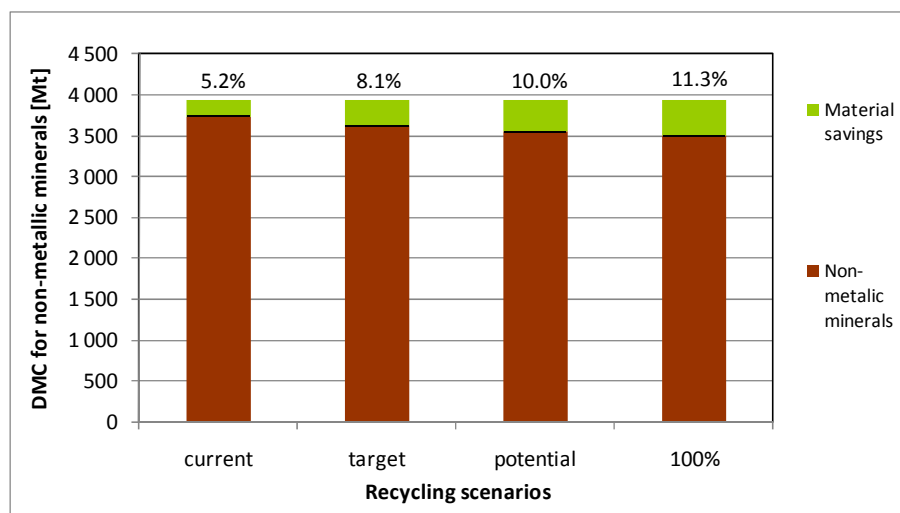


Figure 7: DMC for non-metallic minerals and relevant material savings due to recycling of glass and aggregates in EU-27 based on waste statistics for current situation, targets reached, potential and 100% recycling, in million metric tonnes (Mt) and material savings as a percentage

In the current scenario the recycling of glass and aggregates reduces the DMC of non- metallic minerals by 5.2%. It can be seen that increased recycling can reduce

the relevant DMC for non-metallic minerals up to 10.6%. In the current scenario almost 90% of the material savings of non-metallic minerals are due to aggregate recycling and 10% due to glass recycling.

Fossil energy carriers

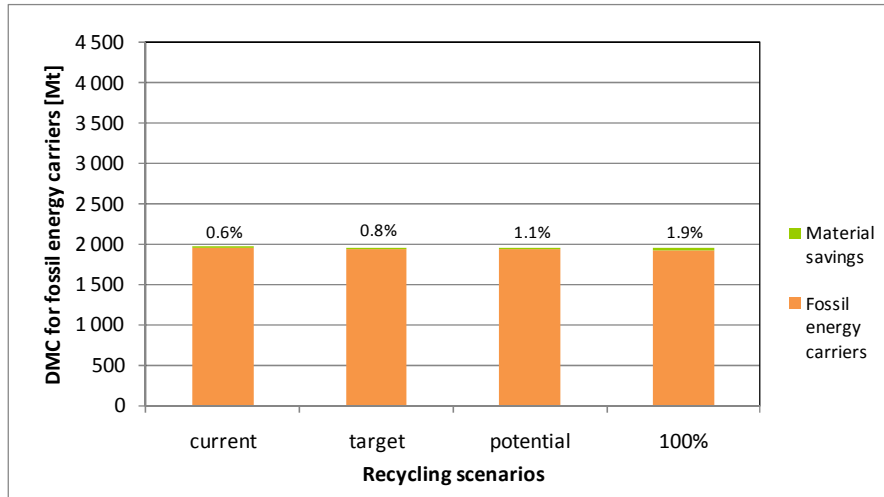


Figure 8: DMC for fossil energy carriers and relevant material savings due to recycling of plastics in EU-27 based on waste statistics for current situation, targets reached, potential and 100% recycling, in million metric tonnes (Mt) and material savings as a percentage

Since plastics only constitute a small part of the overall fossil fuel consumption, the contribution of recycled plastics compared with DMC is relatively low from 0.6% (current) up to 1.9% (100% recycling).

Biomass

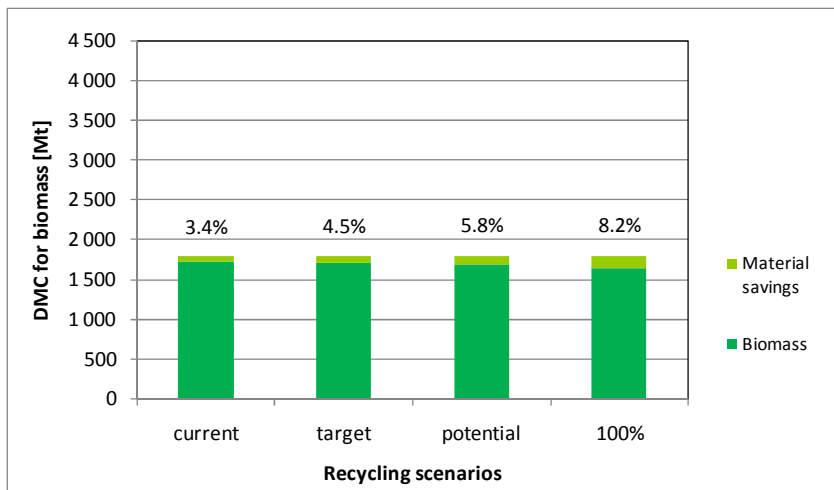


Figure 9: DMC for biomass and relevant material savings due to recycling of paper, wood and biowaste in the EU-27 based on waste statistics for current situation, targets reached, potential and 100% recycling, in million metric tonnes (Mt) and material savings as a percentage

In the current scenario the recycling of paper, wood and biowaste reduces the DMC of biomass by 3.4%. It can be seen that increased recycling can reduce the relevant DMC for biomass up to 8.2% (100% recycling). In the current scenario 35% of the material savings of biomass are due to paper recycling, 28% due to wood recycling and 37% due to biowaste recycling.

1. OVERALL MATERIAL SAVINGS

	Pure material savings (Mt)							
	current		targets		potential		100% recycling rates	
	Low	High	Low	High	Low	High	Low	High
Metals								
Iron	23.6	96.8	28.0	100.6	41.6	122.5	26.2	102.6
Aluminium	3.0	5.1	3.4	5.7	4.6	6.8	3.3	4.6
Copper	0.6	1.4	0.7	1.6	0.9	1.8	0.6	1.4
Lead	0.3	0.8	0.8	1.1	0.8	1.0	1.1	1.1
Non-metallic minerals								
Glass	35.9	36.4	41.5	42.0	52.5	56.2	44.4	21.6
Aggregates	190.4	619.4	297.3	678.8	448.3	894.7	399.2	1045.4
Fossil fuels								
Plastics	29.2	29.8	33.5	34.1	44.6	50.7	36.7	26.5
Biomass								
Paper	73.5	80.6	82.5	96.6	99.5	121.1	84.7	79.3
Wood	30.1	56.2	35.8	90.7	51.1	95.6	37.3	70.1
Biowaste	24.2	48.2	35.1	49.1	50.3	55.1	67.1	88.3
Sum	411.0	974.8	558.7	1100.5	794.3	1405.7	700.6	1440.9

Table 66: Over all pure material savings due to recycling, waste prevention and product design

Raw material savings (Mt)								
	current		targets		potential		100% recycling rates	
	Low	High	Low	High	Low	High	Low	High
Metals								
Iron	43.4	178.1	51.5	185.1	76.5	225.3	48.2	188.6
Aluminium	7.7	13.2	8.7	14.7	11.9	17.5	8.5	11.9
Copper	7.2	16.8	8.4	19.2	10.4	21.8	7.1	16.6
Lead	2.5	6.7	6.7	9.2	6.8	8.7	9.2	8.8
Non-metallic minerals								
Glass	35.9	36.4	41.5	42.0	52.5	56.2	44.4	21.6
Aggregates	190.4	619.4	297.3	678.8	448.3	894.7	399.2	1045.4
Fossil fuels								
Plastics	29.2	29.8	33.5	34.1	44.6	50.7	36.7	26.5
Biomass								
Paper	34.4	37.8	38.7	45.3	46.6	56.7	39.7	37.2
Wood	33.1	61.9	39.4	99.8	56.2	105.1	41.0	77.1
Biowaste	24.2	48.2	35.1	49.1	50.3	55.1	67.1	88.3
Sum	408.1	1048.2	560.7	1177.3	804.2	1492.0	701.0	1522.0

Table 67: Over all raw material savings due to recycling, waste prevention and product design

	Current policies		Targets reached		Feasible potential		100% recycling rates	
	low estimate	high estimate	low estimate	high estimate	low estimate	high estimate	low estimate	high estimate
<i>Recycling</i>	313.3	885.8	466.9	1014.9	580.8	1138.1	701.0	1522.0
<i>Waste prevention</i>	8.2	75.7	8.2	75.7	146.8	244.5		
<i>Product design</i>	87.8	90.1	87.8	90.1	111.6	118.8		
DMC without material productive measures (Mt)	8227.0	8766.6	8227.0	8766.6	8227.0	8766.6	8227.0	8766.6
DMC with contributions from material productive measures (Mt)	7715.0	7715.0	7664.0	7585.9	7387.7	7265.2	7343.5	7244.6
Material productivity without recycling, waste prevention and improvements in design (€/t)	1,201	1,127	1,201	1,127	1,201	1,127	1,201	1,127
Material productivity with recycling, waste prevention and improvements in design (€/t)	1,280	1,280	1,289	1,302	1,337	1,360	1,345	1,364
Material productivity increase due to recycling + waste prevention + ecodesign (%)	6.2%	12.0%	6.8%	13.5%	10.2%	17.1%	10.7%	17.4%

Table 68: An overview of material savings due to recycling, waste prevention and product design from current practices and policies as well as future potentials

1.1 DATA UNCERTAINTIES, RELEVANCE OF ASSUMPTIONS AND CALCULATION UNCERTAINTIES

As discussed at the beginning of this section waste statistics have a very high range of uncertainty. In many cases experts provided estimates that vary by a range of 2 to 18 times for minimum and maximum figures. Since these uncertainties are extremely high – even for the waste streams of high significance (e.g. C&D waste) – other methods were employed to check the plausibility of the data. For this purpose the material flow accounts (MFA) were used. The MFA is based on a very simple, but reliable approach with a reasonable statistical foundation. It accounts all the in and

out flows with other economies (e.g. import and export statistics) and all inputs extracted from nature (e.g. various statistics like agricultural and forestry statistics, mining statistics, etc.). The use of the MFA as a framework was linked with production statistics (see chapter 2 in the report) on the methodology for calculating material savings). Since this approach is already used to model the material streams, it could also be used to check the plausibility of data. The uncertainties of this approach will be discussed under calculation uncertainties.

The feasibility and plausibility check provides the following results:

- C&D waste recycling is by far the most important recycling activity relevant for material savings.
- Metal recycling is plays a major role since it substitutes very material intensive up-stream processes.
- The calculation of the potential based on production statistics assumes an increase of the recycling rate for copper from 41 to 95%. This has a significant effect due to the material intensity of the up-stream processes (the average ore grade is below 18%).

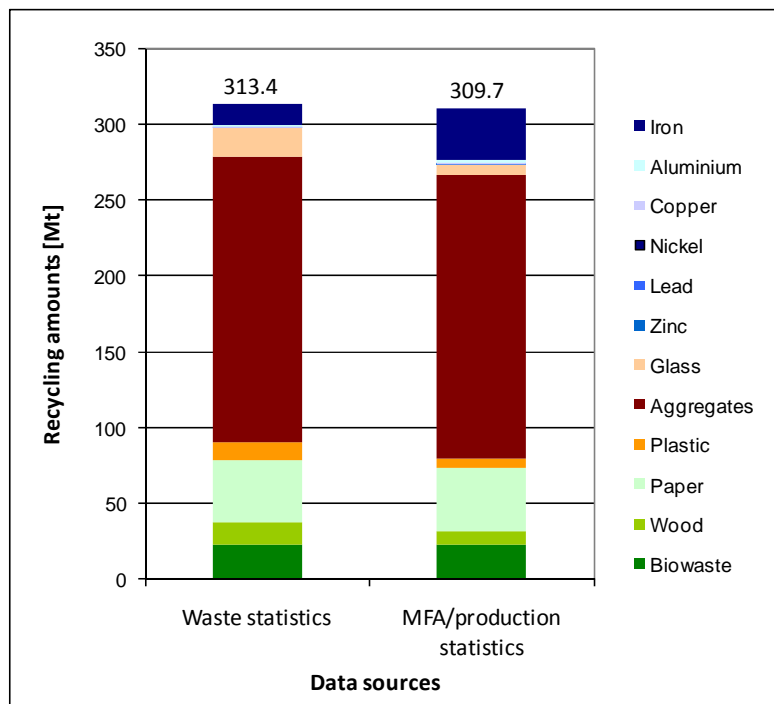


Figure 10: Recycling amounts from waste statistics compared to recycling amounts from MFA/production statistics data, in million metric tonnes (Mt)

Table 69: Recycling amounts from waste statistics compared to MFA/production data and their deviation, current scenario for 2004, amounts in million metric tonnes (Mt), deviation in % (100% signifies that the same production data is used)

Material categories	Data based on waste statistics	Prognos study		Data based on MFA/production statistics	
	Recycling amounts	Recycling amounts	Deviation to waste statistics	Recycling amounts	Deviation to waste statistics
Iron & steel	13.9	77.7	560%	33.0	238%
Aluminium	1.7	3.1	185%	2.4	140%
Copper	0.3	0.9	269%	0.9	256%
Lead	0.2	0.6	392%	0.04	29%
Glass	19.3	10.7	56%	6.7	35%
Aggregates	187.5	769.2	410%	187.5	100%
Plastic ^{f)}	11.8	4.5	38%	5.2	44%
Paper	41.3	44.2	107%	42.2	102%
Wood	15.1	21.7	143%	9.34	62%
Biowaste	22.3	28.8	129%	22.3	100%
Other	74.2	91.1	123%		
Total	388.8	1 052.5	271%	309.7	80%

Comments to differences in data for specific materials:

- Metals:** Iron, aluminium and copper recycling amounts seem to be too low. This could be due to data provided by industry associations include internal recycling of production scrap that never gets registered as waste management. The waste statistics rarely provide specific data on the different types of metals, which is the reason why data for nickel and zinc are missing. Lead is assumed to have a recycling rate (according to the data sources used) of 14%, but in opinion of the experts this rate could be around 49%, and the International Lead Association claims recycling rates between 60%-90%.
- Non-metallic minerals:** The glass recycling amount seems to be too high. As the reporting mechanisms for C&D waste are not well in place and registration is not systematic, the data on this is very uncertain. The estimates for C&D amounts range between 309 Mt and 727 Mt, whilst recycling rates are suggested to be between 30 to 60%²⁰³.
- Plastics:** The recycling amount from the waste statistics seems to be overestimated by a factor two. This is probably due to the double counting of packaging waste recycling in municipal solid waste and packaging waste (packaging waste constitutes the greatest portion of plastic waste).
- Biomass:** Paper recycling amounts from the two different data sources seem to correspond and would therefore seem plausible. The amounts of recycled wood

²⁰³ BIO Intelligence Service, Arcadis & IEEP (2010) Study on management of construction and demolition waste in the EU. Study commissioned by the European Commission, DG Environment.

according to the waste statistics seem to be too high compared with production statistics. This again could be attributed to double counting of municipal and packaging waste data (after C&D, the two greatest contributors). For biowaste the estimated amounts seem to correspond to the assessment of other studies²⁰⁴.

- **Total amounts:** The total amount of recycling estimated in this study is much less compared to the amount that the Prognos study states²⁰⁵. The Prognos study estimates recycling to be up to a factor 2.7 greater than what was found in this study. The sum of recycling amounts from waste statistics and MFA/production statistics is in the same range with less than 2% difference (mainly due to the C&D waste dominating). However, since the composition is different according to the two sources, it matters. While metals in waste statistics seem to be underestimated, the categories glass, plastic and wood seem to be overestimated. Since metals cause higher material savings than other categories the material savings need to be checked as well. The difference in material savings between calculations based on waste statistics and MFA/production statistics is higher than the one in recycling amounts, however, it is still below 7%.

Relevance of assumptions

In order to calculate the material productivity some general assumptions were made.

- Changes of GDP due to increased recycling activity are not considered since there is little information available on this. It is assumed that the difference is minor. More recycling might increase GDP when it replaces imports. At the same time more recycling might reduce GDP, if it replaces a domestic extraction/production chain with a high added value. It is therefore deemed that the overall effects are not significant.
- A pre-condition for all the calculations made is that it assumes equivalent consumption and population in all the scenarios. Neither final consumption nor exports are change in any of the scenarios. The savings in materials assume that the same amounts of production can be achieved.
- All the main assumptions in the calculations tend to overestimate material savings

Assumptions tested in the sensitivity analysis

The following assumptions were tested in the sensitivity analysis for the current scenario. Assumptions discussed here were altered one after the other, while all other assumptions kept the original values.

²⁰⁴ Arcadis & Eunomia (2009) Assessment of the options to improve the management of bio-waste in the European Union

²⁰⁵ Prognos (2008) Resource savings and CO2 reduction potential in waste management in Europe and the possible contribution to the CO2 reduction target in 2020.

- **Assumptions relevant for recycling amounts**

Recycling amounts provided from waste statistics under C&D waste in the category of “other waste” and “miscellaneous” is not included, because it is highly uncertain that it is effectively recycled. Including it would increase the recycling amount and material savings of aggregates by 32% in the current scenario. Overall material savings as well as material productivity would increase by 19% in the current scenario (meaning a material productivity increase of 4.6% instead of 3.9%).

- **Assumptions relevant for the relation between recycling amounts and material savings**

The amount of recycled glass, aggregates (this corresponds to the non-metallic mineral fraction of C&D waste), plastic, wood and biowaste replaces almost the same amount of materials that are domestically extracted. This is assumed firstly, because imports for these materials are quite low so they replace domestic extraction only. Secondly, there are some references for a use of the recycled materials that do not substitute more than the extraction itself in contrast to a replacement of a long production chain. Thirdly, materials (equipment) and energy required to collect and prepare the waste for recycling might equal the materials and energy required for extraction. These reasons explain why the replacement factor of 1 is chosen (1.1 for wood as this is common in the MFA). Increasing all these factors (glass, aggregates, plastic, wood, biowaste) by 30% would increase overall material savings and material productivity by 23% (corresponding to material productivity increase of 4.8% instead of 3.9%).

- **Metals:** The assumptions for metals are especially sensitive since there is a considerable difference between the recycling amounts and the amount of material that can be saved. Refined metals have ore grades that vary from 46% (iron) to 5% (copper). In addition to this, Europe imports about 95% of its metals in various stages of final products (from pig iron to cars). To test the sensitivity of results, all assumptions were altered by 30%. To avoid the effects cancelling each other out, the assumptions were always altered to increase material savings. Specifically, the changes were: lowering the average ore grades for metals by 30%; increasing the share of imported ores in relation to imported products by 30%; and, increasing the recycling amount by 30%. All these changes together increase overall material savings by 13% (meaning a material productivity increase of 4.4% instead of 3.9%).

- **Paper:** Eco-Invent provides some important input for the calculation of the production versus recycling process chain. However, to link this LCA calculation with the amounts of collected paper, the relation between collected paper and pulp from collected paper needs to be made. There is very little information available on this quantitative relation and the little there is offer contradicting figures. In the actual calculation it is assumed that 1 kg of collected (recovered) paper results in 0.51 kg of material savings (wood). This implies that collected paper needs to be sorted by quality. Since a special mix of paper quality is

required there might be some losses. Furthermore, the paper pulp has losses as well (e.g. other matter and short fibres have to be removed). In the actual calculation global figures were used to determine the relation between collected paper and pulp. In the public discourse, it is often claimed that 1 tonne of recycled paper saves a certain number of trees²⁰⁶. There is no proper reference for this, and WRAP does not support the view that recycling paper saves trees (it does however reduce energy consumption, toxicity and the production of waste waster)²⁰⁷. For this reason the figures were not used in the actual calculation. However, to test the sensitivity a figure of 1.5 tonne of materials are saved for every tonne of recycled paper was used. This change increases the total material savings by roughly 40 Mt or by 12% (meaning a material productivity increase of 4.4% instead of 3.9%).

- **Energy:** The assumption in the actual calculation is that recycled material replaces just the relevant raw materials for the respective material, e.g. recycled iron substitutes only iron ores. This calculation neglects for example energy savings and consequently the savings of the relevant saved fossil fuel carriers as mass. In general this assumption is only of significance for metals since these materials are very energy intensive in extraction and production. To check the influence of this assumption the energy savings in mass for iron were estimated.

Table 70: Comparing direct material savings of iron recycling with energy savings expressed in mass (values in Mt)

	Recycled iron in Mt	Direct savings in Mt	Energy savings in Mt of oil	Additional savings in %
Domestic ores	1.47	3.19	0.89	28%
Imports ores	8.46	18.38	4.09	22%
Imports products	3.96	3.96	0.00	-
Sum	13.89	25.54	4.97	19%

- In the case of iron considering energy savings would mean additional material savings for iron of 19%. A similar calculation for aluminium means additionally 82% of material savings for the respective savings²⁰⁸. An estimate shows that considering energy savings for all metals (using the 82% for copper and lead as well) would increase the resource saving of metals by 36% and the overall material savings by 4 % (meaning a material efficiency increase of 4.1% instead of 3.9%).

²⁰⁶ www.wasteonline.org.uk/resources/InformationSheets/Paper.htm

²⁰⁷ WRAP, Environmental benefits of recycling paper. Information sheet.

²⁰⁸ Hammond, G.P. & Jones, C.I. (2008) Inventory of Carbon and Energy (ICE). Version 1.6a. University of Bath, UK. Available at www.bath.ac.uk/mech-eng/sert/embodied/

Assumptions relevant for the plausibility check

- There are assumptions that do not enter the calculations. However, they are relevant for the plausibility check and especially for the plausibility of recycling amounts.
- There is a high uncertainty of the relation between ‘old’ and ‘new’ scrap used in the metal production. Old scrap would mean metal collected after consumption and therewith would be the recycling amount. New scrap is metal from the primary production process and which is recovered internally (either within the same plant or sold to other companies) and recycled. Due to the definition of recycling this is not considered as recycling. To test the significance of the assumptions the share of old scrap was increased by 30%. This increases the plausible recycling amounts by 30% and the overall material savings in the calculation based on MFA/production statistics by 7%. This increases the gap between waste statistics and MFA/production statistics from +71% to +123%.
- There is high uncertainty on how much of the annual production goes into long lasting stocks (e.g. buildings, infrastructure, machines, etc.). The assumption is that 70%²⁰⁹ of the produced metals and the used non-metallic minerals are added to stocks annually. On the other hand stocks are demolished and therefore old flows become available for recycling again. In the calculations it is assumed that 50% of materials are net additions to stocks (additions to stocks minus demolished stocks), meaning that only 50% of the production of the respective materials is available for recycling. If this number is increased 30%, the waste flows would be 30% higher than in the plausibility check. Using constant recycling rates, these would increase as well. Referring to Table 69 (plausibility check) the data from MFA/production statistics for the current scenario e.g for iron would go up roughly from 33Mt to 44Mt and would increase the gap to the data from waste statistics of 14 Mt. This makes these amounts even more implausible. The gap between waste statistics and MFA/production statistics increases from +123% to +204%.
-

Table 71: Sensitivity analysis: assumptions and their relevance for the increase in material productivity

Assumptions as relevant for calculation of material savings and productivity increases	Total material productivity increase	Description of test – testing one assumption means that all other assumptions like in the left column	Total material productivity increase
Aggregates: “other waste” and “miscellaneous” are not included	3.9%	“other waste” and “miscellaneous” to be included	4.6%

²⁰⁹ Julian M. Allwood, J.M, Cullen, J.M & Milford, R.L. (2010) Options for Achieving a 50% Cut in Industrial Carbon Emissions by 2050. Environmental Science & Technology. Vol. 44, Issue 6, pp. 1888-1894

Assumptions as relevant for calculation of material savings and productivity increases	Total material productivity increase	Description of test – testing one assumption means that all other assumptions like in the left column	Total material productivity increase
Glass , aggregates, plastics and biowaste replace raw materials 1:1 and wood 1:1.1		Increase the factors by 30%	4.8%
Metals : various ore grades are assumed, relation imported ores to imported products are assumed based on MFA		Lower ore grades by 30% and increase share of imported ores and increase recycling amounts by 30%	4.4%
Paper : using Eco-Invent data and global data on paper and pulp results in a factor of 1 kg recovered paper replaces 0.51 kg of wood		Changing the factor to 1 kg recovered paper replaces 1.5 kg of wood	4.3%
Metals : no saved energy is considered		To add 19% of material savings due to energy savings in mass for iron and 82% for copper and lead	4.1%

The conclusion of this sensitivity analysis is that considering a mix of possible changes the current scenario has an uncertainty range of 3.9% +/- 20% (assuming that only half of the assumptions might become effective at the same time). The uncertainties with the highest significance are the replacement factor (how much recycled material replaces extracted material); aggregates (other waste and miscellaneous); and, metal recycling.

ENVIRONMENTAL IMPACT ASSESSMENT

The normalised factors were used as a previous step to the weighting. In this sense, the Institute of Environmental Sciences at the Leiden University is working (as December 2010) on a weighting scheme for the overall environmental impact²¹⁰ for the Joint Research Centre of the European Commission, based on the International Life Cycle Data system (ILCD). These weighting sets are from a first review of currently available weighting sets conducted for the JRC. They in no way necessarily reflect the views of the Commission. However, the midpoint impact categories presented in the JRC work are slightly different from the ones in the EMC

²¹⁰ Huppes G, van Oers Laurant (2010). Report on the work towards the weighting scheme for the overall environmental impact. Deliverable A2b. Section 2. Recommended weighting approach for measuring the EU-27 overall environmental impact.

methodology used in the present study, so the weighting scheme needed some adaptations in order to be used. The EMC methodology also proposes equal weighting factors as an alternative method, compared to the EPA/BEE/NOGEPA weighting methods. Table 72 shows these different weighting factors compared.

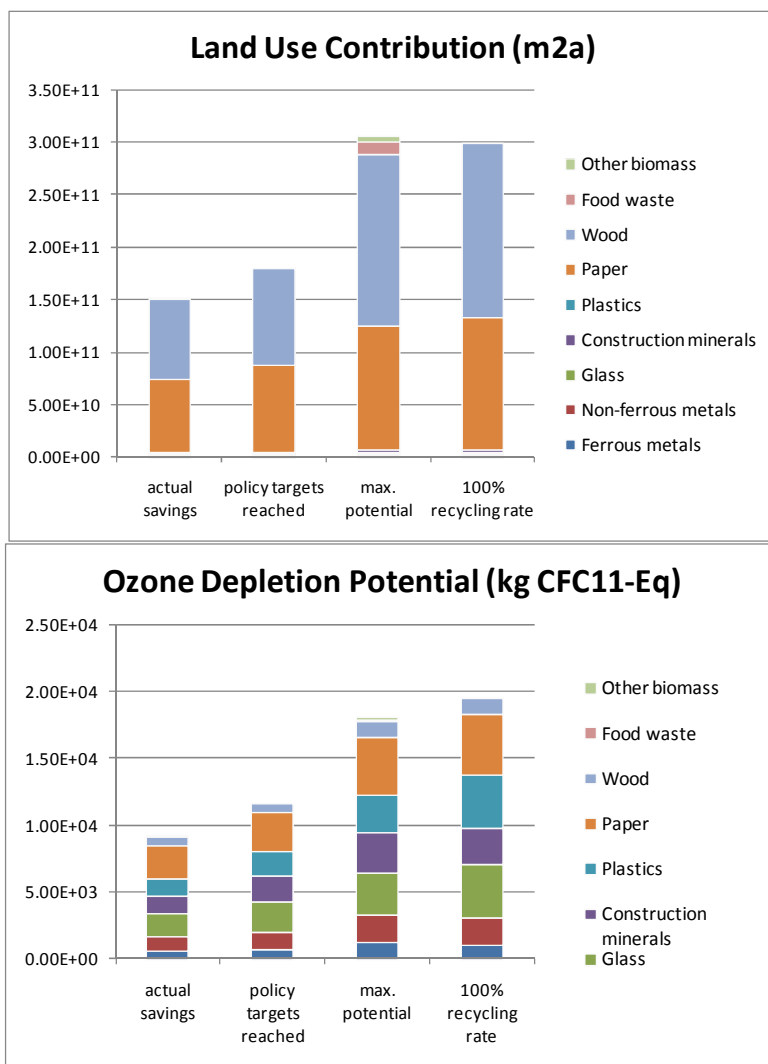
Table 72: Weighting factors used in the environmental impact assessment

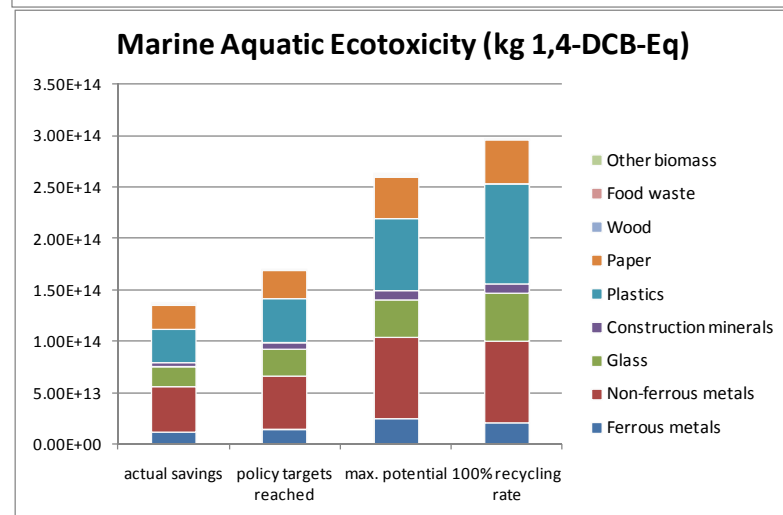
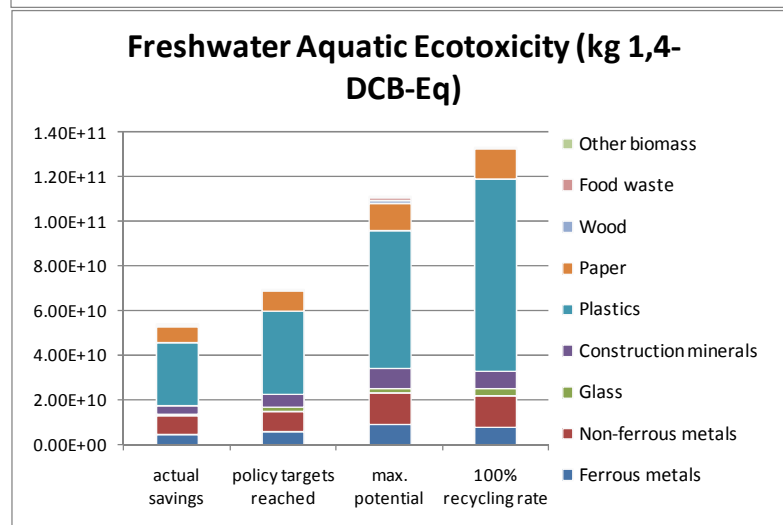
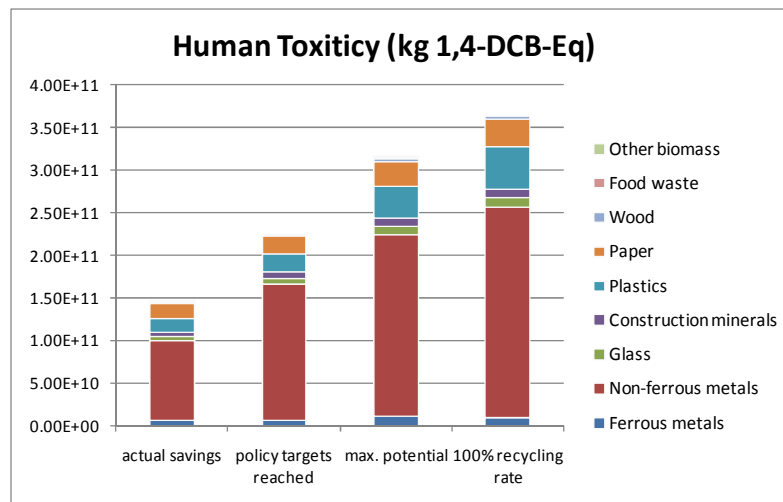
ILCD impact categories	Average EPA, BEES, NOGEPA	EMC impact categories	Average EPA, BEES, NOGEPA	Redistribution to 100	EMC Equal weighting
Climate change	23	Climate change	23	27	11.1
Ozone depletion	4	Ozone depletion potential	4	5	11.1
Acidification	4	Acidification potential	4	5	11.1
Eutrophication	7	Eutrophication potential	7	8	11.1
<i>Terrestrial</i>	7/3	-	-	-	-
<i>Fresh water</i>	7/3	-	-	-	-
<i>Marine</i>	7/3	-	-	-	-
Photochemical ozone formation	5	Photochemical oxidation	5	6	11.1
Human toxicity cancerous	6	Human toxicity	6	7	3.7
Human toxicity non-cancerous	4	-	-	-	-
Particulate matter/respiratory inorganics	7	-	-	-	-
Fresh water ecotoxicity	11	Freshwater aquatic ecotoxicity	11	13	3.7
Ionizing radiation, human health	6/2	Ionising radiation	6/2	4	11.1
Ionizing radiation, ecosystems	6/2	-	-	-	-
Resource depletion	7	Abiotic resources depletion	7	8	11.1
Resource depletion water	5		5	6	
Land use	10	Land use contribution	10	12	11.1
-	-	Marine aquatic ecotoxicity	0	0	Left out because of uncertainties
-	-	Terrestrial ecotoxicity	0	0	3.7
Total	100		85	100	100

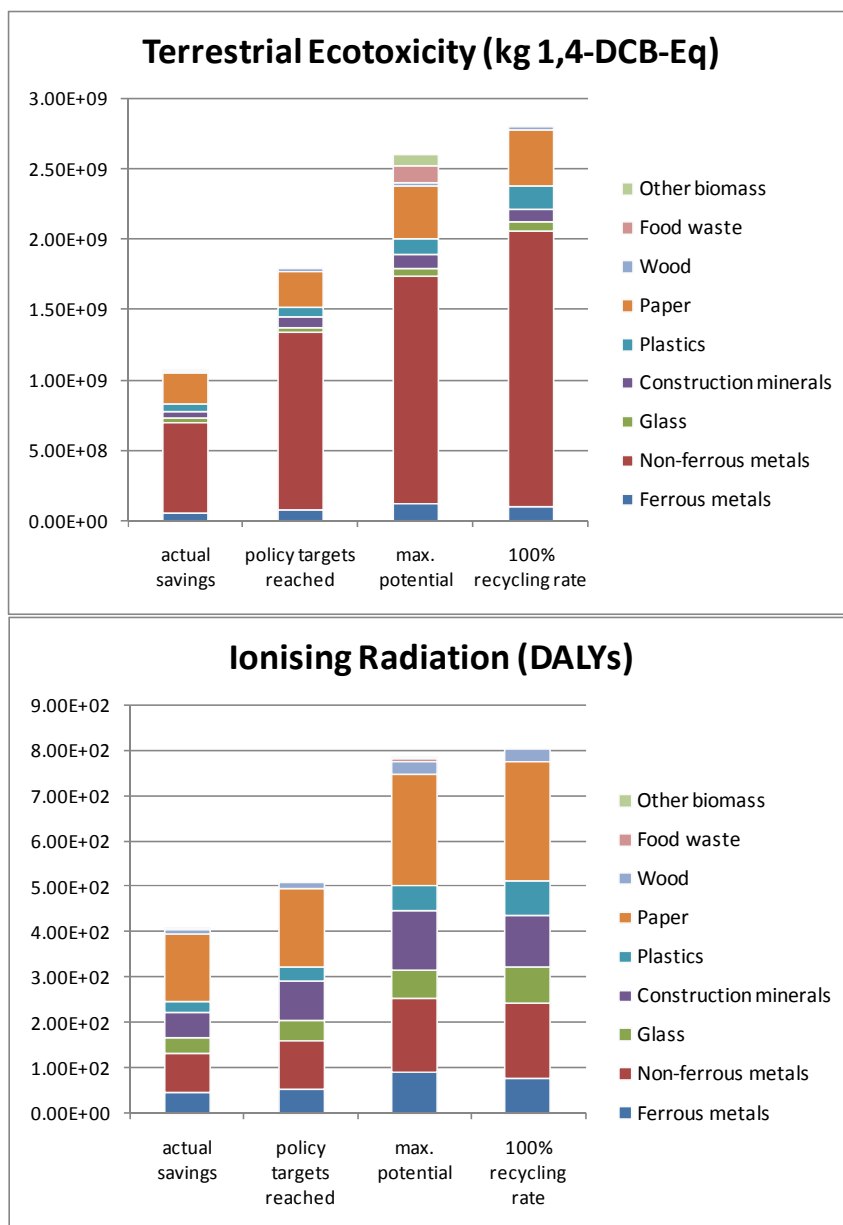
The weighting of environmental impact categories is a controversial issue in the LCA community, but when the aim is to have a single indicator for environmental impacts it is necessary. The weighting methods are not scientifically proved and are seen as subjective steps rather than objective steps in environmental impact assessments.

Results

The choice of the environmental impact categories is also controversial in the LCA community, and is more related to the objectives and limits of the study. For instance, the EIPRO study uses only five impact categories to analyse the results: Climate change, Eutrophication potential, Abiotic resources depletion potential, Human toxicity and Ecotoxicity. For the present study, all the impact categories are used in the calculations and shown in the following.







The monetary values of some precious metals content in EEE are shown in Table 73.

Table 73: Monetary values of metals

Metal	Price (\$/kg) (2007) ^{211,212}	Production (ktonnes) (EU-27, 2007)		Total value
Al	2.78	5 282		14 684
Cu	7.28	2 255		16 416
Zn	3.43	2 490		8 541
Au	22 280	0.32		7 130
Fe	0.06	107 387		6 443
Ni	37.2	149		5 543
Ag	430	6.06		2 606
Pb	2.76	881		2 432
Sb	6	24		144
Pd	11 413	Pt, Pd, Rh, Ir, Os, Ru	12	-
Pt	41 957			-
Ru	18 647			-
Sn	15	-		-
Co	62	-		-
Bi	31	-		-
Se	72	P, As, Se	82	-
Ln	682	-		-

²¹¹ Christian Gagelüken, Christina Meskers (2008) Mining our computers – Opportunities and challenges to recover scarce and valuable metals from end-of-life electronic devices

²¹² USGS (2009) Mineral commodities summaries 2009